Antigua & Barbuda's 2015-2020 National Action Plan:

Combatting Desertification, Land Degradation & Drought

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Foreword

The National Action Plan Is a result of collaboration between local agencies and stakeholders to craft a national response by the Government and people of Antigua and Barbuda to the UNCCD and the wider international community to devise a national desertification, land degradation and drought response system which uses indicators and modern technology to make an assessment of vulnerability by employing the research collected in the process of authoring this plan.

This document seeks to address issues of serious DLDD in Antigua and Barbuda and serves as a guide to the national situation and highlights areas where mitigation and adaptation should occur. It fosters clearer pathways towards coordinated and strategic actions to address the effects of DLDD and identifies gaps in human and technological resources.

The UNCCD 10-Year strategic plan calls for the establishment of sustainable financing at the international level while also encouraging member states to create similar mechanisms at the national level. Antigua and Barbuda achieves this through the Sustainable Island Resource Framework (SIRF) Fund. Established by section 84 of the Environment Protection and Management Act (2015), it will address those areas of SLM and Climate Change Adaptation and Mitigation which cannot readily be planned for under annual government allocations. These funds will strengthen the capabilities of Antigua and Barbuda and its local institutions through drought-related programmes and promote collaborations with relevant agencies to combat drought, land degradation and desertification.

Without the assistance of the United Nations Environment Programme and other members of the international community this document would have been incomplete and I take this time to fully recognise their contributions.

The Honourable Molwyn Jospeh

Minister of Health and the Environment

Acknowledgements

The process of developing "Antigua & Barbuda's 2015-2020 National Action Plan: Combatting Desertification, Land Degradation & Drought" required considerable research and consultation with a variety of agencies and stakeholders. Without the assistance of these partners it is doubtful if this exercise and resultant document would have been possible. To this end the opportunity is being taken to express words of appreciation and gratitude.

The Government of Antigua and Barbuda would like to thank the United Nations Development Programme and the Global Environment Facility for their invaluable support in providing financial and technical assistance toward the elaboration of this document.

Particular thanks is also expressed to the various agencies and stakeholders which participate in the Technical Advisory Committee as they served not only as sources of information which contributed to the elaboration of the NAP but also provided the much needed peer review of the document and project during its various phases.

Finally, the 2005 NAP team needs to be recognised as it was their original work that serves as the basis from which this 2015 version of the NAP was developed.

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Acronyms

ABST-	Antigua and Barbuda Sales Tax
APUA-	Antigua Public Utilities Authority
BPOA-	Barbados Plan of Action
BRC-	Barbuda Research Complex
CARDI-	Caribbean Agricultural Research and Development Institute
CARICOM-	Caribbean Community
CCA-	Climate Change Adaptation
CDB-	Caribbean Development Bank
CHAPA-	Central Housing and Planning Authority
COP-	Convention of the Parties
CSO-	Civil Society Organisations
DLDD-	Desertification / land degradation and drought
DMS-	Department of Meteorological Services
DMS-100-	Switch Digital Multiplex System
ECCB-	Eastern Caribbean Central Bank
EAG-	Environmental Awareness Group
EIMAS-	Environmental Information Management Advisory System
FAO-	Food and Agricultural Organisation
GARDC-	Gilberts Agricultural Rural Development Center
GATE-	Government Assisted Technology Endeavour
GCCA-	Global Climate Change Alliance
GDP-	Gross Domestic Product
GEF-	Global Environment Facility
GIS-	Geographical Information System
GOAB-	Government of Antigua and Barbuda
ICT-	Information and Communication Technology
IICA-	Inter-American Institute for Cooperation on Agriculture
IWCAM-	Integrated Watershed and Coastal Area Management
IWRM-	Integrated Water Resources Management
MOA-	Ministry of Agriculture
NAP-	National Action Plan
NEMS-	National Environmental Management Strategy
NIWRM -	National Integrated Water Resource
NGO-	Non-Governmental Organisations
NODS-	National Office of Disaster Services
NPDP-	National Physical Development Plan
OECS-	Organisation of Eastern Caribbean States
PGDM-	Post Georges Disaster Mitigation
REGATTA-	Regional Gateway for Technology Transfer and Climate Change Action in Latin America and the Caribbean
SIDS-	Small Island Developing State
SIRMM-	Sustainable Island Resource Management Mechanism
SIRMZP-	Sustainable Island Resource Management Zoning Plan
SLM-	Sustainable Land Management
TAC-	Technical Advisory Committee
UN-ECLAC-	United Nations Economic Commission for Latin America and the Caribbean
UNCBD-	United Nations Convention on Biological Diversity

UNCCD-	United Nations Convention to Combat Desertification
UNDP-	United Nations Development Programme
UNFCCC-	United Nations Framework Convention on Climate Change
UNSD-	United Nations Statistics Division
VIA-	Vulnerability Impact Assessment

Executive Summary

Antigua & Barbuda's 2015-2020 National Action Plan: Combatting Desertification, Land Degradation & Drought is a response by the Government of Antigua and Barbuda to the United Nations Convention to Combat Desertification (UNCCD) and the wider international community to:

i. describe how the components of Desertification, Land Degradation and Drought (DLDD) manifest in and affect Antigua and Barbuda;
ii. explain how the nation and its people predict, record and respond to these events; and
iii. outline our desired strategy to effectively achieve resilience to and manage these impacts in accordance to the UNCCD Ten-Year Strategy.

An original National Action Plan (NAP) was drafted (but never approved) in 2005 and is being used as a platform from which to align the nation's DLDD strategy moving forward to the 10-Year Strategy. However, with this version of the NAP being compiled some 10 years after the original 2005 draft, also recognises that there have been significant changes to the national situations which have caused some components to be modified significantly or abandoned all together. A prime example of this is the concept of a National Land Degradation Profile, which sought to identify land degradation hotspots.

This version of the NAP moves away from that approach as it suggests a static nature to DLDD. When one considers the impacts of climate change and that the definition of desertification both stress human activities as key factors behind their occurrence a dynamic and a real time approach needs to be pursued. This document therefore devises a national DLDD response system which uses available indicators and modern technology as a means of prediction, vulnerability assessment, monitoring and impact assessment.

Finally was the reorganisation of the NAP to align it to the five operational objectives of the UNCCD 10-Year Strategic Strategy. Whereas the 2005 draft had two sections, Determination of NAP priority issues and Areas and Formulation of a National Implementation Plan, this NAP merged both into one section focused on Aligning National Action to the 10-Year Plan.

Background

Introduction

The Government of Antigua and Barbuda commissioned the drafting of a National Action Plan (NAP) to address issues of serious land degradation and drought in 2004 as an obligation under the United Nations Convention to Combat Desertification (UNCCD). This exercise was completed through the establishment of a Technical Advisory Committee (TAC), comprising of key stakeholders, which held a series of consultations and site visits to complete the document in 2005.

The resultant Draft National Action Plan was elaborated to meet three (3) specific mandates. These were:

1. Development of National Land Degradation Profile of Antigua and Barbuda.
2. Determination of NAP priority issues and areas.
3. Formulation of a National Implementation Plan.[1]

The act of elaborating a NAP was expected to serve as a mechanism through which affected member parties of the UNCCD could signal to partner agencies the types and levels of interventions which would be required to effectively reduce the vulnerabilities and impacts to desertification, land degradation and drought (DLDD). However, without key guidelines for the elaboration of NAPs, the resultant disparity among the produced documents did not provide clear pathways toward coordinated and strategic actions.

As a result, during COP 8, the Parties to the UNCCD adopted a Ten-Year Strategic Plan and framework to enhance the implementation of the Convention (2008-2018)[2] (The Strategy). Subsequently in COP 9, the parties took the decision to call upon "affected country parties and other relevant stakeholders to use NAP alignment guidelines as a reference tool for aligning NAPs and other relevant implementation activities with the 5 operational objectives of the Strategy"[3].

[1] (2005) Final Report of The Technical Advisory Committee on the Draft National Action Plan under the Convention to Combat Desertification
[2] Decision 3/COP8 "The 10-year strategic plan and framework to enhance the implementation of the Convention"
http://www.unccd.int/Lists/SiteDocumentLibrary/10YearStrategy/Decision%203COP8%20adoption%20of%20The%20Strategy.pdf
[3] Decision 2/COP9

Description of Antigua and Barbuda

Geography

Antigua and Barbuda is a twin island state located in the Caribbean Sea approximately 250 miles Southeast of Puerto Rico and is the most central of the Leeward Island chain which starts with the Virgin islands in the West and ends with Dominica in the South (Fig 1[4]). There are several tiny uninhabited islands surrounding Antigua; Redonda (0.6 sq. miles or 1.6 sq. km) being the largest. The precise coordinates of Antigua are 17°10' latitude, 61°55' longitude, Barbuda is 28 miles north of Antigua at latitude 17°35' and longitude 61°48'. Antigua is roughly round and has an area of 108 sq. miles (280 sq. km) and Barbuda 62 sq. miles (160 sq. km) with an exclusive economic zone of 110,071 sq. km.

Figure 1 Map of Antigua and Barbuda

The islands of Antigua and Barbuda are emergent parts of a 3400 sq. km submarine platform. The depth of water between the two islands is 27.33 m. The coastline of Antigua is indented with numerous islands, creeks, inlets, associated sand bars and wetlands. A large portion of the east, north and south coasts are protected by fringing reefs. On the west coast, there are large areas of sandy bottom in shallow water, with sandy bottom between fringing reefs and the shore. The coastline of Barbuda is less varied but has extensive reef systems especially off the east coast. The Codrington Lagoon is bordered by mangroves and sand ridges. This area is of significant importance to the fisheries and wildlife of Barbuda

Antigua can be described as undulating. The highest point in Antigua is Mt Obama 1,319 ft (402 m) in the southwest where the other steepest slopes are located. Slopes of 11^0 – 20^0 are common in this region but in localized areas in the south, slopes up to 30^0 exist. Antigua has three topographic zones. The first zone considered is the mountainous southwest volcanic

[4] http://www.worldmapsonline.com/academia/academia_antigua_political_map.htm

region. It is comprised of hard igneous rocks in the uplands and sedimentary material in associated valleys. The valley systems of this volcanic region consist of sandy loams or loams of near neutral pH which is conducive to tree growth. The second zone is the relatively flat Central Plains. This region is characterized by heavy clays which are not readily drained and near neutral pH, some calcareous clays are found in parts. In general, these soils are hard to work. The third zone can be described as the rolling limestone hills and valleys of the North and East. The limestone areas in the North have high clay content but possess good structure and have a high base structure and high base saturation, ph 8.2. These soils are generally productive. However, the limestone areas in the East consist of complex shallow and deep calcareous soils and the drier climate restricts productivity.

Barbuda is geologically connected to Antigua but due to sea level rise at the end of the last ice-age around 10,000 years ago, is now separated by a shallow area of sea. Barbuda also has three geological regions:

1. The Highlands limestone area consists mostly of hard limestones, which contain caverns and sink holes
2. The Codrington Limestone region, which contains sandy and fossiliferous sediments less crystalline than the Highland limestone
3. The Palmetto Point Series. This overlies the Highlands and Codrington formations in coastal areas on the western side of the island, especially between Palmetto Point and Sand Ground and is composed of beach sands and ridges, with shelly horizons. Considerable amounts of these sandy deposits have been surface mined for use in construction.

Barbuda is relatively flat with some low lying hills rising to just under 125 ft (40m) in the Highlands area. On the western side of the island is the Codrington Lagoon averaging about one and a half miles in width and separated from the sea by a narrow spit of sand. Barbuda's topography is relatively uniform, sand dunes are present but the land is generally covered by limestone and sand.

Climate

The climate of Antigua and Barbuda is characterized as being moderately arid tropical maritime. It has marked wet (July – December) and dry (January – June) seasons with little variation in daily seasonal temperatures. The 30-year average temperature for Antigua and Barbuda is 29.9°C (1981-2010AD). Trend analysis of average temperatures by the Department of Meteorological Services has shown a generally upward projection, approximately +0.6°C. Additionally, in the 40-year timescale provided in the data the ratio of above/below average temperature years was 15/25, but more importantly 11 of those years occurred within the last twenty of the timescale. (See Fig

2)[5] Over a thirty year period, it was determined that the coolest month tended to be February while the warmest month was August.

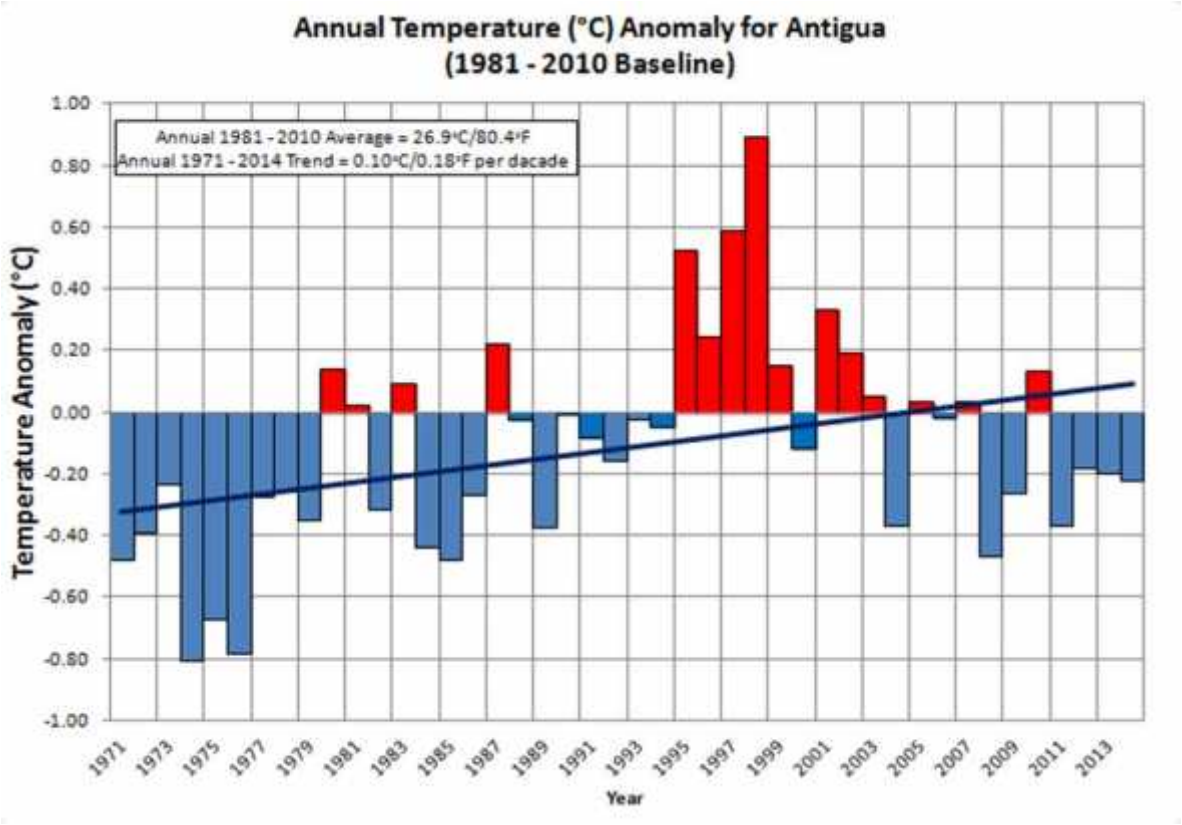


Figure 2 Annual Temperature Anomaly for Antigua

Rainfall tends to be variable, with severe droughts occurring every 5 – 10 years. Evapo-transpiration rates are high. During the drought of 1983 – 1985, less than 1000mm of rain occurred over 21 months. All surface reservoirs had dried up and the supply of groundwater produced only 1/6th of national demand and as a result water had to be imported from neighbouring islands. More recent droughts have been nearly as severe but the availability of desalinized water has made the impact less visible.

The average rainfall across the island in the direction of prevailing northeast trade winds is about 33 inches in the northeast to over 50 inches per year in the southwest. The average rainfall per year (1961-1990) is approximately 46.30 inches. Pan evaporation averages are about 77 inches per year and open water evaporation is estimated at 65 inches per year. Barbuda has a lower rainfall average.

Data from the Department of Meteorological Services are also showing a noticeable trend of rising precipitation (see Fig 3[6]). However if data were to be counted as number of years above/below the mean, then it would be noted that in the eighty years

[5] Source: Department of Meteorological Services
[6] Source: Department of Meteorological Services

spanning 1928-2008 the positive/negative ratio was 35/45. This means that although there was a general increasing trend, the norm would be to have sub-average precipitation.

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

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

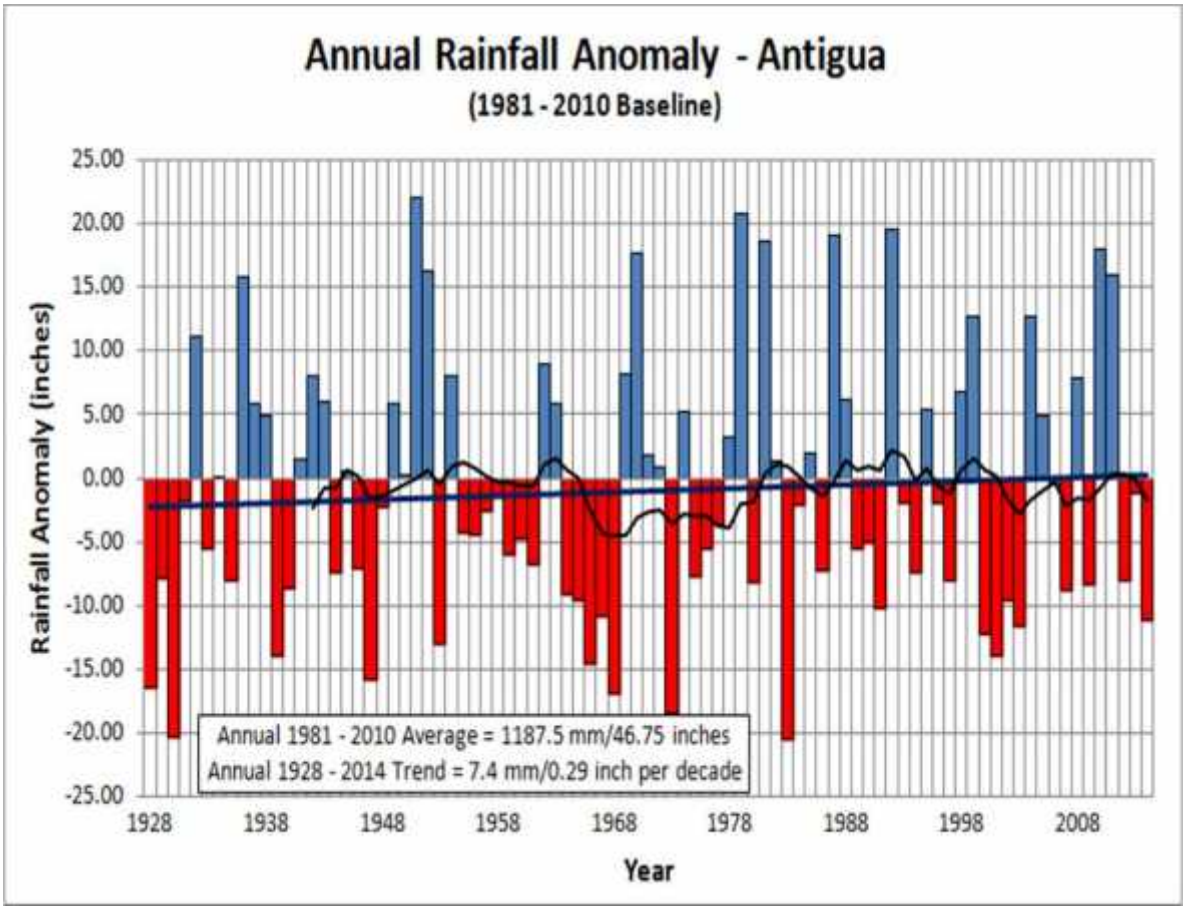


Figure 3 Annual Rainfall Anomaly for Antigua

Natural Hazards

Antigua and Barbuda is prone to a number of natural hazards, chief among these are tropical cyclones, droughts and earthquakes. These events are generally felt nation-

wide. The propensity to experience droughts and tropical cyclones are a direct result of being located within a tropical maritime climate. Antigua and Barbuda is also situated along the West Indies Arc convergent plate margin between the Caribbean and North American Plates, which is a seismically active zone, which makes it susceptible to earthquakes.

On smaller scales, Antigua and Barbuda also experiences occasional floods, bush fires, landslides, storm swells and localized wind events. Many of these localized hazards can also occur as secondary or related events to an island-wide event. Of growing concern, however, is the impact of climate change on the frequency and/or intensity of natural hazard events on Antigua and Barbuda. In fact so significant are these impacts that in the Draft Nation Comprehensive Disaster Management Policy [2013-2016] climate change is recognized as a hazard in itself.

The impacts of climate change are varied on Antigua and Barbuda, but as pointed out in Table 1[7] below many of the observed climate change and climate variability events carry direct links to DLDD manifestations.

Antigua and Barbuda is also susceptible to hazards that can originate from outside its borders. Specifically this pertains to volcanic eruptions in neighbouring islands and tsunamis.

Table 1 Climate Projections for Antigua and Barbuda and the Insular Caribbean

Climate Parameter	Predicted change for the Insular Caribbean	Predicted change for Antigua and Barbuda
Air temperature	Increase of 1.8 - 4.0°C by 2099	Increase of 1.3°C by the 2050s Increase of 1 - 3.5°C by the end of the century
Sea surface temperature	~1.7°C by the end of the century	Up to 2°C by the end of the century
Sea level rise	Rise of 0.18 – 0.59 m by 2099	Rise of 0.24 m by 2050
Carbon dioxide	Reduction in pH of the oceans by 0.14 - 0.35 units by 2099	An increase in carbon dioxide emissions through 2050.
Hurricanes	More intense with larger peak wind speeds and heavier precipitation	More intense with larger peak wind speeds and heavier precipitation. (not necessarily increased frequency)
Precipitation	Unclear	Drier (in the mean) by the end of the century

[7] Source: Antigua and Barbuda's Second National Communication to the UNFCCC

Water Resources

Antigua and Barbuda has been plagued by severe droughts every 5 – 10 years since recorded history. Therefore, its water resources are regarded as precious. Groundwater sources in Antigua consist of approximately 50 active wells with major well fields. There is also surface water storage in the form of 10 medium to small reservoirs, 550 ponds and earth dams with the combined capacity of 6 Mm3 (6000 acre-feet/1.6 billion imperial gallons). Most households have cisterns and other water storage containers. Additionally, there are four utility connected Desalination Plants, one private and three owned and operated by the national utility. A fifth reverse osmosis plant is expected to be commissioned in the latter part of 2015. However, due to the expensive nature of desalinated water, it is prioritized for domestic and tourism sectors, leaving the agricultural sector with an inadequate supply.

Barbuda's primary source of freshwater is shallow aquifers that underlie 650 ha of sand in the Palmetto Point Area. However, the removal of sand deposits in the Palmetto Area has raised the effective water table by several feet and exposed part of the shallow fresh water aquifer and as a consequence some of the aquifer is drying out. It should also be noted that the sand mining activities have increased the vulnerability of the island to saline intrusion and impacts of storm surges. Recently, there has been a desalination plant installed in Barbuda to meet the needs of the domestic and tourism sectors.

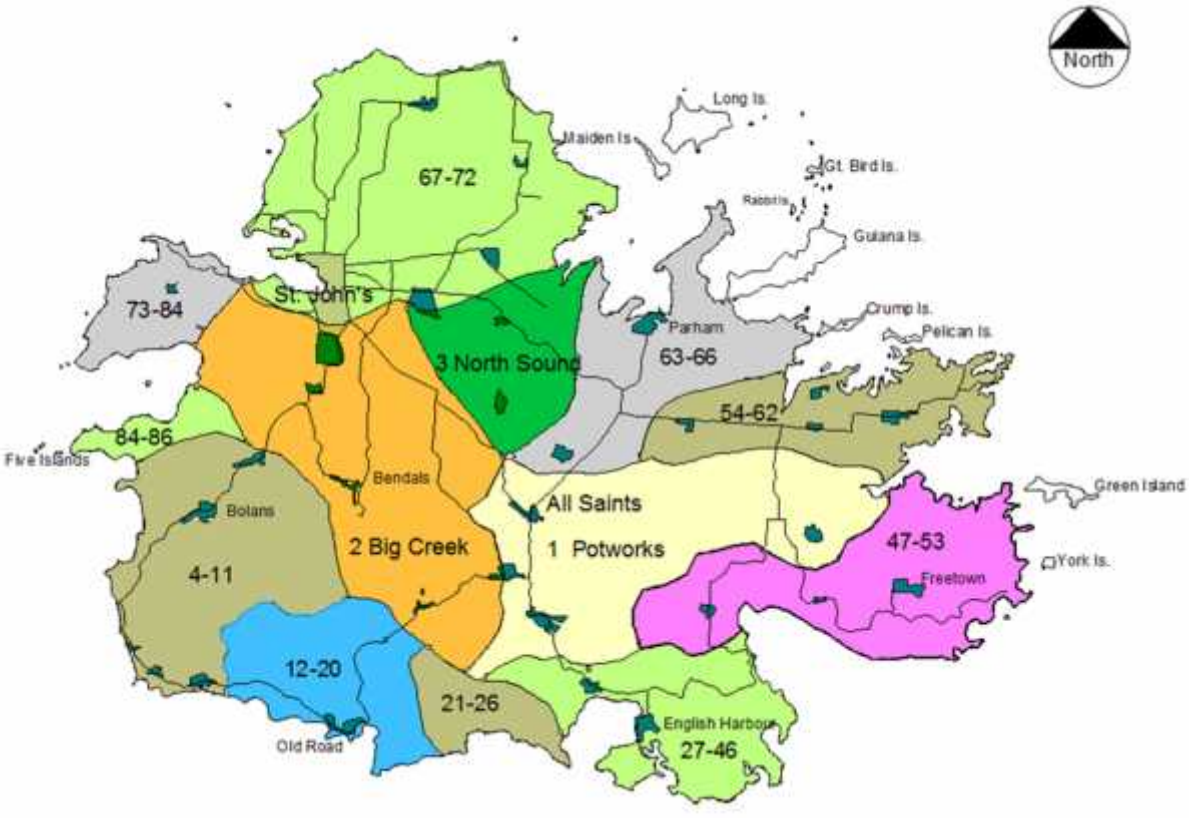
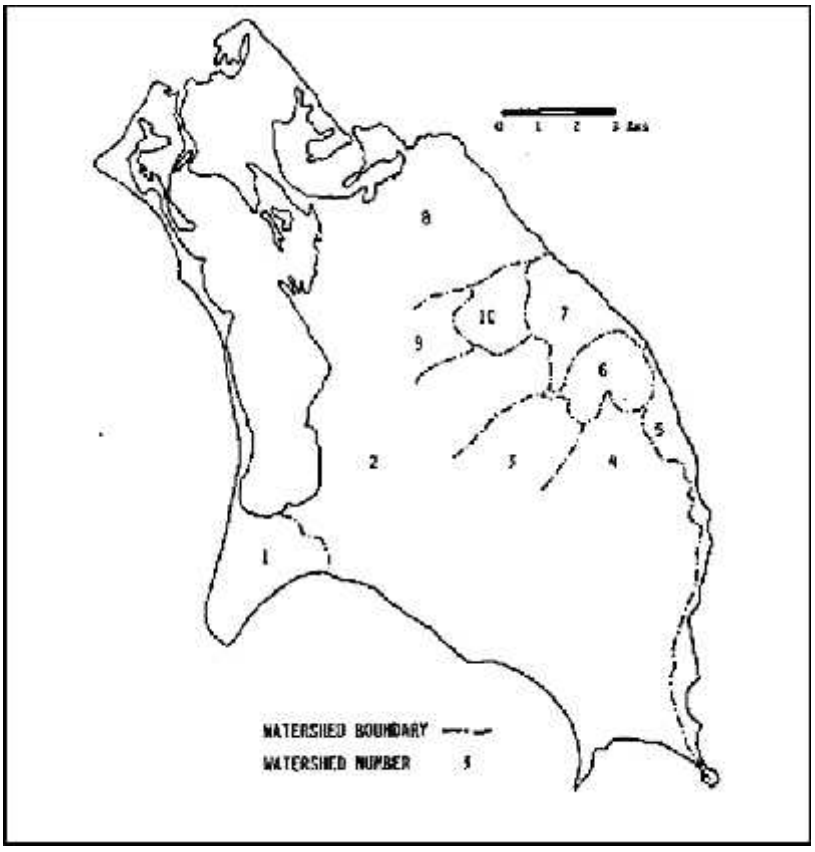


Figure 4 Location of Major Watersheds in Antigua

Watersheds

Antigua has 86 watersheds can be grouped into 13 larger watershed groups. These are depicted in Figure 4. The two largest watersheds are Potworks and Big Creek. The Potworks Watershed drains the northern slopes of the south west volcanic region and the Big Creek Watershed drains main parts of the Central Plain to the east and west. Fitches Creek drains into North Sound. Christian Valley, Parham and Bethesda are also important watershed groups. These six watersheds occupy 43 percent of the land area and contain 80 percent of the groundwater supplies and 90 percent of surface water storage. Within these watersheds are found 50 percent of the island's forest land, 90 percent of its crop production, 60 percent of livestock production and 70 percent of the population (Fernandez 1990). In Antigua, all the watersheds are quite short, the largest being not more than 11 km in length. The two largest have areas of 4000 ha and 3,160 ha respectively. Considerable portions of many watersheds are close to the coast and salt water intrusion is a factor in the quality of some surface storage and ground water supplies in many aquifers.

Figure 5 Location of Watersheds in Barbuda



Barbuda has been divided into 10 watersheds as shown in Figure 5. The relatively flat nature of the topography and permeable nature of the soils in Barbuda make surface runoff minimal and surface catchments impractical.

Ecosystems

Antigua has a variety of vegetation types, however clearing of lands during colonial rule to accommodate sugar production meant that the diversity of vegetation is not as robust as it once was and is in marked contrast to neighbouring Caribbean islands. The current climatic and geological conditions however have contributed to the

development of a diversity of habitats in which species thrive. There are 1158 species from 149 families (Lindsay & Horwith 1997b) of plants found in Antigua and Barbuda. This includes over 80[8] species of ferns and fern allies; 4 species of gymnosperms and 1,109 species of flowering plants. Approximately 197 species of flowering plants merit special conservation measures of which 22 are endemic to the Lesser Antilles, one of which *Pectisericifolia* may be endemic to Barbuda, and 73 are classified as rare.

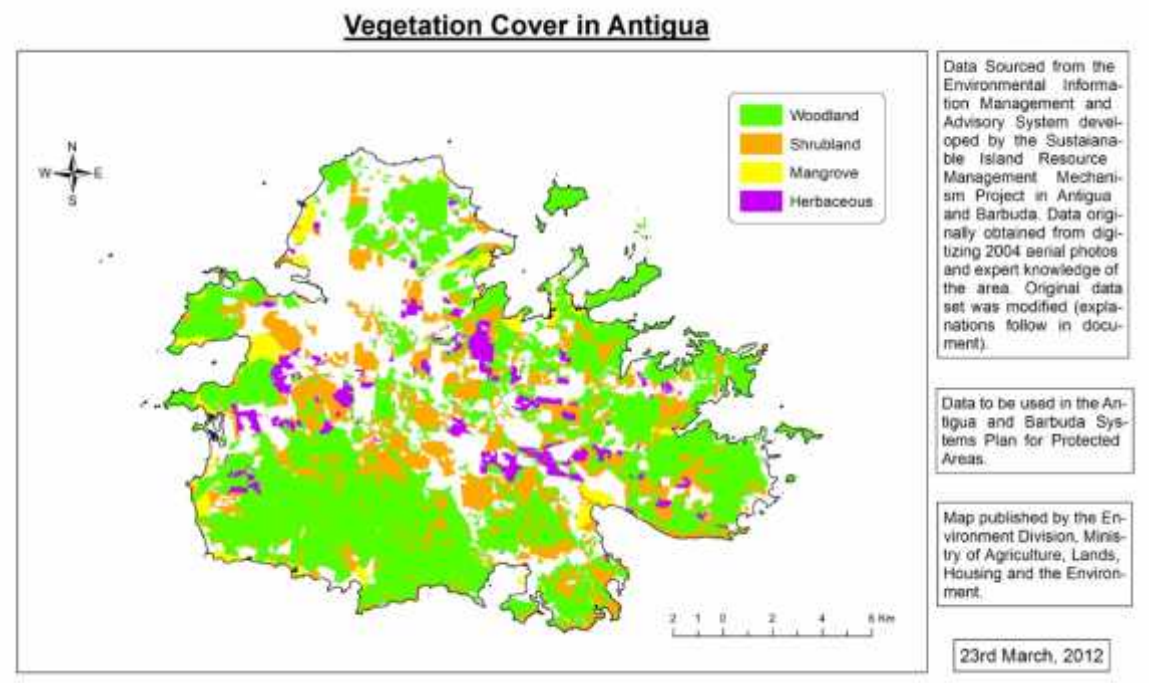


Figure 6: Map of Antigua showing Vegetation Cover in 2010

In Antigua and Barbuda, the inter-relationships of these ecological functions and physical processes result in a number of ecosystems. These include:

1) Evergreen forests
2) Xerophytic (dry) forests
3) Watersheds
4) Scrubland Ecosystems
5) Grassland Ecosystems
6) Mangrove forest Ecosystems
7) Herbaceous swamp Ecosystems
8) Salt pond Ecosystems

[8] Pratt, Lindsay. Pearson & Thomas 2009. Wild Plants of Antigua & Barbuda. An Illustrated Field Guide to the Native and Naturalised Vascular Plants

9) Marine and Coastal Ecosystems - Sandy beaches, rocky shores, coastal lagoons, sea grass beds, coral reefs and oceanic islands and rocks.

Ecosystem variety is enhanced by presence of caves in many sections of the island, and by natural seasonal drainage channels and ponds.

Studies of the seven indigenous forest types in Antigua and Barbuda have documented 54 vegetation communities of which 16 are listed as rare, 26 as uncommon and 12 as common.

In Barbuda, dry woodland covers the highland of the northern section of the island and the western coast sand bar separating the sea from the Codrington Lagoon. Cactus scrub is also found on most of the island. There is a coconut plantation only in the Palmetto Point area though the production has reduced when compared to previous years. It is noted however that there are mangrove-fringing areas of the Codrington Lagoon in addition to sand ridges. This area is of significant importance to the fisheries and wildlife of Barbuda. As a result efforts have been made to establish an operational national park management system with an administrative body to oversee the efficient management and operations of this fragile ecosystem. The fact that over 60% of the economy in Barbuda depends heavily on the fishing industry indicates the critical importance attached to the preservation of the vegetation and the coastline for Barbuda.

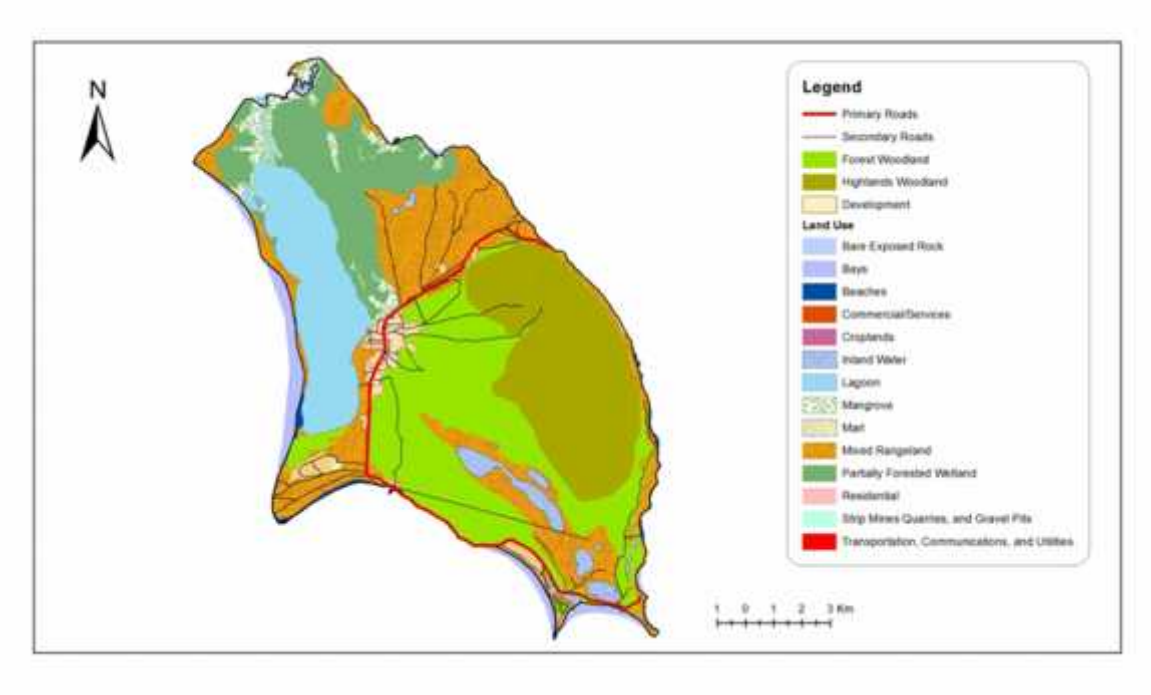


Figure 7: Map of Barbuda Showing Vegetation Cover (source: EIMAS 2012)

With the expected prolonged periods of drought and increase in frequency and intensity of hurricanes as a result of climate change, biologists within Barbuda are

concerned that there may be even further loss of fragile vegetation with replacement by hardier cactus scrub.

Antigua and Barbuda has the most extensive mangrove wetlands in the Eastern Caribbean. There was an estimated 4,900 ha of mangroves found in the twin island state in 1991.There are thirty-six (36) mangrove sites in Antigua and nine (9) sites in Barbuda. In Antigua, the sites range from very small single layer stands of trees to large, complex swamps. In Barbuda, there is the luxuriant 352 ha fringe mangrove of Codrington Lagoon and narrow scrubby borders of mangroves around salt ponds. Four kinds of mangroves exist in Antigua and Barbuda. They are *Rhizophora* (red), *Avincenis* (black), *Laguncularia* (white) and *Conorcarpus* (buttonwood). It is estimated that in the 1980s approximately 11%[9] of Antigua and Barbuda was covered with wetlands. In 2001, a survey of sites estimated that mangrove wetlands covered only 3% of the land area in Antigua and 22% in Barbuda.

Mangroves essentially are vital to maintaining healthy beach and reef systems. They act as natural breakers and buffer zones which protect the coastline from erosion during storms. Additionally, the mangroves act as sediment traps, protecting the reefs from being smothered by eroded soil and other geological material from the land. Finally they act as nurseries, breeding and feeding grounds and provide a habitat for both marine and terrestrial wildlife.

Beaches and sand bars provide a major barrier to the constant force of coastal erosion. Antigua and Barbuda boasts a multiplicity of beaches as the corner stone of its tourism industry and culture. The beaches provide a habitat for nesting turtles and other animals and plants. Unfortunately, some beaches are illegally used as a source of fine aggregates in construction; therefore, sand mining is a significant concern in addition to the potential impacts of sea level rise and other climate influenced coastal erosion events. Additionally, another major source of coastal erosion is the building of concrete structures too close to the shore line and the use of poorly designed and unregulated sea defences.

On the northwest coast, the coastline is gradually eroding away. The Dickenson Bay shoreline eroded at a rate of 2m/yr between 1992 and 1999 and 1.09m/yr between 2006 and 2008 (Source: Fisheries Division, Antigua & Barbuda). The shoreline at Fort James eroded at a rate of 0.5 m/yr. (1992-1999) and recorded accelerated rate of erosion between 2006 and 2008 at a rate of 3.39m/yr. However, although the northern end of Runaway Bay was found to be eroding the southern end accreted by 0.2 m/yr during 1992 – 1999 however between 2006 and 2008 there was erosion at a rate of 2.34m/yr. The northwest coast is especially known for the large numbers of concrete buildings in close proximity to the shore line. The concrete structures and general slope of the land considerably restrict drainage in the area. The mean profile for this area has decreased

[9] Caribbean Conservation Association, Antigua and Barbuda, Country Environmental Profile : (Barbados, 1991), pp 87 - 90

by 10% between 1992 and 1995. It should be noted however that Hurricane Luis (1995) and other storms have significantly contributed to this severe erosion.

Land Use

Under the title Sustainable Island Resource Management Zoning Plan (SIRMZP) Antigua and Barbuda updated and approved the Physical Development Plan initially drafted in 2001. As a result, data is now available on the current land use patterns for the country up to 2010.

The data showed that land used for agricultural crops increased from 5,501 to 7,740 acres over the ten year period (1985 -1995). In 2010, that actually decreased to only 6,855 acres. However, the agriculture livestock grazing land (improved pasture, mixed scrub and rough grazing) which had decreased from 26,252 to 13,482 acres, in the 10 year period between 1985-1995 once again increased to 17,349 acres between 1995 and 2010. Though this shows that farmers are becoming more involved in the rearing of livestock, it is worth noting that these agricultural areas are under increased threat from invasive species. In 2010, the introduced citronella grass, one of the most noted invasive species in Antigua and Barbuda, occupied over 345 acres of land and is constantly pushing out the native species from their natural habitats.

Urban/rural areas slightly decreased from 17,189 acres to 16,177 acres by 2010. Industrial acreage on the other hand, increased from 584 acres to 778 acres. Recreation and Historic Areas, decreased from 1,558 acres to just over 400 acres. Airport and Military land increased from 763 acres to 829 acres between 1995 and 2010. Swamp and Mangrove acreage remained almost the same during that ten year period, 2,164 acres in 1985 to 2,142 acres in 2005 and between then and 2010 has only slightly increased to 2,161 acres.

In Barbuda (Figure 7) (1985), less than 1 % (269 acres) of the land area was occupied by human settlement and related uses, 19,521 acres were occupied by dry forest areas (Limestone Highlands) and swamps and mangroves occupied 9,214 acres. In 2010 the situation had changed slightly with 882 acres being occupied for human settlement. The related services such as commercial services, croplands, strip mines quarries and gravel pits occupied 269 acres. Mangrove and swamps now occupy 14468 acres while dry forest areas occupy only 3896 acres.

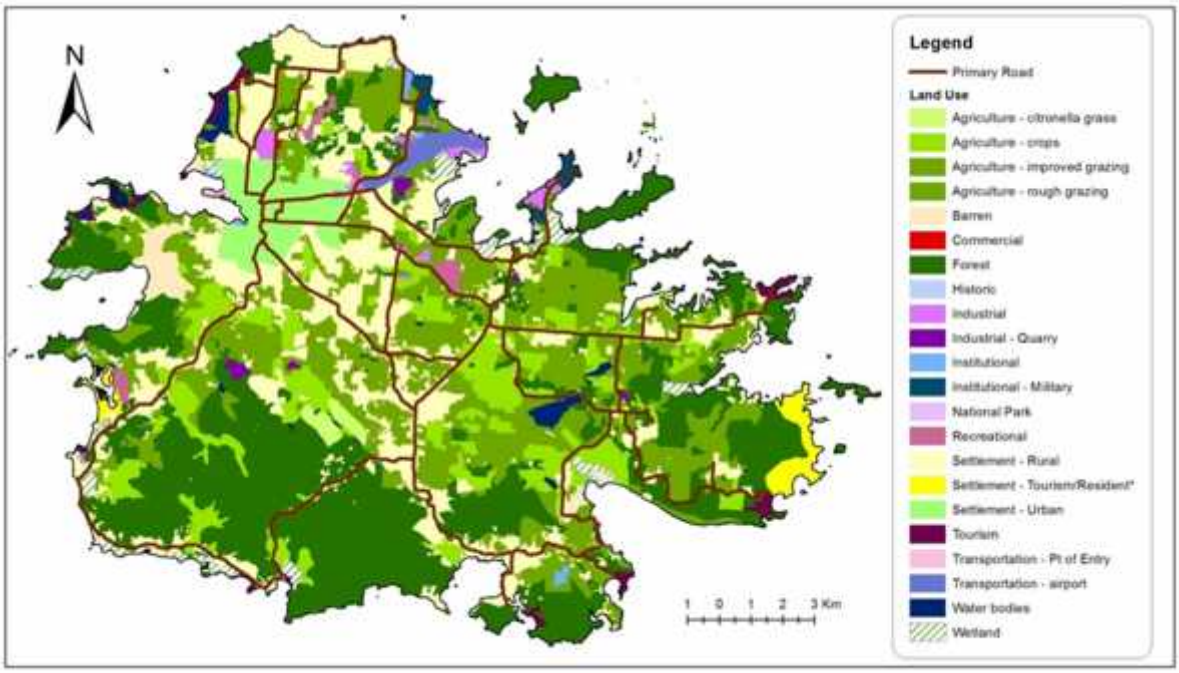


Figure 8: Map Showing Land Use Patterns (2010) for Antigua (Source: EIMAS 2012)

Population

In 2011, when the last census was conducted Antigua and Barbuda had a combined population of 87,774 people, and a gender radio of 91.4 males to every 100 females. Individually, Antigua had 86,159 people and the total population for Barbuda was 1,615 people in 2011. In terms of gender ratio, Barbuda maintained its unique feature of having 110.3 males to every 100 females on the island. The National Statistics Office conducts national censuses every ten years. In 2001, they projected that in 2007, Antigua and Barbuda should have a combined population of 84,330 people (9.7% more than the 2001 population). As was predicted, the population has grown since the last Census in 2001. In the 2001 Census, there was a population of 76,886 persons and as mentioned previously the 2011 Census showed a population of 87,774, which would indicate a population growth of 15.6 between 2001 and 2011.

In Antigua, most of the population can be found in the city of St. John's and St. Johns rural (surrounding areas). St. John's City also still has the highest population density of 7,652.8 which shows a slight decrease for that of 2001(8,431) even though it occupies the smallest land area of 2.90 sq. miles. Barbuda has the least number of people in the largest land area. There are significantly less people who live in the parishes outside of St. John's. This most likely has occurred because people like to live close to their workplaces and also to areas of entertainment.

Information on the age structure of the population from the 2011 census was as follows; 7.7% of the people were between 0 – 4 years, 16.1% of the people were 5 – 14 years of

age, 47.4% of people were 15 – 44 years, 21.1% of the population are 45 – 64 years of age and 7.7% of the people are over 64 years.

The 2011 Census showed that the predominant ethnicity within Antigua and Barbuda was persons of African descent (87.3%). Additionally, 76.5% of the population claim to be Christian. Also, 68.5% of the population were natives of Antigua and Barbuda.

Employment

Antigua and Barbuda has a labour force of 45,260 people. More people are working in the Tourism sector and Tourist related services, than any other sector. The estimates for this sector vary seasonally based on industries such as yachting which brings employment during special yachting events and through seasonal usage of the docks. The Construction sector also has a high level of workers which would correlate with the increase of the contribution to the GDP by this sector. Also, as expected, Agriculture has one of the lowest numbers of workers. The following sections expand on the social indicators for the country with emphasis on poverty levels, health care, education and other social amenities.

Poverty Estimates:

The indigent population was estimated at 5%[10] of the population, constituting 4.4% of the households in the country. An indigent person was defined as someone whose expenditure was below EC$2449 (US$917) per annum, since this amount should provide an adult male with 2400 kilocalories per day. The Poverty Line was estimated at EC$6318 (US$2366) per annum (adjustments made for non-food expenditure). 18.4% of the population fell below the poverty line, indicating that 18.4% of the population is unable to meet basic needs. However, it is customary to include into the poverty line, the percentage of vulnerable persons, that is, persons who are likely to be at risk of falling into poverty if there is a shock to the economy, which may occur with climate change.

Therefore, it is estimated that the cumulative total of 28.3% of the population is estimated to be at risk. These results are amongst the lower range when compared to other Caribbean countries. Spatial differentials in poverty are also evident in Antigua and Barbuda. The poorest districts are St. John's City (22%) and St. John's rural (18%); followed by St. Philip (26%); St. Paul (16%); St. Peter (15%); St. Mary (14%); St. George (12%); and Barbuda (11%).

The Government of Antigua and Barbuda is developing its social safety net but the burden of the fallout of the international economic crisis and rising debt that is over 100% of GDP makes the situation worrying. It is obvious that major social and economic transformation is required. Based on the current developments involving climate change and its impact on the country's most vulnerable, such issues will have to be addressed on the basis of current climate change discussions.

10Living Conditions in Antigua and Barbuda: Poverty in a Services Economy in Transition: CDB Poverty Assessment Report

Crime, Poverty and Environmental Degradation

Crime, poverty and environmental degradation are considered major issues affecting the future development of Antigua and Barbuda. The CDB in its recent economic review noted that violent crime involving firearms had the potential to undermine the "... social and economic fabric of the country, but also because of its potential impact on tourism". Poverty is also a major concern with estimates as high as 18% being quoted, up from an estimated 12% in 1994. A survey conducted in 2006 estimated the country's poverty levels at 18.4%. In 2012, however, poverty estimates have decreased to 9% based on a survey done by the Food and Agriculture Organization[11]. The poverty level is of concern and the Government is well aware of this situation. In October 2012, the Ministry of Agriculture initiated steps to address this situation by signing an agreement with the FAO to reduce extreme poverty in the twin island state.

It is worth noting that the previous report mentioned from the CDB also noted that there was an increase in evidence of coastal degradation which could have adverse impacts on the quality of the environment and the tourism industry. Antigua and Barbuda enjoys a high standard of living but the economy like many SIDS, is fragile and vulnerable to social and environmental issues, which includes the impacts of disasters, in particular hurricanes.

Economy

The economy of Antigua and Barbuda is service based. Tourism and government services represent the key sources of employment and income. Tourism accounted for more than half of the GDP in 2005 and is also the principle earner of foreign exchange. The situation has not changed much for 2011 to 2012. However, the tourism industry is vulnerable to environmental factors such as violent Hurricanes which are expected to increase in intensity and occurrence because of climate change.

Over the years, Antigua and Barbuda's economic performance has fluctuated significantly. In the 1980's average growth can be estimated to about 7%, while in the 1990's growth slowed to approximately 3.3% and then between 2000-2004 it further decreased to about 2%.This could have been attributed to the country experiencing several devastating hurricanes from 1995 – 1999, the economic growth rate plummeted. However, the growth rate seems to be on an upward swing again. In 2005, Antigua and Barbuda had a GDP of US$ 874.9 million, with a growth rate of 7.07 and an inflation rate of 2.10. Between 2005 and 2008, growth averaged 7.1% primarily as a result of activities related to the hosting of the Cricket World Cup. From 2009-2011 with the onset of the global financial crisis, the economy experienced an average contraction of 7% per annum. In 2011[12] there was an improvement in the GDP which was USD$1.125 billion, with a growth rate of -0.98%.

[11] http://www.caribarena.com/antigua/news/latest/101977-agreement-signed-to-eradicate-extreme-poverty.htm

[12] ECCB GDP data 2000-2014

The recent global financial crisis has caused the Government of Antigua and Barbuda to dramatically reduce its financial commitments in many areas. The Comprehensive Gap Analysis to Assess the OECS Commission's And Member States' Status In Terms Of Land Management Institutional, Technical and Human Capacity provided the basis of financial analysis for land management. The GDP (Nominal) of Antigua and Barbuda in 2013 was USD 1,176,000,000 (EC$3,175,200,000). Of this, budgetary allocations for SLM-related Divisions amounted to EC$ 9174,269 or 0.29% of the overall national revenues. Investments in technology and training have mostly been afforded through projects undertaken with international donor funding and these training opportunities are usually short courses. No budgets are annually assigned specifically for purchase of new equipment and there is a general lack of financial resources available to technical staff.

Of note, is the significant failure to collect revenues from the land information services offered by the Lands and Surveys and Land Registry Divisions and this is a lost opportunity to offset the shortfalls in budget allocations to cover operating expenditure. In Barbuda, no property taxes are charged and therefore the Barbuda Council cannot fund the establishment of development infrastructure or SLM for CCA in Barbuda.

Table 2 GOAB Agency Specific Allocations to SLM/DLMM Support

AGENCY	Estimated BUDGET (2015)	(Original) BUDGET (2014)	Actual Expenditure (2013)
Development Control Authority	777,050	771,134	586,265
Surveys Division	1,184,736	1180,666	972,507
Lands Division	636,111	573,347	489,936
Extension Division	1,094,114	1,279,263	1,151,658
Cotton Division	716,887	722,443	679,583
Forestry Department	484,011	489,472	365,954
Soil and Water Conservation Unit	0	0	0
Fisheries Division	1,315,862	1,414,106	1,135,164
Environment Division	1,294,204	1,224,869	1,124,552
Department of Meteorological Services	2,191,167	2,327,136	1,851,494
National Office of Disaster Services	856,832	824,243	817,156
TOTAL	**10,550,974**	**10,806,679**	**9,174,269**
GOAB Total Expenditure	*1,037,446,295*	*873,153,397*	*1,067,653,153*

It is evident that national priorities for budgetary allocations ascribe a relatively low importance to investments in building human and technical capacities for SLM in terms of upgrading of skills, tools and technologies, maintaining currency of data and reviews of policies, laws and regulations. Crown lands rental rates are low ($100/acre/annum) and are not related to market value, thus inhibiting the ability to raise funding from this source. Consequently, funding for building SLM capacity is usually addressed through projects funded by donor agencies and therefore lacks succession and sustainability.

The net effect of the inadequacy of the human, technological and financial resources including monitoring and enforcement of decisions, requirements and information management, is a weak institutional capacity for SLM in Antigua created by an insufficient critical mass of qualified personnel, a fragmented organisational structure, an inadequacy of funding and lack of public support to address the challenges of SLM that can support CCA.

The strengths which can be used to take maximum advantage of the opportunities presented to implement donor/funding organisations' requirements and policies on land policy, land tenure and housing development to enable access to funding for rehabilitation and reconstruction after a natural disaster are:

- The annual scrutiny of expenditure of GOAB allocations can enhance the ability to meet Donor requirements for funding for SLM/CCA, particularly in the area of counterpart funding; and
- Basing land taxes on GOAB Fiscal policy can generate increased revenues to address SLM/CCA activities.

The strength that can be used to minimize the threat of underfunding of human capacity enhancement, upgrading of tools and reviews of policies, laws and regulations is the efficient use of funds allocated to land administration agencies.

The action that can be taken to minimize the weaknesses of underfunding human capacity enhancement and tools and technologies for SLM/CCA is to increase the revenues from land rents, house taxes, stamp duties and other fees.

The weaknesses which can be minimized to avoid the threats of withdrawal of Donor funding/inability to attract Donor funding for SLM in Antigua is to invest in funding human and technological capacity development and to capture revenues from land administration services provided.

Tourism

Tourism is Antigua's most important productive sector, and was in 2007 estimated to account for 40 % of all employment, 85 % of foreign exchange earnings, 52 % of total investment and 70 % of GDP (directly and indirectly). In 2012, the Index Mundi shows that tourism now accounts for almost 60% of the country's GDP and 40% of investments. Total earnings, and tourist arrivals saw a strong growth in 2007 (up 26.5% from 2006), but has

since declined with the economic crisis. For Antigua and Barbuda, economic growth in the medium term will continue to depend on income growth in their tourist markets, the US and UK. There are signs of recovery however. April 2012 saw the highest hotel occupancy rates (63.8%) since 2008 surpassing 2010 (58.4%) and 2011 (61.3%) for the same period.

Agriculture

Agriculture at one time was one of the major contributors to the GDP because of large scale sugar production along with its by-products, molasses and rum. Several factors caused its decline namely the shrinking international market, inadequate water (severe droughts), destructive hurricanes and the inability of the sector to lure labour forces away from the tourism sector which proved more immediately lucrative. However, some agriculture production still occurs. Antigua and Barbuda's agricultural sector accounted for 3.3% of GDP in 2007, in 2010 this had decreased to between 2.5 and 3 %.Agricultural production is focused on the domestic market and is further constrained by a shortage in labor. A labour force survey from 2004 found near full employment, at approximately 4% unemployment. This has changed however. Recent information on the GATE[13] website shows that the "Unemployment figures in Antigua and Barbuda currently stand at an estimated eleven percent (11%) and of this eleven percent, 19.9% represent youth ages 15-24". Not many of these individuals seem interested in the agriculture sector however as the tourism and construction sectors compete with higher wages. Furthermore, local production has not been able to meet local demand all year round. There are less than 300 acres of sea island cotton under production. The major crops produced are vegetables, food crops, vine fruits and tree fruits. The Local Antigua Black Pineapple is one of the tourist favorites. However, the market for most agricultural products is domestic. Livestock production (5000 cattle, 28,000 goats, 15,000 sheep)[14] is difficult because of severe droughts and low international market value of the animals even though they are organically grown. Owners have taken to allowing their animals to stray unimpeded. This practice has led to severe environmental damage; goats have debarked and destroyed trees on hill sides and sheep have overgrazed. The combined effects have led to land slippage and loss of top soil during heavy rains.

Fisheries make the greatest contribution to the agricultural sector with its lobster and fish exports. The fishing sub-sector grew by almost 5 % from 2006 to 2007, reflecting new facilities for fisheries in St. John. The sub-sector contributed almost 52 % of the sector's output. Barbuda depends significantly on its fishery sector as a source of income. In an effort to protect this sector and also address the issues affecting the sector as a result of climate change the government has sought to integrate this sector into its biodiversity protection plan. Apart from the Codrington Lagoon, several coastal and marine areas

[13] GATE: Government Assisted Technology Endeavour: http://gateantigua.ag/ictcadets_background.php

[14] Veterinary & Livestock Division, Ministry of Agriculture, Govt. of Antigua & Barbuda, June 2007

have now been designated as protected areas. Antigua and Barbuda has also initiated the establishment of a System of Protected Areas

Communications

Communications is also a notable direct and indirect contributor to the GDP. In the 90's, there was a significant increase in offshore business in Antigua; including off-shore gaming and betting, benefiting from the high quality telecommunications and internet services available.[15] Since the late 80's, the telephone service was upgraded from old "switching" technology (analogue) to a more modern digital system DMS-100 (Antigua & Barbuda was one of the few Caribbean islands with updated telecommunications at that time). Investments were maintained and many upgrades were installed over the years to keep the telecommunications system up to date; for example the Centrex system. The local telecommunications company APUA (Antigua Public Utilities Authority), in consultation with Cable & Wireless, installed fiber optic cables underground, island wide encased in conduits. Although, the major hurricanes of the mid to late 90's destroyed much of the telephone wiring above ground, the major network cables were unharmed being buried. Once the wiring above ground was replaced, the telecommunications system was up and running. The increase in the number and intensity of storms that is expected with climate change is a motivating factor to bury as many cables as possible but at this stage it would be more expensive to bury even more cables than to replace above ground cables annually.

Manufacturing

The GDP statistics from the ECCB showed that manufacturing is declining. In 2010 this sector contributed 2.54% of GDP and 2.57% in 2011 however in 2012 there was an estimated decrease to 2.32% partly due to high cost of production (mainly labour utilities and high port and shipping charges), small local market and intense regional and international competition. Most of the raw materials for manufacturing have to be imported. However, paints, furniture, household fitting and garments are still manufactured along with soft drinks, water rum, and a nascent cottage agro processing sub sector.

Institutional and Legislative Framework

At the drafting of the NAP in 2005, the institutional situation of land management in Antigua and Barbuda could be defined as lacking well-defined institutional roles and responsibilities. This was due in part to the fact that much of the legislation enacted failed to clearly define the institutional roles, jurisdictional competencies and mechanisms for collaboration and coordination. The result has been overlap,

15Environment Division, Integrating Management of Watersheds & Coastal Areas in Small Island Developing States of the Caribbean - National Report for Antigua & Barbuda:(January 2001), p 14

duplication and conflict particularly in planning for development and the allocation of public lands.

In addition to this fragmentation, a number of agencies lack the resources and capacity to effectively meet even their own limited mandates. Chief among these deficiencies was the then status of the DCA, which although having a well-developed legislation (as a result of a regional UNDP project to improve physical planning) had not been granted the approval of its policy guidance document the NPDP. Further undermining the role and performance of the DCA was the reassigning of its GIS-trained personnel to other departments and functions (primarily tax compliance).

At present, there has been noticeable improvement is the coordination of agencies in their ability to effectively manage land. This may be attributed to two specific interventions, namely agencies were able to experience and develop better coordination through the increased collaboration of technicians as a result of regular meetings under the Sustainable Island Resource Management Mechanism (SIRMM) project and the adoption of the National Physical Development Plan titled the Sustainable Island Resource Management Zoning Plan (SIRMZP).

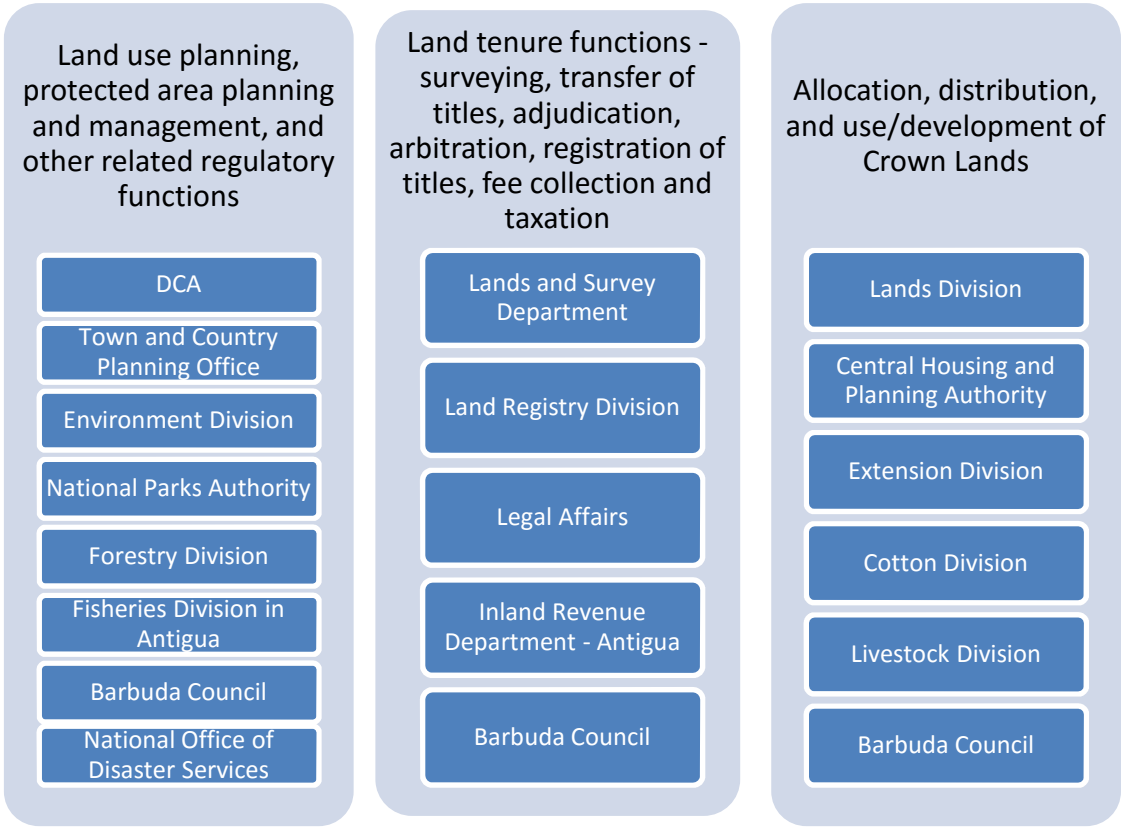


Figure 9: SLM Categorization of Agencies in Antigua and Barbuda[16]

[16] OECS (2015) Comprehensive Gap Analysis to Assess the OECS Commission's And Member States' Status In Terms Of Land Management Institutional, Technical and Human Capacity (Draft)

Land Management Agencies

Barbuda has a different land tenure system from Antigua. In Barbuda, all land is vested in the Crown on behalf of the people in perpetuity. Land is entrusted to the Barbuda Council for all Barbudans, who are defined by the Barbuda Land Act, as persons born in Barbuda and who have at least one grandparent who was also born in Barbuda, or the child of a person who meets the above conditions, wherever born. Lands cannot be sold but can be conferred by right to Barbudans over 18 years of age for residential, crop and livestock farming purposes. The Barbuda Council has the authority to designate land for specific purposes, as well as grant exclusive rights to Barbudans for the aforementioned purposes, as well as, with the approval of Cabinet, grant leases to non-Barbudans for major developments up to a maximum of 50 years.

In Antigua, the management of land is more complex with a number of agencies and interests involved. A recent OECS sub-regional project sought to better rationalize and define the roles for these agencies so as to promote greater cooperation and by extension achieve the principles of sustainable land management.

The government institutions involved in land management are highlighted in Figure 9 above.

The following table highlights all the agencies which conduct any aspect of land management within Antigua and Barbuda. It also identifies the primary pieces of legislation which these agencies rely upon to conduct this work.

Table 3 Institutional Framework of Land Management in Antigua and Barbuda

AGENCY	LEGISLATION	FUNCTIONS
Development Control Authority	Physical Planning Act (2003)	This Act outlines the regulatory functions of the DCA as pertains to development application review and approval; development surveillance and development control. The act also gives the DCA the powers to develop Local Area Plans as a means of guiding and advising development activities. The act also recognises certain categories of land as needing additional development control measures. Draft regulations are currently being drafted for this act.
Lands Division	Crown Lands Act (1917) and Land	Planning and allocation of government lands for residential, agricultural and other land use

	Settlement Regulations(1952)	purposes including land reclamation, the management of water bodies and to take the appropriate action for forest conservation; administration of Government of Antigua and Barbuda land leases and rentals. Regulations have been prescribed to assess watershed management. Since a little less than half of the land in Antigua and Barbuda is government-owned, this Division has a key role in determining the conversion of land to non-agricultural use.
St. John's Development Corporation	St. John's Development Corporation Act (1986)	Upgrading of downtown St. John's through urban renewal and implementation of other development projects. This Act empowers the Corporation to initiate development without reference to any national development plans.
National Parks Authority	National Parks Act (1985)	Development and management (including development Control) of national parks
Antigua & Barbuda Port Authority	Port Authority Act (1989)	Development and management of lands at any harbour owned and operated by the Government of Antigua and Barbuda.
Central Housing & Planning Authority (CHAPA)	Slum Clearance and Housing Act (1948)	At one time CHAPA functioned as Government's primary residential land allocation agency, but some of its functions have been assumed by the Lands Division, Ministry of Agriculture; Implementation of low income housing schemes.
Department of Agriculture (Extension Division)	Antigua and Barbuda Agricultural Development Corporation Act (1978)	Like the St. John's Development Corporation, the Agricultural Development Corporation is authorized under this statute to conduct development activities outside of the requirements of any national development plans. The effect of this power can operate to compromise the successful implementation of Physical Planning Act (2003)
The Cabinet	Land Acquisition Act (1982)	The Cabinet with the approval of the Legislature has the authority to acquire land for public purposes. The public purpose for which

		the land is required must be determined by the Cabinet.
Central Board of Health	Burial Ground Act (1926)	This Act determines the areas which may be used for the purposes of burial.
Public Works Department	Public Works and Road Act (1981)	This Act requires the classification of road and establishment of widths corresponding to each class. The Act gives the Governor General a wide discretion to declare and declassify road and empowers the Surveyor to make temporary roads over any land as is convenient.
	Beach Protection Act (1957 & 1993)	This act vests regulatory responsibility in the Ministry of Public Works to control and manage the mining of aggregates from beaches.
Forestry Department	Forestry Act (1941) and Regulations (1941 & 1952)	This Act establishes the power to declare forest reserves on State lands and requires forest reserves to be acquired by the State. The Governor General is empowered to make regulations in respect of specified matters, including the management of protected forests and forest reserves. The Act authorizes the Chief Forest Officer to prepare a national forest plan.
Soil and Water Conservation Unit		This unit has responsibility for soil conservation activities within the Ministry of Agriculture. It also assists farmers with the development of irrigation systems and in improving drainage. The Unit is currently without staff.
Agriculture Committee	Barbuda Local Government Act (1976)	This Act requires the local authority to administer forestry services in Barbuda and subordinate legislation established thereunder regulates the cutting of timber in the locality.
	Bush Fires Act (1901)	This Act establishes an offence regime regarding bush fires.
Water Division	Public Utilities Act (1973) Watercourses and Waterworks Regulations (1954 and 1961)	This Act requires the Authority to supply potable water supplies and empowers the Minister to make regulations for the protection of watercourses and catchment areas.

		These regulations prescribe methods for the extraction of water to protect against contamination
Fisheries Division	Fisheries Act (1983)	Under Part III of the Act, the Minister may declare any area of Antigua and Barbuda waters and as appropriate, any adjacent or surrounding land, to be a marine reserve where special protection is considered necessary.
Environment Division	Environmental Protection and Management Act (2015)	An Act to provide for the management of the environment within Antigua and Barbuda. The definition of environment includes the land, water and atmosphere and plant life. One of the more relevant features in the act is the creation a body specifically to manage watersheds to ensure access for all stakeholders.
Barbuda Council (in conjunction with Barbuda Planning Commission)	Barbuda Land Act (2007)	This act confirms that all lands on the island of Barbuda are held in commons and managed by the Barbuda Council. Manage here means authority to make development plans and issue leases. The act also prohibits certain activities without permit. This act also amends the Physical Planning Act to allow the Barbuda Planning Commission to act in place of the DCA for non-major projects. Major projects require the input of the DCA and Cabinet.
Land Registry	Registered Land Act (1975)	The Land Register Division is responsible for the administration and execution of the Land Registry functions prescribed by the Registered Land Act

Coordination among Agencies

Many of the agencies within the GOAB can be characterized as suffering from weak human and fiscal capacity. One of the methods of overcoming this is through the use of coordinating mechanisms. The Draft NAP recognized this and recommended bodies such as a Drought Management Council to be called into effect during times of drought to ensure that there is effective management during time of scarcity. However the APUA Drought Management Plan has revised this approach in two ways. Firstly, although there

is consultation throughout, by identifying levels of drought, it employs a strategy that increases the levels of consultation proportional to the extremity of the situation. To this end there are a number of consultative bodies which already exist to address certain SLM/DLDD and as such the NAP alignment may consider greater utilization of these structures.

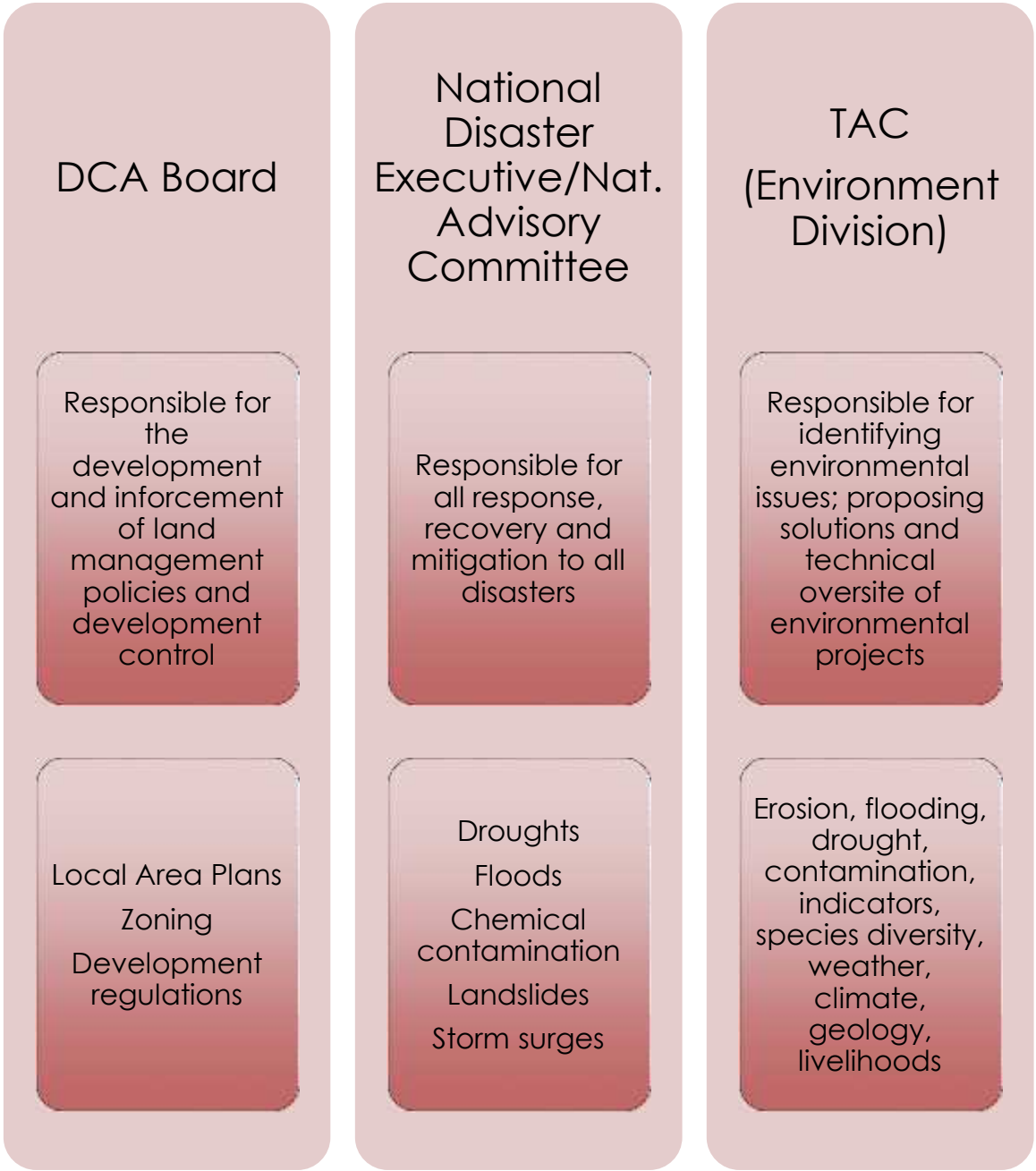


Figure 10 Existing Coordinating Bodies Available to SLM and DLDD Issues[17][18][19]

[17] Physical Planning Act 2003
[18] Disaster Management Act 2002
[19] Environmental Protection and Management Act 2015

Non-Governmental Organisations

The NGO/CBO sector in Antigua and Barbuda is small and limited in capacity. The numbers involved in environmental functions have grown significantly over recent years. However, the few groups which do exist have regularly proven themselves as significant and valuable partners in sustainable resource management.

Environmental Awareness Group (EAG)

The Environmental Awareness Group or EAG is the oldest non-profit, non-governmental environmental organisation in Antigua and Barbuda, established in 1989. The EAG's vision is for a world where we are environmentally conscious, coexisting in harmony with a healthy natural environment, through respect for our biodiversity and sustainable development. Some of its achievements include rescuing the Antiguan Racer from the brink of extinction, ecosystem restoration on offshore islands (which contributed to the establishment of the North East Marine Management Area), the inclusion of environmental education in the national school curriculum, ground breaking work on plant conservation, the publication of the Red List of threatened plant species and also the Wild Plants of Antigua & Barbuda.

Figure 11: Evidence of How Invasive Species Eradication can Enhance Ecosystems[20]

The rescuing of the Antigua Racer Snake is of special note because that achievement best illustrates the link between land degradation and effective biodiversity conservation and in particular the dangers of invasive species. Simply explained the key remedy to reviving the snake population and by extension bird and vegetation diversity was the eradication of invasive rats from off shore islands.

Currently, the EAG manages nine main projects. A key feature of these projects is to promote educational campaigns such as the Endangered Species Presentations and

[20] Source; EAG

the Floating Classroom aim to bring residents, especially students, teachers and parents in direct contact with our local biodiversity and the threats that they currently face. In addition to these initiatives, the EAG also runs a school reading programme, publishes books, brochures, educational calendars and hosts monthly environmental fieldtrips. The monthly field trips often emphasize climate change vulnerabilities when visiting sites around Antigua and Barbuda, whether terrestrial or marine, highlighting ways of mitigating such vulnerabilities where possible. The EAG works with several local partners including the Ministry of Agriculture, and the Gilbert Agricultural and Rural Development Center (GARD). The EAG and GARD have collaborated to execute a successful summer camp, Camp GROW, Gaining a Respect for the Outdoors and our World.

Gilbert Agricultural and Rural Development Center (GARD)

The Gilbert Agricultural and Rural Development (GARD) Centre - a non-profit NGO specializing in certified technical, vocational and enterprise development training for vulnerable youth and women. Its original mandate was to encourage youth to select agricultural and its related ventures as worthy occupations and not view it as drudgery and having a slave image. Over the 23 years of existence the GARD Center has been demonstrating that agriculture is a business and must be competitive with other sectors and meet the global challenges and requirements of safety, sustainability and, traceability through the use of Good Agricultural Practices (GAP). The Center has collaborated with a number of partners to strengthen the response to climate issues affecting the country. The Center has partnered with the Ministry of Agriculture's Environment Division, Forestry Division and Agricultural Extension; and the Environmental Awareness Group in projects to promote SLM by protecting the nation's watersheds and plant biodiversity. GARD Center's training programs included introduction to agro-ecological, agro-forestry and organic farming practices for farmers. The Center has been involved in public awareness activities with the production of videos for public media, brochures and flyers for distribution, demonstrations for schools, agricultural producers and the general public highlighting climate change effects on biodiversity, increased risk of droughts, disasters and the preparation. Camp Grow was introduced in collaboration with the Environmental Awareness Group as a summer vacation camp for young children between the ages of 8 to 11 years to sensitize the youth of the importance of preserving their environment and to create an appreciation of the role of agriculture and its interrelationship with the environment.

Humane Society

Traditionally, the Humane Society's focus has been on the ethical treatment of animals and not so much the safe guarding of the physical environment. However, in recent years, it has realized that by achieving effective control over many of the animals which it seeks to assist that there are positive benefits to the physical environment.

One of the flagship projects undertaken by the Humane Society is the establishment of a Donkey Sanctuary. Throughout Antigua, due to modernization the vast majority of the

population has moved away from an agrarian economy. As a result, many donkeys have been abandoned and are not only running wild but are damaging the environment through unmanaged feeding of vegetation. This leaves many areas bare and subject to soil erosion and land degradation. The establishment of the Donkey Sanctuary has allowed for stray donkeys to be collected into one area and managed. As a result the widespread erosion and loss of vegetation has been dramatically reduced around the country.

Barbuda Research Complex

The BRC is the first scientific research facility to be established in Barbuda and was officially registered as a non-profit organization on June 14th, 2013. As Barbuda's first and only research facility it is committed to the preservation and conservation of heritage and environment. BRC includes the Barbuda Archaeological Research Center, Barbuda Museum, Barbuda Children's Museum and the Barbuda Aquaponics Facility.

BRC offers the following services through its educational research programmes which may prove beneficial to addressing SLM and DLDD- environmental monitoring, erosion mitigation, field research, aquaponics and field research.

The BRC offers a great opportunity for SLM and DLDD research as there is little and outdated information with regard to Barbuda.

Community Based Organisations

Recent droughts have stressed the importance of safeguarding water resources throughout the country. A number of community-based organization have thus taken up the challenge by working to revitalize reservoirs from the nation's colonial past to increase the availability of water. There are three groups currently undertaking such activities- the Freetown Community Group, Freetown Sports Club and the Barnes Hill community group. The lesson learnt from these project will hopefully increase awareness of SLM and DLDD issues as well as rebuild capacities long thought forgotten. More groups are expected to replicate reservoir revitalization. Efforts should be made to assess the number and status of reservoirs and a rehabilitation guide developed to guide future actions.

Professional Associations

Like many countries, Antigua and Barbuda has professional associations which serve as the key media for ensuring global standards of practice are adopted and maintained. Additionally, it is through these organisations that nations hope to find and build important capacities so as to achieve and maintain development goals. However some of the most important associations which should act as drivers of sustainable development and modernization have become inactive and dysfunctional. Organizations like those for architects and engineers, whose functions directly affect SLM have long ceased to exercise their collective voices to promote appropriate SLM standards. Less directly connected groups like the Bar Association, though present, offer

little by way of collective conscience to the development process or even promoting the necessary skills for development planning.

The situation of professional organisations requires deliberate intervention to remind, revitalize and retrain them to function as active participants in the processes which can reduce Antigua and Barbuda's vulnerability to DLDD and other sustainable development issues.

Identification of Degraded Sites

Methodology

To effectively address issues of desertification, land degradation and drought, one must first have a clear understanding of the key terms associated with DLDD and then apply them to appropriate baseline data through the use of verifiable indicators that can spot trends to predict or confirm actual events of DLDD.

Definitions

The 2005 draft NAP utilized the following definitions as provided by the UNCCD:

(a) **"*desertification*"** means land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities;

(b) **"*combating desertification*"** includes activities which are part of the integrated development of land in arid, semi-arid and dry sub-humid areas for sustainable development which are aimed at:

(i) prevention and/or reduction of land degradation; (ii) rehabilitation of partly degraded land; and

(ii) reclamation of desertified land;

(c) **"*drought*"** means the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems;

(d) **"*mitigating the effects of drought*"** means activities related to the prediction of drought and intended to reduce the vulnerability of society and natural systems to drought as it relates to combating desertification;

(e) **"*land degradation*"** means reduction or loss, in arid, semi-arid and dry sub- humid areas, of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as:

(i) soil erosion caused by wind and/or water;

(ii) deterioration of the physical, chemical and biological or economic properties of soil; and

(iii) long-term loss of natural vegetation;

(f) ***"arid, semi-arid and dry sub-humid areas"*** means areas, other than polar and sub-polar regions, in which the ratio of annual precipitation to potential evapotranspiration falls within the range from 0.05 to 0.65

Due to being located within the tropical maritime climatic region, Antigua and Barbuda is not immediately viewed by outsiders as being at risk of desertification. . However, according to the broad definition of desertification given above, namely any significant land degradation occurring in arid, semi-arid or dry sub-humid areas falling within a ratio of annual precipitation to potential evapotranspiration range from 0.05 to 0.65, firmly places, Antigua and Barbuda does fall under the ambit of work of the UNCCD. Although datasets are limited, the ratio of annual precipitation to potential evapotranspiration (ET) values for Antigua and Barbuda is estimated at 0.57 for an average year.

Additionally, land degradation is described as consisting of reduction or loss of the biological or economic productivity of rain-fed or irrigated land used for crops, or range, pasture, forest or woodlands, which results from land uses or human actions, or combinations thereof. Antigua and Barbuda experiences reduction in soil productivity through a number of factors. Droughts, flash floods, climate change and even invasive species and species loss have in various ways impacted on soil productivity.

This aligned NAP also includes definitions from key national documents which in some cases define specific DLDD issues or may introduce a more detailed classification to further illustrate the level of impact.

The Post-Georges Disaster Mitigation (PGDM) defined:

(a) ***Flooding*** "a general and temporary condition of partial or complete inundation of normally dry land areas from overflow of inland waters or from the usual and rapid runoff of surface waters from rainfall."

(b) ***Drought*** is further elaborated into three categories,

a. "Meteorological drought is defined mainly by deficiencies in precipitation. Along with deficient rainfall, conditions during drought may be accompanied or aggravated by high temperatures, strong winds, low relative humidity, greater sunshine and less cloud cover. "

b. "Agricultural drought occurs when plant water demands cannot be met due to soil water deficiency resulting from dryness brought on by meteorological or hydrological drought."

c. "Hydrological drought can be considered a third stage in the evolution of drought conditions evidenced by significant reduction in surface reservoirs, drying of dams and wetlands."

(c) '***Erosion'*** is natural forces at work. The word erosion is an inclusive term for:

a. wearing away and removal of soil or rock material by the effect of:

i. rainfall: water washing across the land or a rivulet or stream wearing away its bed or its banks, and depositing its load

somewhere else, on land, in the stream bed or at sea, the processes that are thought of as 'normal' erosion

ii. wind: wind-driven loose particles scouring the land surface and blowing away to be deposited against the nearest obstacle– perhaps a clump of bushes or a house – common only where the surface is bare and very dry and the wind is strong

iii. percolating water dissolving rock: solution – especially in limestones and young volcanic ash, but difficult to analyse. This type of erosion is omitted in this report.

b. rock falls and landslides slips etc, which are together called 'mass movements', and which are like any movement of unsecured objects under gravity.

c. Erosion by running water is usually divided into several phases, some of which have names which are reasonably well known:

i. *sheetwash* describes erosion where water flows across land more or less in a sheet, and picks up particles of soil and carries them away. Its effects are often not very obvious to casual observation and it grades into

ii. *rilling* is where flowing water makes very shallow sometimes broad channels across land and also picks up and wears away soil. Both sheetwash and rilling leave patches of deposited material wherever the gradient slackens and the slower flow will not carry all the load. When there is heavy rain and a large load is carried, deeper deposits form, often where the flow crosses a flat track or road and so becomes much more obvious.

iii. *gullying* is where quite deep and relatively narrow channels are formed, by water running off the land. These may become very deep and large like the St. Kitts ghauts, and cut below the soil into underlying soft rocks. Gullies sometimes develop from the joining of rills but more often start because the existing natural drainage system has become overloaded as a result of a change of land use or a massive burn etc. Gullies usually start short, but may lengthen quickly with the head of the gully moving back up slope. At the lower end gullies may produce a deep fan of outwash material.

iv. *stream cutting:* established streams have courses which change all the time. For long periods there may appear to be very little change but whenever the river flows really full—full to the top of its banks or overflowing—it will scour its bed and cut away at bends.

d. All of these are normal natural processes, but human activity often multiplies them greatly, both in frequency and size. Sheetwash and rilling are not common under natural vegetation in these islands, except where fire or hurricane has bared the land, but they have become very common on certain soils when farmed. Gullying is uncommon under natural

vegetation but where vegetation has been disturbed by hurricane or burned off, which can happen naturally in volcanic territory and may explain the ghauts, gullying will occur.

e. Mass movement—landslide and rock fall—is relatively common under natural vegetation in the steeper landscapes of the Lesser Antilles. There are several different types of landslide, partly dependent on the kind of materials involved, but we can generalise by saying that most landslides (not rock falls) occur when, or just after, a mass of porous material is saturated or super-saturated with water. Prolonged heavy rain brings landslides. Rock falls may be triggered by rain in the odd case, but seismic events and gradual loosening under weathering are more common causes. However human activity once again multiplies the frequency and size of these events.
f. Wind erosion, where the wind picks up and carries light small soil particles (especially organic matter) and bounces or rolls larger particles along the land surface, cannot occur under a vegetation cover and is only found naturally in the formation of dunes in dry sandy beach or desert areas, or where some other factor has left a bare surface.

Developing a Hydro-Geological Baseline

In trying to determine the vulnerability of any area to DLDD, one must first establish the appropriate baseline from which measurements and extrapolations can be made. With regard to issues affected by DLDD there are two principal categories of features which combine to make a suitable baseline, the hydrology and the geology. Presently different aspects of this data are collected by various agencies however to ensure that an effective DLDD monitoring system is developed a hydro-geological dataset needs to be established and available to the relevant agencies and stakeholders in a GIS database.

Geological Features

The soil resources of Antigua and Barbuda were described in detail following the soil survey carried out by the Regional Research Centre of the University of the West Indies in the early 1960's and mapped at 1:25,000 scale. This was published in 1966 (Hill 1966). Some additional descriptions were added during the mid-1980's by Ahmad and published by the Organisation of American States (OAS 1990) when a new map at 1:50,000 was provided.

Soil formation has been determined primarily by the parent materials, topography and rainfall regime. As indicated in the background, Antigua has three main geological regions the volcanic hills of the southwest; the lower central region of volcanic related deposits and the limestone region of the north and east. Hill described 33 soils in his

survey, but these may be conveniently grouped into five broad groups according to depth and texture (CEP 1991). These comprise:

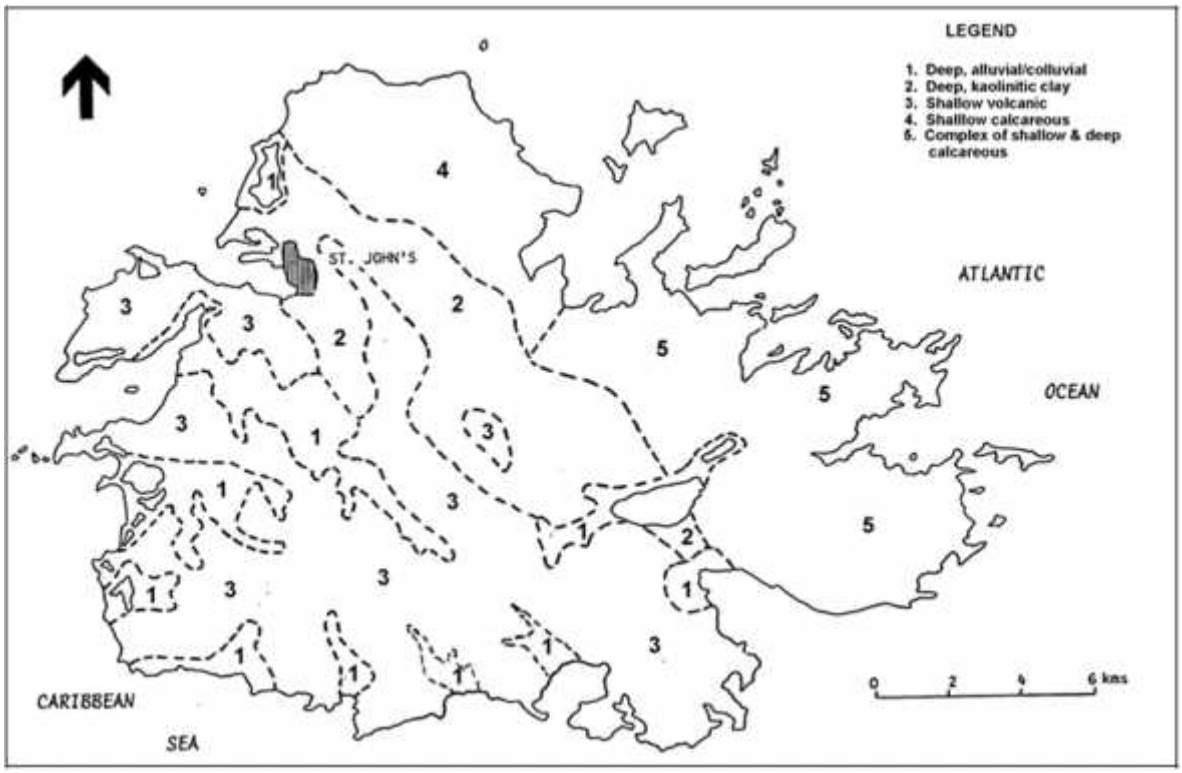


Figure 12 Distribution of Major Soil Types in Antigua

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

Figure 12 shows the distribution of these soil groups. The deeper marl soils and the alluvial soils of the volcanic area are the most productive soils for agriculture and will support production of a range of vegetables and tree crops. Water remains the biggest limitation to agricultural production

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

Soil Productivity

The main determining factor in the degradation of land is the loss of soil productivity. This can result from a number of causes. Soils provide physical support, water and nutrients to the plants that grow on them. Loss of any of these characteristics can reduce productivity. In dry environments, moisture holding capacity is a key soil characteristic, so any factor, such as soil depth, particularly of top soil, organic matter content, or compaction can negatively affect the moisture holding capacity of the soil.

It should be re-emphasized here that sugar cane cultivation during much of the last three centuries and especially in the late 18th century, (when up to 90% of Antigua land was cultivated for sugar) forest cover was removed and large acreages of land which were unsuitable for sustainable production, were cleared and planted. Much of this land had only shallow soils to begin with and was highly erosion prone due to the steepness of the slopes it occupied. One result of this was the loss of significant amounts of topsoil from many areas, especially in the volcanic region in the south-west of Antigua. In some areas, it appears that much of the A and B horizons was eroded away. Recovery from this kind of soil degradation takes place only at geological time scales and although the worst affected areas are no longer in cultivation, the natural vegetation that has recolonised these areas is much poorer in species composition and accumulated biomass than the original soil cover. Unfortunately, no adequate records exist of the previous state of the vegetation before the wholesale clearing took place, so it is not possible to determine such changes accurately.

Soil Depth

Soil depth is determined by a dynamic balance between processes of soil development, which tend to increase soil depth with time and those erosive processes that work to reduce soil depth. In general, dry areas tend to have shallower soils, except where alluvial processes have provided good depths of suitable parent material. Low rainfall and frequent periods of drought stress generally produce poor stands of sparse vegetation, which provide ineffective protection to the soil from the erosive effects of

rainfall. The same low rainfall reduces the rates of weathering that lead to soil formation, thus tilting the balance towards a shallower soil.

However, from a productivity point of view, it is the effective soil depth, or "root room" that is important rather than total depth. Where a compact layer, high water table or excessive salinity form a barrier to root growth, productivity will be constrained.

In Antigua, soil depth is a major limiting factor to high productivity in several contrasting soils. The Monteros and Ffryes series, which are formed on volcanic rock, are found in extensive areas of steep hillsides formed from old volcanic remnants. The slow rate of soil development due to the slow weathering of the hard rock has allowed only a thin soil to develop. Strong erosive forces derived from the steep slopes and intense rainfall, particularly during storms, have accelerated soil loss, even where the hillsides have remained forested. Once the vegetative cover has been lost, degradation of these soils can be quite rapid. Some areas of the Monteros series in the hills south of Body Ponds have little more than the sub-soil horizon remaining and are very unproductive. In places, this is due to a combination of erosion and burning that has led to accelerated loss of vegetation and consequent loss of soil in a vicious spiral of degradation from which it will be very difficult to recover.

In the central plain, which is in fact, far from flat in many areas, there is a wide variety of soil parent materials, most of which are more conducive to faster soil formation. However, even here there are areas with steep slopes and unfavourable geology for soil development. Here, soils with high erosion potential and shallow depth would include the Liberta, Picadilly, Isaac and Indian Creek series.

On the harder limestone areas of Antigua and Barbuda, similar considerations apply, although slopes are frequently less severe on these formations and are also shorter. Important soils in this category would include the Weatherills series in Antigua and the Barbuda series on the edges of the Barbuda Highlands. In some of the flatter parts of the marly areas in the north and east of Antigua, where soil depth to the parent rock was marginal, deep ploughing by powerful tractors pulling chisel or large disc ploughs, has brought the marl to the surface and reduced the effective depth of the soil over time.

Slope gradients

The slope of a given area can directly impact on issues such as rate of run off and levels of mass wasting and mass movement. Simply explained the steeper the slope the greater the potential for the forces of gravity to act on soil or any other materials found on the surface.

Erodibility

There are several factors that favour a high soil erosion risk. These factors include the following:

1. Steep slopes: Erosion potential increases dramatically as slope angle increases.

2. Poor vegetative cover: A good permanent vegetative cover is essential for the protection of steep slopes. Without cover, most sloping soils will degrade
3. Low organic matter content: Organic matter, or humus as it is usually called.
4. Rainfall: Any increase in rainfall and especially in the intensity of rainfall, such as that accompanying Hurricanes and Tropical Storms will increase the potential for soil erosion.

Table 4 shows Antiguan soils identified by Hill (1966) as having a moderate to severe potential for erosion and Table 5 shows similar information for Barbuda

Table 4 Soil Classification and Erosion Potentials in Antigua (Hill, 1966)

Soil No	Soil Name	Erosion Hazard[1]	Erosion Factor[2]	Acreage	% of Total
23	Boon sandy loam	M/S	S/E	466	1.4
24	Elliots clay	M/S	S/E	370	1.1
20	Wetherills clay loam	M/S	S/E	844	2.6
25	Belmont clay	M	S	246	0.8
21	Fitches clay	M	--	8,560	26.3
62	Ottos clay (stony	M	--	2,190	6.7
74	Shirley loam	M/S	E/S	1,632	5.0
76	Indian Creek loam	M/S	E/S	898	2.8
73	Isaac clay loam	S	E/S	208	0.6
75	Picadilly clay loam	M/S	E/S	994	3.1
77	Liberta clay loam	M/S	E/S	1,850	5.7
70	St. Clair clay	M/S	E/S	1,960	6.0
80	Ffryes clay loam	M/S	E/S	2,966	9.1
90	Monteros clay loam	M/S	E/S	8,716	26.8
81	Spring Hill loam	VS	E	628	1.9

Notes:

(1) M = Moderate; M/S = moderate to severe; S = severe; VS = very severe

(2) E = erosion; S = shallowness; S/E = shallowness + erosion; E/S = Erosion + shallowness

Table 5 Classification of Barbuda Soils According to Erosion Hazard (Vernon, Lanh and Hill, 1966)

Soil No	Soil Name	Erosion Hazard[1]		Acreage
		Wind	Water	
26	Codrington clay	L	L	6,640
27	Blackmere clay loam	VH	M	12,280
28	Barbuda clay loam	M	H	9,536
29	Highland ridge clay	M	M	--
Bs	Beach sand	VH	Nil	3,720
SAL	Salinas	M	Nil	3,178

Organic matter

Humus is the result of the first stage of decomposition of leaves and other plant parts and frequently forms an organic rich layer on the top of undisturbed soils. As this material breaks down further into simpler organic molecules, these react with other soil minerals in the clay fraction to form complex structures that profoundly affect the structure and chemical characteristics of the top layers of the soil. These features of top soil include a stable crumb-like structure that provides space for air and water to be held and also provides a suitably porous material that roots can easily penetrate. This organic component is not easily visible and its importance is often underestimated or overlooked.

Organic matter is always lost when vegetation is removed or soils are ploughed. As the loss is slow, the resulting loss of productivity may not be very noticeable. The burning of vegetation, principally in the Citronella covered hills in the Body Ponds – Brecknocks area is also responsible for regular loss of almost all vegetative matter, including surface humus from these soils. There have been no studies of loss of productivity in these soils, but the steady loss of the forest to the encroaching grass is visible to even casual observation over time.

While there is very little published data on organic matter levels in Antiguan or Barbudan soils, it is likely that organic matter levels have been declining in many areas of both agricultural lands and in watersheds. On agricultural lands, regular use of inorganic fertilizers to supplement natural levels of the macro-nutrients (in most cases Nitrogen, Phosphorous and Potassium [N,P and K) have been the norm for at least two decades. This has led to a major reduction in the use of animal manures for soil amelioration. Fortunately, many farmers do not use more than a portion of their land for active production at any one time and therefore sometimes half the total area may be in weed fallow, allowing some opportunity for organic matter recovery. In addition, most farmers rely on ploughing services provided by the Ministry of Agriculture or by private contractors to plough their lands. This is costly and not always easy to procure, which minimizes the frequency of ploughing somewhat and helps to protect the remaining organic matter.

Hydrological Features

Antigua and Barbuda has long been recognized as one of the drier countries within the Caribbean region. As a result there are very few natural water features. This dearth of aquatic features has led to the nation's extensive period of reliance upon man-made systems as the primary mechanism to meet the needs of the populace.

Surface Water

Antigua has some 10 medium to small reservoirs and about 550 ponds and earth dams. The total combined capacity of all reservoirs, ponds and mini-dams is approximately 6

Mm3 (6000 acre-feet/1.6 billion imperial gallons). Agricultural reservoirs are detailed in Table 6 and municipal reservoirs in Table 7.

Table 6 Agricultural Reservoir Location in Antigua

Reservoir	Location	Storage (m^3)
Bethesda	Bethesda	537,000
Red Hill	Red Hill	46,000
Gunthorpes #4	Gunthorpes	26,000
Gunthorpes #7	Gunthorpes	67,000
Olivers Dams	Olivers	59,000
ASF Dams	Sugar Factory	116,000
Langfords	Sugar Factory	110,000
Gaynors	Collins	32,000
Bendals	Bendals	23,000
Total		1,016,000

Within major watersheds, there are important catchments which yield water to major reservoirs, which include:

Blubber Valley Catchment: the Blubber Valley Catchment supplies water to the Dunnings Reservoir. This stored water is then pumped eastward to the Bendals Water Treatment Plant.

Fig Tree Catchment: this catchment supplies water to the Fig Tree Dam. Water is pumped from this dam to the Wallings Reservoir where it is treated and gravity fed to a number of lower elevations in the water system.

Bethesda Catchment: the Bethesda Catchment supplies water to the Bethesda Reservoir (constructed in 1968). This water is normally used as an Agricultural supply, however, during some drought periods this water is pumped to the Delapps Water Treatment and added to the APUA supply network.

Potworks Catchment: the Potworks Catchment is located in the southern part of the central plain region. This watershed supplies two major Reservoirs (Potworks Reservoir and the Collins Reservoir) includes 2600 hectares (6,500 acres) drainage area which are sparsely covered with vegetation. Inhabited areas occupy only 5% of the watershed with the remainder being pasture and agricultural land. Relatively large scale agriculture is being carried out on the land adjacent to the Potworks Reservoir which does cause some concern relative to silting and organic and bacteriological contamination. The Potworks Catchment is the largest of the APUA's National Water supply. Water from the Potworks Reservoir (constructed in 1968) is pumped to the Delapps Water Treatment Plant before pumping to the National Water system. The Collins Reservoir (constructed in 1966) is used primarily as recharge for some 4 wells located in the area. The topography of the watershed is that of low lying land, and the

entire watershed is less than 150 meters (490 feet) above the sea level. The two reservoirs within the watershed have a combined storage capacity of 4.5 million m3 (1,180 million imperial gallons).

83% of the total surface storage capacity. It receives runoff from a drainage area of 430 hectares (1,071 acres). Its maximum surface area is about 192 hectares (475 acres) has extensive shallow zones with high evaporation rates.

The Creekside Watershed provides a drainage area of 780 hectares (1927 acres) for the body ponds/fisher dams and is the second largest surface water source in the APUA water supply system. (The analysis of the Creekside Watershed has not been included in this draft report due to time limitations, but will be considered as a part of the final report.)

Due to the low quality of the surface water from the reservoirs (high turbidity and bacteriological contamination) the water is being fully treated in mechanical-chemical treatment plants before disinfection. This is one of the reasons for the relatively high price of surface water supply.

Table 7 Municipal Reservoirs of Antigua

Reservoir	Drainage Area (ha)	Spillway Elevation (m)	Storage Volume (m3)
Potworks	2,430	20.42	4,142,000
Collins	172	11.89	342,000
Wallings	44	150.88	51,680
Fig Tree	72	112.78	2,280
Dunnings	146	30.38	136,040
Brecknocks #1	56	73.15	20,520
Brecknocks #2	48	39.93	76,380
Hamilton	175	46.94	104,120
Body Ponds/Fisher /Fiennes	779	27.43	101,460
Total	3,922		4,976,480

Groundwater

The active groundwater in Antigua consists of approximately 50 active wells with major well fields located in the Bendals Valley, Bolans and Collins areas. Wells have been drilled around Antigua but detailed information on the water bearing aquifers have not been recorded until recently. In aggregate, these wells yield approximately 875 cubic meters of fresh after maximum recharge periods. The major well-fields are identified in Table 8.

Table 8 Well Fields in Antigua

Well Field	**Location(s)**	**Remarks**
Bendals	Bendals valley	13 operational wells

The Valley	Blubber, Christian, Roses &Orange	Approx 20 wells
Cades Bay/ Claremont	Cades Bay and Claremont Valleys	5 active wells producing 30,000 gpd supply villages of Old Road, Urlings & Johnson's Point/Crabb Hill
Follies	Between Swetes & John Hughes	5 active wells producing approx 40,000 gpd
Bristol Springs/Collins	Eastern end of Collins Dam	7 wells supplying 150,000 gpd water for Willikies, Newfield, St. Phillips, Mill

In Barbuda most of the water supplied to the population of twelve hundred (1200) comes from shallow wells. At present, the water obtained from wells in the Palmetto Point area is potable but other wells around the island have been found to be saline in content. The Antigua Public Utilities Authority (APUA) has recently installed a Reverse Osmosis (RO) Plant in Barbuda which will produce approximately 113.6 m3 (30,000 GPD) of water daily to meet the needs of the residents of Barbuda.

Desalinated Water

There are three utility scale desalination systems situated is operation around Antigua. The Crabbs – SEMCORP (private) facility which has a production capacity of 3.8 million gallons per day; the Camp Blizzard facility which has a maximum capacity of 600,000 imperial gallons; and the Ffryes Beach facility producing some 600,000 imperial gallons. By the end of 2015 there is expected to be a fourth facility at Pigeon Point Beach producing 400,000 imperial gallons. This gives a projected maximum production of 5.4 million imperial gallons. Under normal conditions, desalination constitutes some 57% of our potable water production, with surface catchments contributing 28% and 15% from the ground water[21].

Rainwater Harvesting

Harvesting of rainwater by households contributes an important source of safe drinking water provided the collection and storage system is kept in a hygienically good condition. By law, all new houses are supposed to be equipped with rainwater collection and storage systems. The average size of this storage is 19m 3 (5,000 gal) and the number of households is approximately 30,213.

[21] Destin, D. (2015) Antigua out of surface water again. Antigua Met Service Blog August 17, 2015 https://anumetservice.wordpress.com/2015/08/17/antigua-is-out-of-surface-water-again/

Gaps in the Baseline

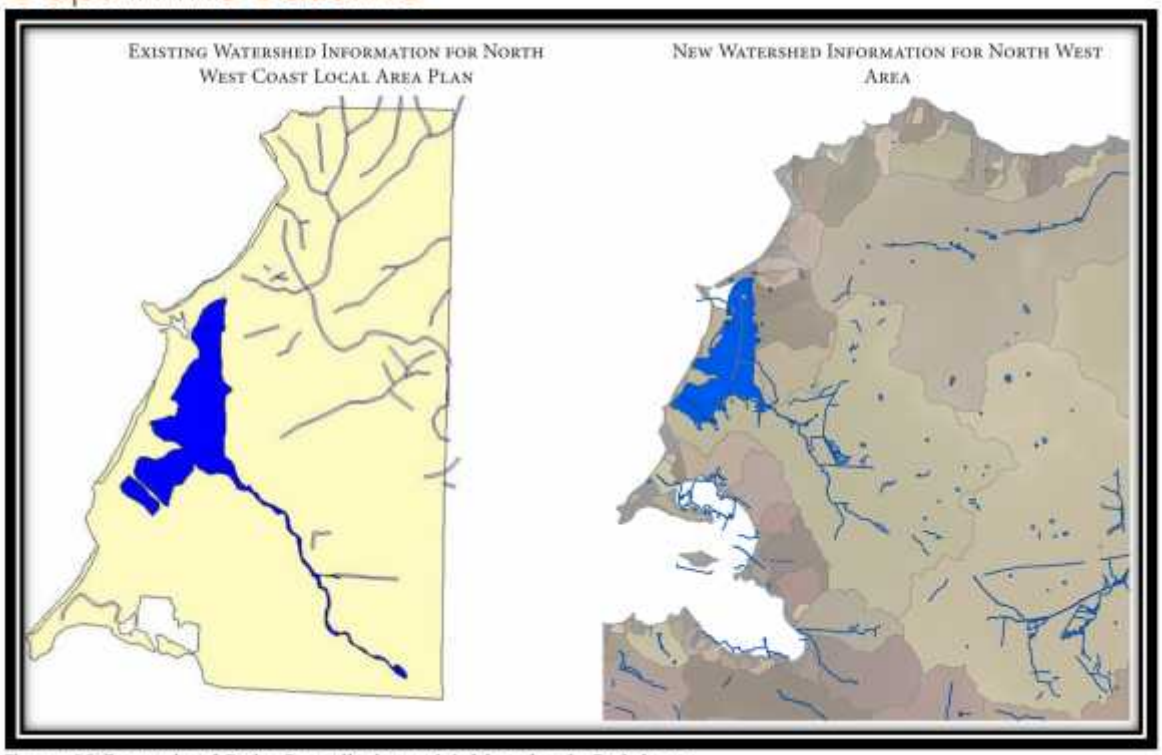


Figure 13 Example of Data Gaps that need Addressing in Database

Although there is considerable information already being collected or existing which would contribute to the ensuring a robust database to support SLM and effective predictions and management of DLDD issues, there are some areas noted to be absent or at least incomplete. The listing of the available datasets are listed in Annex 1.

It should also be noted that a recent review of the hydrological layer determined that the previously accepted watershed and a few other key hydrological features need to be checked for errors and updated. It is recommended that the agencies which participate in the National GIS system seek to ensure regular checks for accuracy and updating. Additionally, these agencies need to set targets to capture missing data and integrate it into the system as the more detailed the data available the more accurate the predictions, monitoring and assessment of the DLDD events.

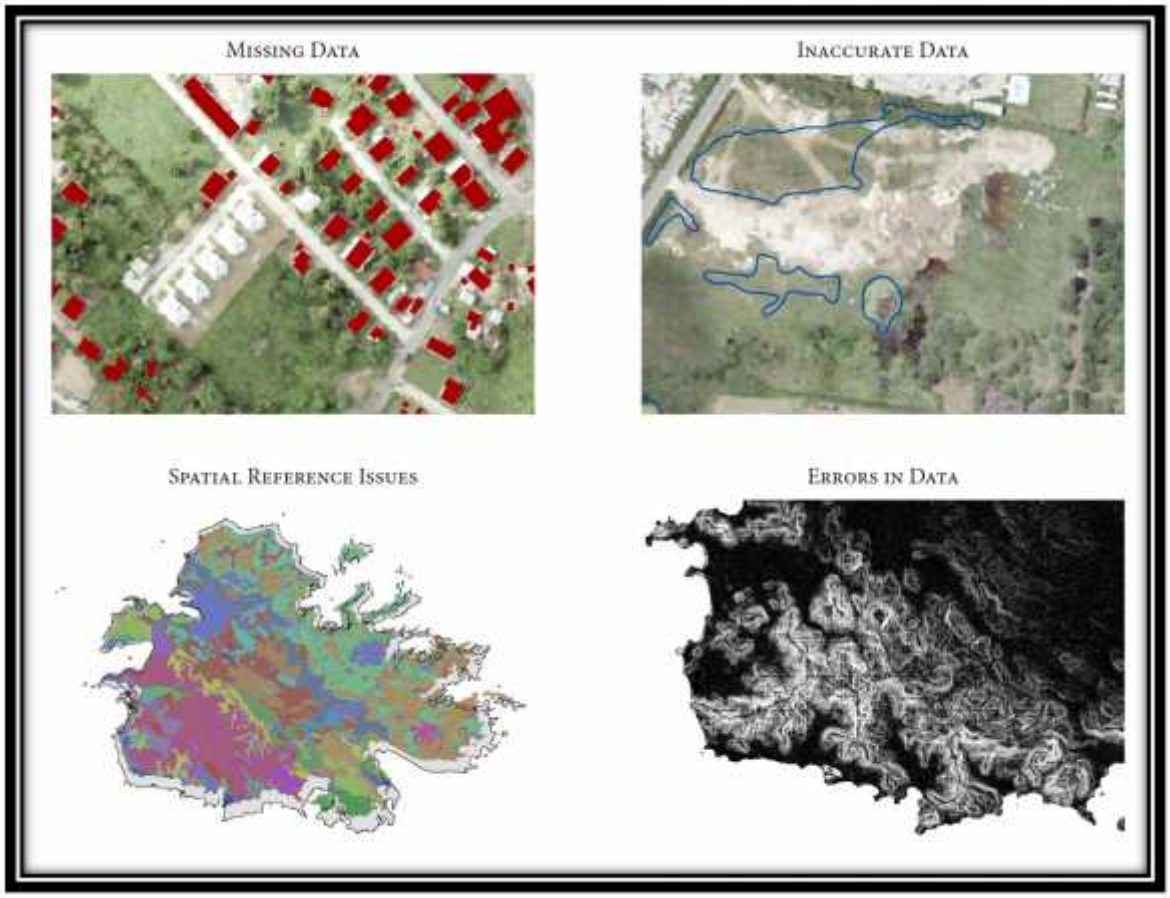


Figure 14 Potential Errors that can Exist within a Database

Use of Indicators

After establishing a workable baseline, it is then necessary to ensure appropriate indicators are selected, recorded and applied to the baseline to help predict and record the impact and intensity of DLDD events. However, the effectiveness of an indicator is dependent upon its accuracy and its applicability. It is therefore necessary for indicators to be reviewed for their appropriateness and new ones considered at regular intervals.

Meteorological Data

The Department of Meteorological Services (DMS) is responsible for the recording and dissemination of meteorological data and predictions for Antigua and Barbuda. Located within the compound of the V. C. Bird International Airport, the DMS is a critical and essential service for aviation, tourism, disaster monitoring, water and agricultural sectors. The DMS also serves as the National Focal Point to the IPCC, which as will be

seen, facilitates the consideration of climate change issues and predictions into national planning to address DLDD issues.

With regard to addressing DLDD issues, meteorological indicators can be classed into three general categories for better interpretation of scale and scope of events.

Weather Indicators

The first category of meteorological data is based on those measures which are collected daily which through their scale and scope are only expected to influence behaviours of people and systems for very short periods of time spanning from a few hours to a few days. Physical impacts can be highly localized and in some cases may not be readily identifiable. An example of this is the drought cannot be determined in one day. On the other hand, extreme weather events such as torrential rains and high winds can be sufficient to trigger aspects of land degradation. The weather indicators collected and reported by the DMS are: wind direction, wind speed, temperature high and lows, precipitation, cloud cover, dew point, relative humidity and pressure.

Climatic Indicators

Over a prolonged time and given to a specific area, meteorologists can recognize repetitive trends in weather and can define and learn to rely on those trends as depicting the climate. However, the manifestation of climatic indicators is not limited to dominant weather trends. As climatic trends also tend to influence seasonal behaviours in indicator species and visible traits in the vegetation and geology.

The DMS produces historical, seasonal and monthly average data for the various measurement of weather as a means of defining the climate existent within Antigua and Barbuda. However, the variety of data is not uniform from all stations.

Table 9 Available Climate Data in Antigua and Barbuda

Station	**Element**						
National	Rainfall	Pressure					
Coolidge	Rainfall	Max Temp	Daily Max Temp	Mean Temp	Daily Min Temp	Min Temp	Relative Humidity
		Wind Speed	Wind Dir	Cloud			
Jolly Hill	Rainfall	Max Temp	Avg Temp	Min Temp			
Green Castle	Rainfall						
Cades Bay	Rainfall						

Christian Valley	Rainfall						
Cobbs Cross	Rainfall						
Cochrane	Rainfall						
Renfrew	Rainfall						
Dunbars	Rainfall						
Orange Valley	Rainfall						
Codrington	Rainfall						

Climate Change Indicators

Anthropogenic Climate Change has to be included in the reported and considered meteorological data because climate change has been proven to shift climatic norms in space and time and it has been shown to increase the intensity of extreme hydro-meteorological events. To this extent, the DMS has to not just produce the raw data but provide analysis to better explain to communities and stakeholders how these changes are expected to impact upon them. As a result, the DMS produces several reports to assist in explaining the observed changes and some of the impacts.

- Antigua and Barbuda Agromet Bulletin
- Drought and Precipitation Statement
- Temperature Statement
- Dry Season Statement
- Wet Season Statement

It should be noted however, that although meteorological data is the principle mechanism through which climate change indicators present with regard to DLDD issues, in the more general sense climate change covers a wide range of factors and in many cases the secondary impacts of climate change can be similar to or influence the DLDD impacts.

Agricultural Data

Farming is potentially the human activity most sensitive to DLDD issues. Whether through crops or livestock the access to quality land and water is essential. This being said, agricultural holdings offer an opportunity for early warning and assessing the impact of DLDD issues and even confirming changes in climatic norms. The following minimum size criteria have been established from the 2007 Agricultural census:

The presence of any of the following constitutes a 'holding'.

- At least two head of cattle AND/OR breeding cattle.
- At least 5 sheep OR goats OR pigs AND/OR breeding such animals
- A combination of at least 5 sheep, goats and pigs.
- At least 25 poultry AND/OR annual sales of eggs from these poultry of at least EC$1000 AND/OR annual sales of poultry meat from these poultry of at least EC$1000.
- At least 20 bearing fruit trees AND/OR annual sales of fruit from these trees of at least EC$1000
- At least 10 Banana/Finger Rose Mats AND/OR annual sales of bananas from these plants of at least EC$1000
- At least 10 Plantain Mats AND/OR annual sales of plantains from these plants of at least EC$1000
- At least one eight of an acre (0.12 ACRES OR 5445 Sq. Ft. (75 x 75 Ft)) of any garden crop AND/OR annual sales of garden crops from this land of at least EC$1000 (garden crops include vegetables, ground provisions, food crops, pineapple, papaya, herbs or any other crop not elsewhere included).

Based upon input like the Agricultural Census researched will then know number, size and general location of holdings. Further, the data can also indicate trends within the industry.

Table 10 Livestock Summary and Comparison Between 1984 and 2007

	No. of HHs 2007	**No. 2007**	**Expansion factor**	**No. 2007 expanded**	**No. 1984**	**% change**
Cattle	217	3134	9	3143	11064	-72%
Sheep	213	7713	35	7748	6092	+27%
Goats	468	12878	144	13022	9548	+36%
Pigs	136	2045	25	2070	2437	-15%
Poultry	337	22957	1017	23974	20083	+19%

Agricultural indicators and data can also be determined from economic performance. Table 11 shows the impact of drought years on meat production.

Table 11 Meat Production in Lbs

Year	***Pork***	***Beef***	***Lamb***	***Goat***	***TOTAL***
2010	121,165	325,500	42,665	14,245	***503,575***
2011	164,689	336,000	25,515	7,140	***533,344***
2012	146,737	343,350	23,275	3,045	***516,407***
2013	90,977	267,750	12,478	5,040	***376,245***
2014	81,554	203,350	13,720	3,885	***302,509***

Land Use Data

Whether land is left as its original environment or modified or developed in some way, there will be an effect on natural processes like erosion, runoff and percolation. Additionally, there is evidence that certain types of landscapes and physical structures can even affect localized weather.

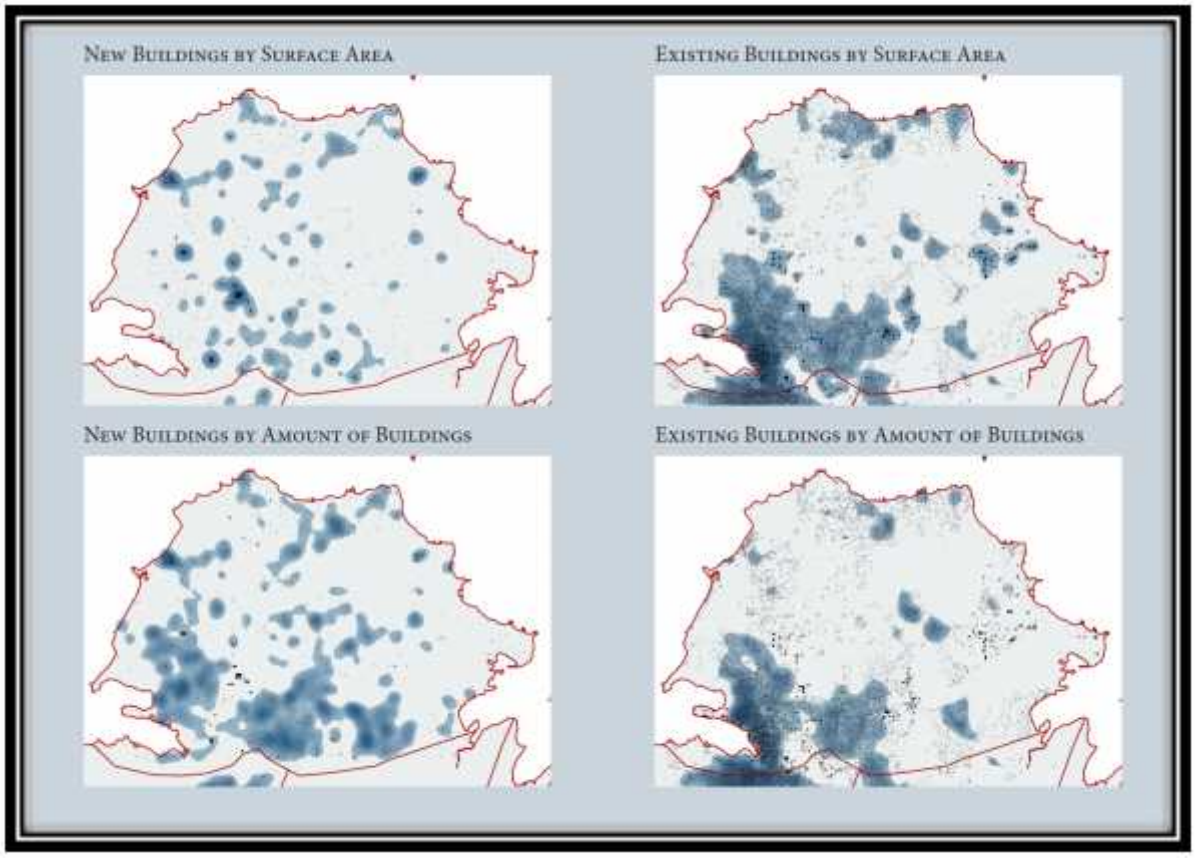


Figure 15 Example of how Impervious Surface is Considered

However, studies need to be done to fully determine how different categories and intensities of land classifications impact on the factors of DLDD so that they can be factored into model projections.

Socio-Economic Data

Socio-economic data can come in a wide variety of forms. However for ease of reference, they can generally be grouped into two categories when considering DLDD issues. The level of vulnerability has to be determined first followed by the impacts. Fortunately there are frameworks to guide the collection and application of socio-economic data as it relates to DLDD issues.

One approach is to use the Marshall et al (2010)[22] Framework for Assessing Coupled Socio-Ecological Vulnerability. This framework as explained by the author follows the logic that "[i]n the ecological domain, ecological exposure and ecological sensitivity create impact potential. The impact potential and the ecological recovery potential together form the ecological vulnerability or exposure in the social domain. This ecological vulnerability combined with the sensitivity of people form the impact potential for society. The social adaptive capacity and the impact potential together create social-ecological vulnerability".

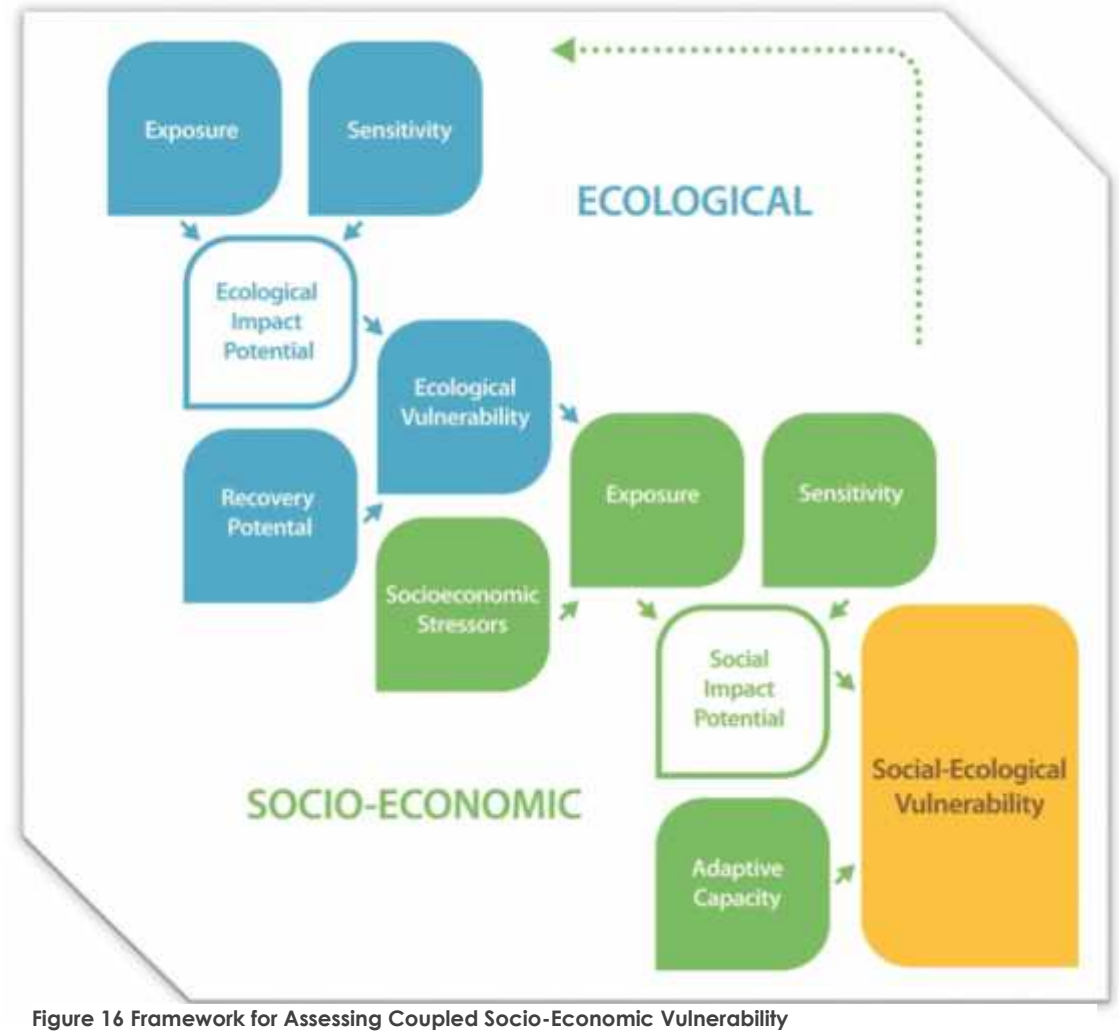


Figure 16 Framework for Assessing Coupled Socio-Economic Vulnerability

Another approach which was utilized recently to assess vulnerability of three local communities to climate change impacts can also be utilized not just because of the synergies between desertification and climate change but because the principles of assessing the socio-economic impacts are the same.

[22] Marshall NA, Marshall PA, Tamelander J, Obura DO, Mallaret-King D, et al.. (2010) A framework for social adaptation to climate change: sustaining tropical coastal communities and industries. GlandSwitzerland: IUCN. 36 p.

The REGATTA VIA Methodological Framework [23] provides a more comprehensive framework that seeks to cross-reference community, government, private sector, academic and NGO perspectives in hopes of developing a more rounded view of vulnerability and impacts. Additionally, this approach also provides adaptation recommendations to reduce the potential for adverse impacts.

Along with conducting vulnerability assessments socio-economic data can also be represented in GIS databases and utilized to determine vulnerability and impact.

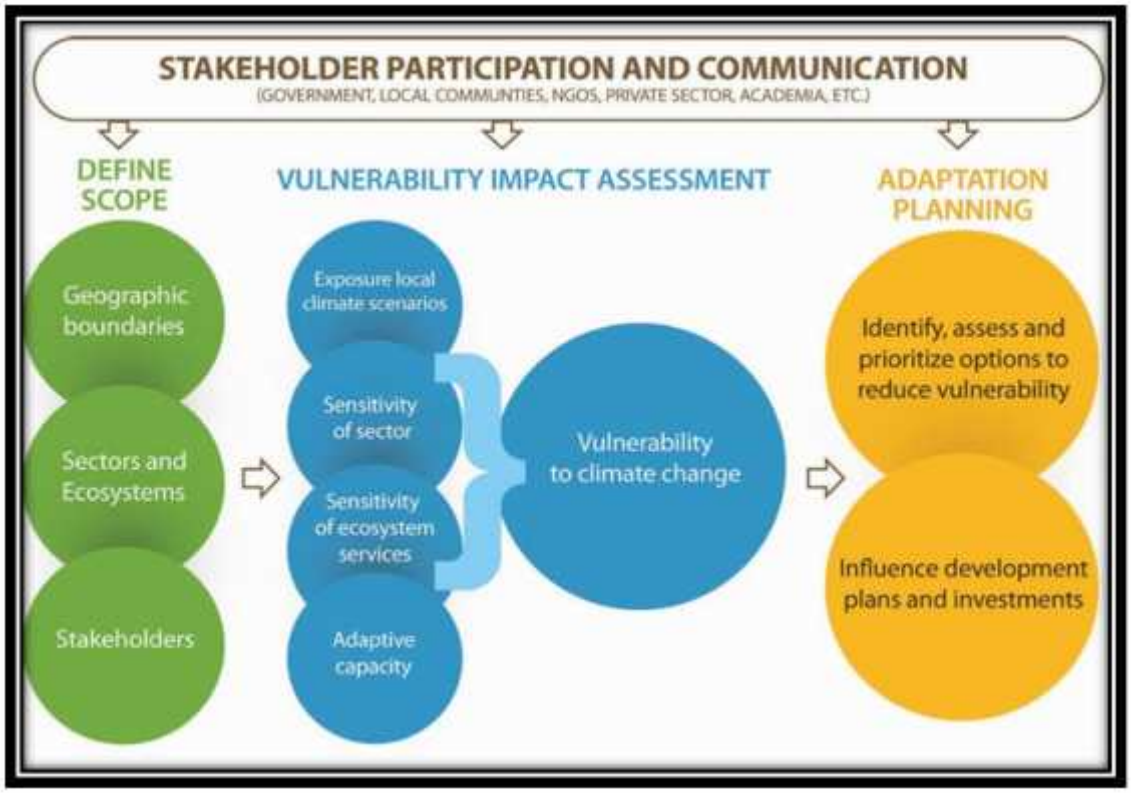


Figure 17 REGATTA VIA Methodological framework

Disaster Vulnerability Risk Mapping

In 2000-2001, Antigua and Barbuda participated in an OAS funded hazard mapping project. Titled the Post Georges Disaster Mitigation Project (PGDM) after an extremely powerful hurricane which brought significant damage to Antigua and Barbuda, (as well as other neighbouring states) the project not only provided vulnerability assessments but also GIS capacity building and mitigation options.

[23] Caribsave (2015) Vulnerability Impacts and Adaptation Analysis in the Caribbean; Local Vulnerability Analysis for Antigua and Barbuda

Coastal Erosion[24]

Several methods and techniques were used in developing this project, including surveying beach profiles, analysis of the beach data, and the use and application of various GIS computer hardware and software. The following activities are included in this hazard assessment work:

- Assembling of existing beach monitoring data for each island.
- Calculation of erosion/accretion rates for all monitored beaches.
- Assigning of coastal erosion hazard risk categories (very low, low, medium, high or very high) at the monitored beaches in each island.
- Production of island-wide geographic information system (GIS) data layers depicting the coastal erosion hazard risk zones. For each monitored beach, the layers show the calculated erosion/accretion rate. These data are in ArcView format, georeferenced to the common mapping standard for Antigua and Barbuda, and accompanied by the appropriate GIS metadata. The data dictionary is shown in Appendix II while the metadata are given in Appendix III.
- Production of island-wide coastal erosion hazard maps for Antigua and Barbuda, using the GIS data described above. These maps depict the coastal erosion hazard risk along the coastline using the following risk categories: high, medium, low and 'not monitored' for Antigua with two additional categories 'very high' and 'very low' for Barbuda. Maps include a common set of reference features that were provided by the PGDM.

Using the beach monitoring and other data, major operational processes and activities were determined so that beaches affected by storms or other factors were identified. A coastal erosion hazard index was developed for the various beaches that are monitored around Antigua and Barbuda. The categories for the erosion hazard index are derived using the equal interval/class method. The rates of coastal change in Antigua and Barbuda were grouped and the range between the highest and the lowest erosion rate was determined. The range was then divided by the number of categories, which had been predetermined as five. The limits of each category were then determined as shown in the table below.

Table 12 Rate of Coastal Change Hazard Category [m/yr]

Hazard Category	Rate of Change
Very Low	+3.38 to +5.28
Low	+1.18 to +3.37
Moderate	-0.43 to +1.47

[24] OAS (2001) Post-Georges Disaster Mitigation in Antigua & Barbuda and St. Kitts & Nevis, "Coastal Erosion Hazard Assessment and Mapping for Antigua and Barbuda"

High	-2.34 to –0.44
Very High	-4.25 to –2.35

Inland Erosion[25]

The models used in this study have been developed using the general understanding that has developed of the processes involved and the role of various land characteristics in these processes. They are simple models using the following land characteristics as variables to estimate the effects of the apparent processes:

- Topography: slope, aspect, etc.
- Physical geology: tectonics / lithology
- Geomorphology
- Soils: physical and chemical
- Rainfall
- Wind
- Present and antecedent Land Use / Vegetation
- Current status of erosion / landslide
- Hydrology
- Models similar to these are widely used in the absence of local experiment and the kind of local data which engineers might provide.
- The data used in these models is often a simpler version of what appears to be the appropriate data, which are used because they are available and the "better" data are not. Some better data can and should be obtained.

Hazard maps

1. Single feature maps

1. Simple models were used to produce hazard scores for each land unit. The score is an estimate of the relative likelihood of the hazard at the land unit, but it has no physical meaning, like 'days per year' or 'tons per acre', etc.
2. To make the scores more useable, they have been classified. For each hazard, the scores have been divided into 5 classes having equal land area (representing very low, low, medium, high and very high groupings)

[25] OAS (2001) Post-Georges Disaster Mitigation in Antigua & Barbuda and St. Kitts & Nevis, "Inland Erosion Hazard Assessment and Mapping for Antigua and Barbuda"

3. Combining the effect of different types of hazard would be like adding apples and pears, with no common element like calorific value to use. Adding classes rather than scores reduces this problem. Composite maps were produced by adding classes and then reclassifying.

2. Composite maps, choosing the most appropriate classes for defining land-based erosion hazard for development sites

Erosion hazards are most commonly defined in relation to open land either under agricultural use or intended for an agricultural use. The application to development sites where some kind of construction is intended is related to localised incidents rather than a general picture. This emphasises the need for data at a more appropriate scale, which are not available at present.

1. Overall, *rill and sheet erosion* should be given little importance in assessing possible impacts on building development sites, while gullying is important.
2. The natural evolution of *streams* means that bank erosion is inevitable without canalisation of the stream course. Overall the stream bank erosion / stream adjustment effect could be important for development sites.
3. *Wind erosion*, although it can cause problems in certain circumstances, is unlikely to affect a building site seriously at the levels at which it is probable in the present circumstances except in Barbuda, where it might cause problems and other types of erosion are of less importance.
4. *Mass movement*, on the other hand, both the site from which the movement takes place and the destination of material, can produce major difficulties for building development.

The final map for Antigua combines gullying and mass movement (landslides and rock falls). This is done by adding together the land unit by land unit values for gullying and mass movement. For Barbuda alone, with a generally lower level of hazard, wind erosion is included. It should be noted that in the recent past in Barbuda, more damage was caused to soil, vegetation and some buildings by incursion of the sea, than by events originating on land.

3. Individual hazard maps and composite maps presented

The final maps (one each for Antigua and Barbuda) are composites, derived from the whole set of individual "erosion" process maps for each island. The full set, shown below and available as larger maps, comprises:

Antigua

Composite A: Combined hazard of gullying and landslides. (The hazards of sheet and rill erosion and of wind erosion in Antigua are not considered of great importance in relation to building development sites)

1. Rill erosion, bare soil, hazard classes
2. Landslide overall hazard classes
3. Wind erosion hazard classes
4. Gully hazard (an overlay on 1, Rill etc)

Barbuda

Composite: Combined hazards of wind erosion and rock falls / debris slides. (The hazards of sheet and rill erosion and of gully erosion in Barbuda are minimal but wind erosion is relatively important and may provide a building development hazard)

1. Rill erosion, bare soil, hazard classes:
2. Wind erosion hazard:
3. Barbuda rock fall hazard is not mapped separately, Gully erosion hazard is near zero

Table 13 Factors Used in Assessing Inland Erosion Risk

Factor	**Type of variable**	**Low value**	**High value**	**Ratio**	**Distribution of values [1]**	**Actual, field distribution [2]**	**Mapped approximation [3]**
Soil (rainfall) erodibility K	constant	5	46	10	rectangular	~ discrete units	discrete units
Soil (wind)erodibility I	constant	11	66	6	near square	~ discrete units	discrete units
Slope angle	constant	0	57.6	¥	"L" shape	continuous	discrete classes
Rainfall intensity	temporal variable	150	750		Left-skewed normal	continuous	discrete classes
Land cover	human control	0	60	6000	irregular	~ discrete units	discrete units
Erosion control	human control			10	irregular	~ discrete units	discrete units
Landslide susceptibility	artificial	1	4	4	-	discrete units	discrete units
Infiltration reduction	human control	10	100	10	Left-skewed normal	discrete units	discrete units
Streamsinuosity	artificial ratio	1	1.5	1.5	"L" shape	artificial ratio	discrete units

Note 1 Frequency distribution: number of observations of each class or score

2 Discrete units, uniform areas, such as a single rock type. Continuous, varying continuously over the whole island

3 Discrete units, delineated areas with a single value, or discrete classes, continuous variable with isopleths ("contours") delineated

Drought Vulnerability[26]

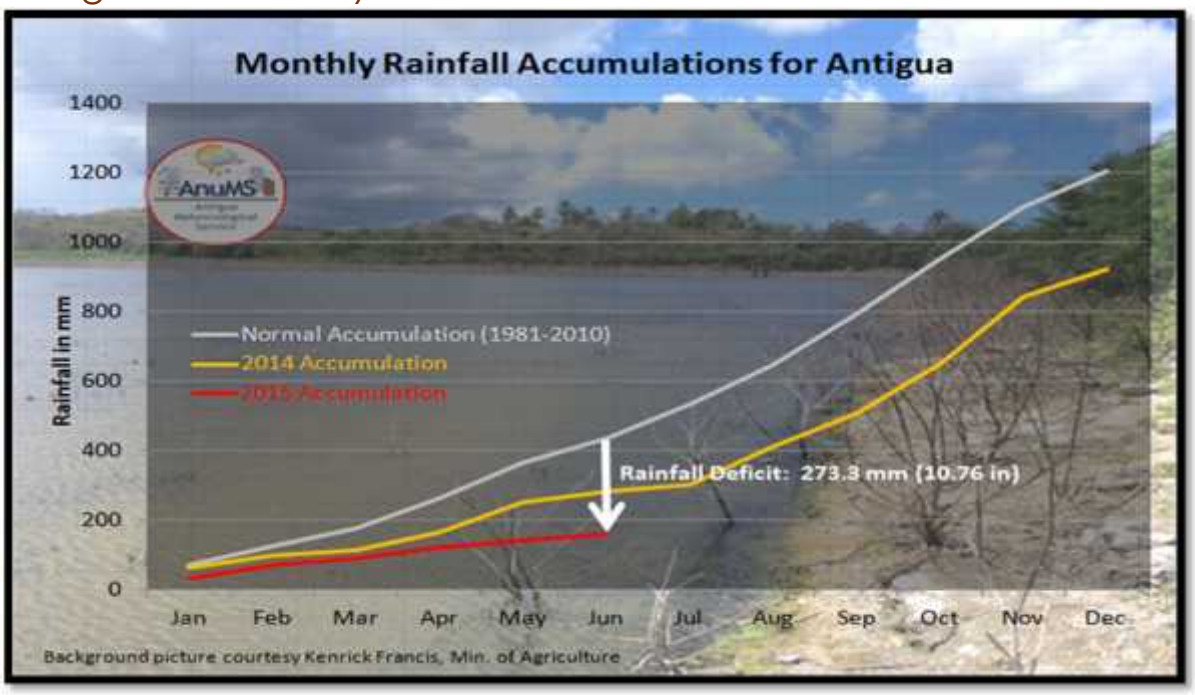


Figure 18 Graphic Representation of Rainfall Deficit with Most Recent Drought[27]

Prior to 2005, droughts were assessed based upon annual net precipitation. The DMS has realized that recognised that this methodology carried a flaw in that the nation could spend the first 9 months of a year under extreme drought conditions but the passage of one or a series of rainfall events could cause net precipitation at the end of the year to be within the normal range or even in excess. The DMS has therefore opted for using drought levels, based on consecutive three-month historical data, are defined as follows[28]:

- **Slight:** rainfall ranges from less than 30th percentile to the 20 percentile
- **Moderate:** rainfall ranges from less than the 20th percentile to the 10th percentile
- **Serious:** rainfall ranges from less than the 10th percentile to the 5th percentile
- **Severe:** rainfall less than the 5th percentile

Recognising the perceptive lag time between meteorological and hydrological droughts, the APUA in its Drought Management Policy seeks to identify drought onset at the 6-month mark.

[26] OAS (2001) Post-Georges Disaster Mitigation in Antigua & Barbuda and St. Kitts & Nevis, "Drought Hazard Assessment and Mapping for Antigua and Barbuda"
[27] https://anumetservice.wordpress.com/2015/07/15/record-low-rainfall-for-the-past-24-months/
[28] DMS (2015) Drought and Precipitation Statement for Antigua – June 2015

The PGDM provided a detailed variety of measures and indicators to be used to assess the risk and impact of droughts.

Table 14 Drought Risk Criteria Index

Criteria Category	Weight
Environmental Meteorological	
Rainfall < 35 inches	1
Exposure to wind and marine influences	1
Shallow soils	1
Slopes >11°	1
Cactus scrub vegetation	1
Hydrological/Infrastructure	
Absence of wells	1
Absence of agricultural reservoirs	1
Human/Landuse	
Grazing	1
Crop location	1
Population density > 5,000 per sq. mile	1

a) Environmental Indicators

Reduction in biomass production of common grass species. Early warning is wilting, as grass roots become progressively damaged by lack of soil water. Grass cover becomes patchier as fallen leaf debris is blown away by wind in exposed areas. Homeowners find no need to use lawn mowers.

Leaf fall and litter in Forests. The Forestry Division uses the increase in leaf fall and litter (detritus) on the forest floor as one indicator of drought. No measurement of volume of weight is done. Since leaf fall varies between species, measurement would need to be correlated with plant associations.

In Cactus Scrub forests, xerophytes (plants growing in dry areas) with small hard leaves can decrease water loss when the area begins to get drier and will drop their leaves in prolonged drought.

Damage to "indicator" plant species. The Ficus, planted as hedge or trees, normally stays green; its small and shiny leaves limit moisture loss and its wide spreading root system allows it to seek moisture and nutrients beyond its drip line. When the Ficus loses a lot of its leaves it is an indication that the country is in a period of prolonged drought.

Some types of xerophytes, (succulents, such as cacti and agaves) utilize stored water in dry periods without noticeable damage. In fact, such plants can survive for weeks when uprooted, so that signs of damage (dried leaves or broken stems) may be an indication of negative water balance resulted from extended drought.

b) Hydrological

Reduction in Ground Water levels. The APUA Water Division uses ground water levels at various well fields as an indicator of hydrological drought.

There is a time lag between meteorological and agricultural drought conditions and hydrological drought as indicated by ground water levels. The latter occurs later but the time lag cannot be accurately predicted in the absence of rainfall data that could be correlated with rates of pumping and recharge, for the watersheds in which the well fields occur.

Recovery from meteorological and agriculture droughts occurs in advance of the replenishment of ground water to average levels. Again, the data does not exist to accurately predict the gap in time between these events.

Reduction of Water Levels at Municipal Reservoirs. Receding water levels at municipal reservoirs is another drought indicator used by APUA. However, it was not determined if specific indicator levels for the various municipal reservoirs were established. Indicator levels at selected reservoirs could be determined over a period of time by widening the scope of monitoring to measure consistently meteorological and hydrological data, including, rainfall, temperature, wind speed, evaporation and seepage.

Water Rationing. APUA begins to ration water before ground water levels recede to critical points. In fact, the decision to begin rationing water appears to be influenced by perceived meteorological and agricultural drought conditions.

Reduction of Water Levels at Agricultural Reservoirs. This is another indicator observed but not measured by authorities.

c) Agricultural

Livestock

Livestock gain water from drinking water, foraging plants and water molecules produced in the breakdown of food. They lose water through urine, feces and water evaporated through skin and lungs.

Some livestock can reabsorb water in their intestines to produce dryer feces and can reduce water used to excrete nitrogenous wastes of the urine (Brewer, 1994).

As animals well adapted to drought conditions goats are presumed to use similar physiological measures to conserve water. Despite this, they and other livestock will show signs of stress during extended drought:

- ***Weight loss***. Symptoms are reduced muscle density, visible ribs. Effects are more associated with tethered livestock. However, untethered animals foraging larger areas for food use more energy and may suffer similar weight loss.
- Higher incidence of disease.
- Unusual high incidence of miscarriage among pregnant females.

Crops

Indicators may include:

- Negative water balance as evidenced from wilting and ultimately death of plants in extended droughts.
- Unusually high incidence of diseases, as plants are unable to obtain needed moisture and nutrients from the soil.

d) Socio-economic

Socio-economic indicators include changes in water use practices by households and businesses:

- Storage of water in existing or temporary storage facilities as a result of water rationing.
- Reduction of water used for landscaping of household and hotel gardens.
- Regular trucking of water to meet water deficit due to rationing.
- Higher incidence of respiratory ailments due to excessive dust in a very dry landscape. Respiratory ailments related to drought are not recorded for Antigua and Barbuda but are generally considered a drought related health impact.

Flooding[29]

The characteristics of areas prone to flooding are as follows:

— They have very gentle slopes—0.2% to 0.5% (2 to 5 metres in 1 kilometre)—and are likely to be poorly drained as their streams also are likely to have a very small slope;

— Their natural drainage may be constricted owing to, for example, a heavily vegetated area, such as mangrove forests, a meandering stream, or to tidal influences. If communities are located around the outlet, then the hydraulic structures, such as bridges and culverts, may constrict flows and thus may further limit the natural carrying capacity of the rivers;

— They have large ratios of the contributing watershed area to their floodplain area;

— They are so positioned within the watershed that runoff from the surrounding lands concentrate at the floodplain. For watersheds with

[29] OAS (2001) Post-Georges Disaster Mitigation in Antigua & Barbuda and St. Kitts & Nevis, "Inland Flood Hazard Assessment and Mapping for Antigua and Barbuda"

long longitudinal axes, the time of arrival of a flood wave is generally longer than for equivalent watersheds having shorter longitudinal axes;

— The surrounding land has a high runoff potential, due to impervious soils, impervious ground cover, or/and limited abstraction losses by vegetative cover.

Thus the methodology aims at locating areas having the abovementioned properties. The approach for producing the flood maps was as follows:

1. Identify areas, called floodplains, having mild slopes (0.2% to 0.5%);
2. For each plain, delineate the watershed draining into the plain and then determine the ratio between the watershed area and plain area (from (i) above);
3. For a particular 24-hour return period rainfall, generate runoff hydrographs discharging into the plain, based on the shape, the drainage network, the soil properties and the land use.
4. From the hydrographs, determine the volume entering the plain and estimate an average discharge rate over the hydrograph period.
5. Estimate a discharge rate from the plains and use it to determine the maximum volume of water (expressed as depth of water) that is likely to be stored on the plain.
6. Determine the hazard category of each plain according to water depth within the plain from the 100 year return period storm (roughly equivalent to the maximum 24 hour rainfall period within Hurricane Lenny), using the following classification:

Table 15 Hazard Classification According to Mean Depth of Water

Water Depth (mm)	Hazard
>600	Very High
600-300	High
300-150	Moderate
150-50	Low
<50	Very Low

The categorization of the hazard in this way provides a measure of the magnitude of flooding to be expected from such an event. It also provides a measure, certainly by rank if not in absolute terms, of the severity of flooding among the identified zones.

National DLDD Response System

In the 2005 draft NAP, 18 sites were chosen through local knowledge and consultation as land degradation hotspots. Although there are benefits to this methodology in that it encourages a participatory approach, it is limited to the participants' knowledge of areas and their understanding of DLDD issues. Another limitation of the 2005 approach is that it treats DLDD as a static issue where the problems and events will always be confined to specific areas.

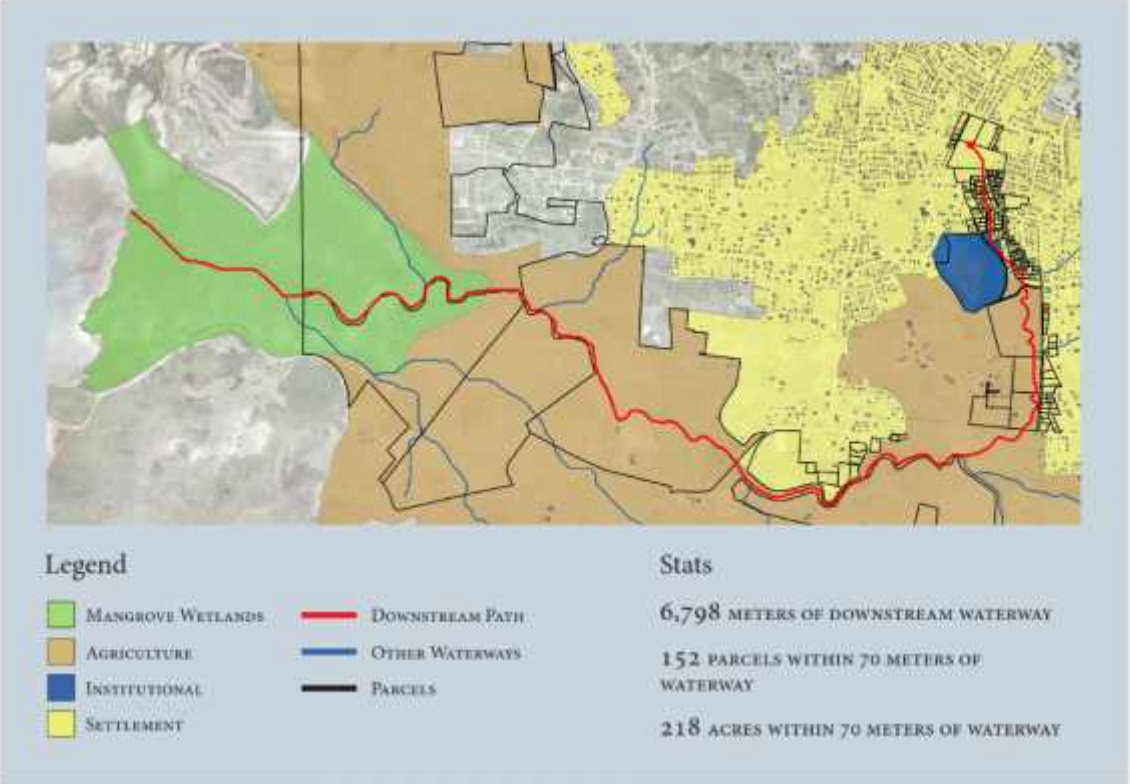


Figure 19 Example of Forecasting and Monitoring Possible with National Database

The approach that is being encouraged here is much more data driven and is made possible through computer-aided spatial analysis. Local knowledge is still an important component to this process, but the important thing here is to capture that knowledge and include it within the database. However, as seen in Annex 1 and some of the indicators all relevant datasets are not complete. Further, there is insufficient monitoring in some areas.

Another important component of this approach is the ability of agencies and stakeholders to share information. This means that by having a shared and interconnected GIS database, each agency should be able to access the necessary information to determine early warning, projected vulnerability and actual impact assessments at as close to real-time analysis as needed.

Figure 19, for example, provides analysis of potential impacts of one watercourse in a given flood-prone area. This will therefore allow a targeted response to a specific threat. Vulnerable stakeholders and sectors can also be identified through this approach. Area specific adaptation planning can also be utilized here.

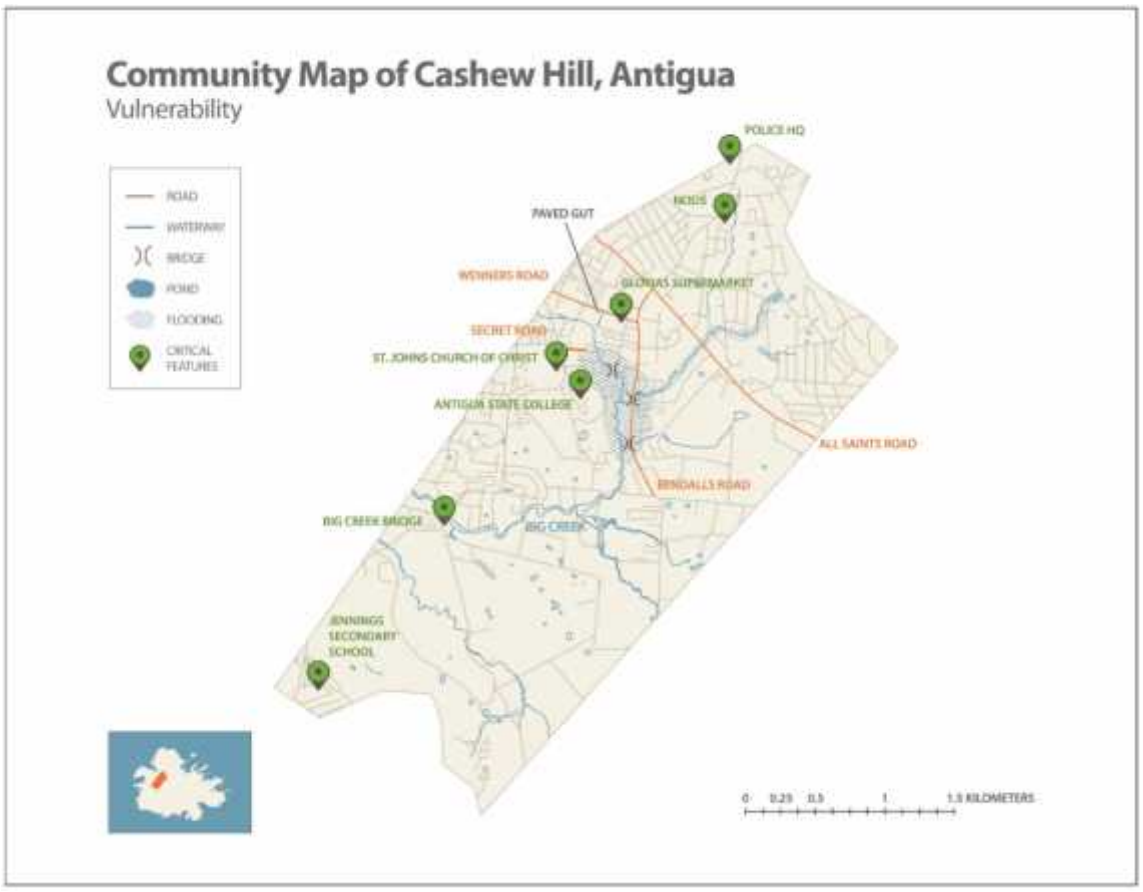


Figure 20 Community Wide Forecasting Example

Figure 20, provides another example of this approach where vulnerability was identified at the community level.

The coastal zone management is another area where an effective DLDD system can prove beneficial to Antigua and Barbuda. Currently only monitoring (beach, reef and seagrass) is done. In the short term, this monitoring data can be used to review coastal setbacks. However, every aspect of capacity building is needed to increase the scope, coverage, effectiveness and contribution to Antigua and Barbuda's development. In the long term a fully outfitted and functional coastal zone management unit should be established to not only monitor the coastal features but will have the ability and capacity to prevent and recover from any coastal damage.

Figure 21: Example of Cost (USD) and Type of Shoreline Protection[30]

2 Runaway Bay			
Submerged Breakwaters	3600/metre	350 metres	1,260,000.00
Extension to existing groyne	1000/metre	30 metres	30,000.00
Beach Nourishment	15/m^3	25,000 m^3	375,000.00
New Groyne at south end	1000/metre	30 metres	30,000.00
Buried Revetments	1500/metre	500	750,000.00
Sub-Total			2,445,000.00

At present, without such an agency, any effective coastal zone rehabilitation has to be outsourced most likely from outside the country. This makes it a particularly costly activity. Figure 21 provides an example of the type of work that a Coastal Zone Management Unit and the costs of coastal zone rehabilitation.

[30] Smith and Warner Intl./OECS (2002) Shoreline Protection in Antigua

Aligning National Action with the 10-Year Plan

Operational Objective 1: Advocacy, awareness raising and education

To actively influence relevant international, national and local processes and actors in adequately addressing desertification/land degradation and drought related issues.

Outcome 1.1: Desertification/land degradation and drought issues and the synergies with climate change adaptation/mitigation and biodiversity conservation are effectively communicated among key constituencies at the international, national and local levels.

Outcome 1.2: Desertification/land degradation and drought issues are addressed in relevant international forums, including those pertaining to agricultural trade, climate change adaptation, biodiversity conservation and sustainable use, rural development, sustainable development and poverty reduction.

Outcome 1.3: Civil society organizations (CSOs) and the scientific community in the North and the South are increasingly engaged as stakeholders in the Convention processes and desertification/land degradation and drought are addressed in their advocacy, awareness raising and education initiatives.

The general public was deemed to have limited awareness and understanding of SLM and DLDD issues. This then caused there to be little public demand to more effectively manage these issues and by extension little political will to effect change. As such it was felt a successful public awareness campaign would have to be centered on a strong education strategy, particularly within the schools. It was also determined that the public awareness needed to help the general public to develop a firm appreciation of the economic impacts of poor land management practices and DLDD. It was also felt to be imperative to ensure that key stakeholders, especially those who primarily rely on the land for their livelihoods, were provided with targeted awareness campaigns.

Education strategy

Land degradation is not a very well understood phenomenon. This is so for the reasons identified below:

1. Degradation of land is generally a slow, gradual process: Loss of topsoil, reduction in soil fertility or structure are generally slow processes that happen gradually over many years. A forested area with good sized trees and bushes that is being overgrazed by goats will not suffer in a very visible way until the present vegetation has reached the end of its normal life and no new saplings are present to fill in the gaps. Such processes are not particularly evident to the casual observer, since, except for landslides and erosion or deposition from major floods or storms, the process is incremental. People tend to forget how things were, especially when a generation has elapsed.

2. Effects of degradation can have consequences far from their original cause. Few of us are sufficiently aware to connect something taking place around our off- shore reefs with the cutting of trees several miles away on a steep hillside. Brown silt-laden streams do not set our alarm bells ringing, even though most of us know at a theoretical level, that coral reefs need crystal clear water to prosper. How many would even think where such silt-laden water was going?

3. The public is generally not well informed about matters of soils and vegetation: Secondary school teachers are alarmed at how few wild plants many of our secondary students can recognize. Birds, insects, fungi – the story is much the same. How then can there be concern for such things if their very existence is not recognized?

For the above reasons, greater emphasis has to be directed at these very basic levels and with special emphasis on the young. Schools have already been targeted by various groups dealing with environmental issues and some attention has been given to curriculum development in the environment. Considering moves to integrate the use of mobile applications and other modern technology into education. It is recommended that a comprehensive education project be pursued to integrate environmental issues throughout the curriculum. This should include the development of mobile applications, text books, multi-media reference tools, teachers' and parent guides. As much as possible this should integrate the issues under various MEAs and represent them in ways that highlight who and what they impact in the local context. Further recognizing the potential high cost of such an activity it is advisable to consider pursuing as an OECS or Caribbean sub-regional project.

Sector Specific Awareness Targets

Another key issue is doing a good job of relating degradation concerns to economic development and livelihoods. For older persons, who are more concerned about making a living, the economic costs of neglecting our watersheds, coastlines and farmland may be more easily recognized.

Specific target groups need also to be recognized. Those who cut wood for charcoal or fish pots, those who operate backhoes for land clearing, agriculturalists or backwoodsmen who set fires without any care for where the fire goes after it has burnt

their own plot – such people need special awareness building and sensitivity training programmes to bring about some change of practice in their work plans. Further, this needs to be backed up by a knowledge of sensible laws and practices that support them.

Synergies with Other MEAs

All of the above points could probably be equally well related to the needs of the Biodiversity Convention and to some extent, the Climate Change Convention. These three conventions cover a lot of common territory and it will be important to avoid duplication and to make better use of scarce resources, both financial and human, by combining effort and pooling resources in public awareness programmes and in other common areas of activity. Each Convention programme will also benefit, because the public's understanding will be deepened as they begin to understand how all of these things are interrelated in a holistic way.

Revitalizing Professional Associations

Although laws and regulations are enacted by governments, it is the existence of a strong and vibrant class of professionals that raises the standards and modernizes society. The absence of strong professional association stands as a risk to new entrants into the profession not benefitting from the sharing of unique and vital local knowledge which may as a consequence not be learned for years. Additionally, these associations ideally offer a means through which all members can keep up-to-date with new trends and techniques.

It is therefore important that efforts be made to engage the various professional associations and would be members. This could include:

- Legislative review of association charters/constitution
- Convening a symposium on the importance of professional associations in the national development framework.
- Providing workshops to assist local professionals to successfully apply/ qualify as international consultants

Operational Objective 2: Policy framework

To support the creation of enabling environments for promoting solutions to combat desertification/land degradation and mitigate the effects of drought

Outcome 2.1: Policy, institutional, financial and socio-economic drivers of desertification/land degradation and barriers to sustainable land management are assessed, and appropriate measures to remove these barriers are recommended.

Outcome 2.2: Affected country Parties revise their national action programmes (NAPs) into strategic documents supported by biophysical and socio-economic baseline information and include them in integrated investment frameworks.

Outcome 2.3: Affected country Parties integrate their NAPs and sustainable land management and land degradation issues into development planning and relevant sectoral and investment plans and policies.

Outcome 2.4: Developed country Parties mainstream UNCCD objectives and sustainable land management interventions into their development cooperation programmes/projects in line with their support to national sectoral and investment plans.

Outcome 2.5: Mutually reinforcing measures among desertification/land degradation action programmes and biodiversity and climate change mitigation and adaptation are introduced or strengthened so as to enhance the impact of interventions.

Unless the use to which a portion of land is put is well suited to its attributes, it is likely that the land will become degraded or will lose its potential value. This indicates the need for careful land use planning and the enforcement of such plans and regulations, especially in an island nation where land resources are quite limited.

Although the framework for addressing unauthorized development is addressed under the Physical Planning Act, Environment Protection and Management Act, and the Sustainable Island Resource Management Zoning Plan, the problem persists as one of the major impediments to sustainable land management and combatting DLDD issues.

That unauthorized development activities exist as a significant problem needing to be addressed suggests there is a gap in the understanding of the importance of land classification and the dangers of using lands for purposes which have not been prescribed. It is recommended that the public awareness strategy include better explanation of the dangers and impacts of unregulated development.

Watershed Management

The major issue for watersheds is arguably the lack of recognition at a national level of their fundamental importance to the water supply situation for the nation.

The two major issues for improving the management of many of the major watersheds are:

1. Reduction in the number of livestock using these watersheds as pasture and forage. A serious reduction of the goat population, or even elimination in some cases, will be needed to allow re-vegetation to take place.

2. Control of fires in the citronella grass areas and its gradual replacement with less fire prone species and the eventual reforestation of these areas. This will reduce

siltation in the ponds and reservoirs and will possibly improve recharge of the ground water sources.

Both of these "problems" require a multifaceted approach. In both cases, behaviour patterns have to be changed and attitudes have to be altered. Public awareness is needed regarding the effects of burning and overgrazing and perhaps more importantly the recognition by livestock owners that roaming livestock left to feed as they can is not a sustainable approach to livestock farming in the 21st Century. Alternatives to "landless" livestock production have to be found as well as to uncontrolled burning of Citronella grass as a way of clearing land for agriculture of providing palatable forage. Fires can be controlled if certain precautions are taken. Fire traces can help the spread of fire if it gets out of control. Unfortunately there is little awareness of these technologies.

A third problem is the unmanaged removal of wood from watersheds for charcoal production. It is not clear how significant a problem this is, but it should not be difficult to estimate probable sustainable harvest rates for a typical density of acacia and other hard wood species in a watershed.

The big question behind all these management issues, of course, is who (or what agency) will be responsible for doing this kind of research, developing practical policies and monitoring how they are carried out. When awareness and persuasion fail to stimulate the necessary level of compliance, how can sound practices be enforced?

The issue of legal responsibility for watershed management has been addressed, under the EPMA. The Act calls for the establishment of the Watershed and Wetland Management Committee. This will be a special grouping of key stakeholders charged with the responsibility to prepare and implement management plans for individual watersheds and wetlands. Specifically, these management plans should feature:

a) protection against storms, winds, rolling stones, floods and landslides;
b) prevention of soil erosion and landslip, formation of ravines and torrents, and deposit of mud, stones and sand upon agricultural land;
c) maintenance of water supplies in springs, rivers, canals and reservoirs;
d) protection of topography and vegetative cover;
e) protection from free roaming livestock and invasive alien species.

Other issues regarding water rights and cost recovery may also be addressed through the management plans and the committee. However, this will require significant capacity building through the demarcation of watersheds and wetlands. An important activity of the NAP will therefore be to promote discussion amongst all watershed users and other stakeholders in an attempt to get these issues addressed and to ensure clear boundaries are included within the EIMAS and any other national geographical information system databases.

Crown Lands Management

Any lands currently unowned by private enterprise are deemed vested in the crown for their safe keeping. The Government utilizes this management oversight as a mechanism to identify land to be used for future development needs of the country. This can include land to be used for municipal infrastructure, farming or housing developments. Additionally, many locals view these lands as a form of traditional 'commons' for livestock grazing, wood harvesting, fishing or other 'livelihoods'-type activities. In the most remote and hence unregulated and unmonitored plots, illegal farming, squatting and unregulated soil and water extraction may be attempted. Unsurprisingly, these unauthorized and unregulated activities have the ability to cause and in some cases exacerbate DLDD issues.

What is therefore required is for the Lands Division in the Ministry of Agriculture, Lands, Surveys & Housing, as the agency with responsibility for the management of crown lands, to develop a land use guide for crown lands based upon their classification. As pointed out earlier, the Land Division routinely assesses crown lands to identify sections for needed development. However, the current approach is somewhat devoid of appropriate methodology in site selection. As a result of land being selected for ease of access and availability instead of appropriateness to the desired usage and developmental potential an area selected could turn out to be flood prone, contain seasonal water bodies or even be prime agricultural land.

By conducting the assessment of crown land and then elaborating a management plan for those lands, the Government would then achieve the following:

- Prime agricultural lands will be identified and committed to the national food security process
- Water courses and other water bodies can be effectively buffered to prevent, contamination, flooding, backfilling and can even be integrated in drought management plans.
- Land suitable only for livestock grazing can be put to those purposes thereby reducing the damage caused by unregulated free-range grazing.
- Urbanization can be better coordinated with stakeholders thereby promoting long term development planning.

This activity cannot be achieved solely by the Lands division, however, the Ministry of Agriculture has negotiated with the Government of Turkey to conduct an updated assessment of the productive capacity of all lands. The Ministry of Agriculture should therefore ensure that this data be integrated into the national GIS database.

Pasture and Range Management

The problems relating to misuse of hillsides as pasture and rangeland for goats, sheep and cattle, as well as sundry horses and donkeys, will require a major investment of

human resources to educate, promote, monitor, legislate and, when necessary, enforce a major change in the habits of our livestock owners over time.

The problem of uncontrolled grazing on public and private lands can only be solved within the wider context of the whole livestock industry and what is required of it. At present, there is very little direction. There are no targets for meat production or livestock populations. Apart from some general rules of thumb, there is very little specific information on the carrying capacities of different types of pasture. Few studies have been done in Antigua on the effects of different pasture variables, such as location, rainfall, slope, wind speed and grass type on the carrying capacity of pastures, improved or otherwise. The effect of different grasses and grazing systems is also not well known. The length and severity of the dry season is a major determinant of the carrying capacity of a piece of pasture over the course of a year and this can vary drastically, restricting calculations to a matter of probabilities.

If these issues can be satisfactorily addressed, it should be possible to develop a national livestock industry plan. This would provide a basis for a consensus on the pasture and range areas needed for a viable livestock production sector, taking into account the available areas of land most suitable for providing adequate fodder. These can then be factored into a national land use strategy.

Measures to control roaming livestock would also need to be incorporated into the national livestock production plan.

Animal and Plant Control

Invasive species have repeatedly proven themselves to negatively impact on land and land management practices. From the citronella grass which is susceptible to wild fires to the Eurasian rat which was proven in offshore islands to degrade entire landscapes, the impact of species acting out of sync with the ecosystem is obvious.

The situation in Antigua and Barbuda is, however, not limited to invasive species. Recently abandoned animals and resurgent populations have also been making an impact on the quality of ecosystems and productive sectors. Additionally, there is also a health risk to these uncontrolled and unmanaged populations. Currently, the nation is seeking to address invasive giant African snails, resurgent monkeys and iguana which all can impact negatively on local farms and then move on to eventual ecosystem and soil degradation.

Unfortunately, Antigua and Barbuda has few legislative or policy measures to guide uncontrolled species populations and needs to develop such so as to ensure that effective response mechanisms are available when the necessity arises.

Coastal Management

Effective coastal management is also constrained by a multiplicity of agencies and laws that do not provide adequate demarcation of responsibility or authority to manage coastal zones in a sustainable manner. The Watershed and Wetland Management

Committee called for under the EPMA 2015 will only provide recommendation for the effective management of watersheds and wetlands. Although this will support efforts to address issues such as official building set-backs, sand mining and contamination from upstream activities, there will still need to be a direct means of enforcement. Additionally, there are natural events and actions that the Committee will be unlikely to address suggesting an even more substantive approach than policy recommendation.

The OECS is currently seeking to develop an Eastern Caribbean Regional Ocean Policy. This document will assist in bridging the gap where local mechanisms are inadequate. However, A Coastal Zone Management Unit will likely be inevitable.

National Drought Mitigation System

Whereas the 2005 Draft NAP envisaged the setting up of a Drought Management Council to raise awareness of the problems associated with drought and to help increase the nation's preparedness and ability to mitigate the effects of drought episodes, the APUA has opted to implement its Drought Management Plan by utilizing the existing coordinating mechanism provided through the Disaster Committee. This approach by the APUA has its merits as it utilizes an existing and understood mechanism and that droughts being classified as natural hazards can appropriately be handled through that mechanism.

However, the APUA system only takes effect after a meteorological drought has been determined. The Management Plan specifically states, "A level (I) Drought Watch shall be declared by the Authority (APUA) on the advice of the Antigua & Barbuda Meteorological Office that …(a) meteorological phenomena) is occurring … that conditions may moderately impact the country's water supply vs. demand or there has been unusually low rainfall for a period of 3 to 6 months."

Although this is accurate, there is no early warning included in this management system. As a result, residents, stakeholders and any other consumers will not be afforded the option to act until a drought event is already upon them. However, the DMS does utilize multiple mechanisms and media to provide early warning of low levels of precipitation or drought.

The recommendation therefore is to integrate both sets of actions into a National Drought Mitigation System to be guided through the Disaster Management Council. The key activities which would need to be achieved here are:

1) Elaborate a National Drought Mitigation Strategy
2) Improve delivery mechanism for early warning to key stakeholders and groups
3) Assist stakeholders in developing appropriate actions for drought in the corresponding stages: (i) preparation, (ii)early warning, (iii) level 1, (iv) level 2, (v) level 3
4) Public awareness

Operational Objective 3: Science, technology and knowledge

To become a global authority on scientific and technical knowledge pertaining to desertification/land degradation and mitigation of the effects of drought

Outcome 3.1: National monitoring and vulnerability assessment on biophysical and socio-economic trends in affected countries are supported.

Outcome 3.2: A baseline based on the most robust data available on biophysical and socio-economic trends is developed and relevant scientific approaches are gradually harmonized.

Outcome 3.3: Knowledge on biophysical and socio-economic factors and on their interactions in affected areas is improved to enable better decision-making.

Outcome 3.4: Knowledge of the interactions between climate change adaptation, drought mitigation and restoration of degraded land in affected areas is improved to develop tools to assist decision-making.

Outcome 3.5: Effective knowledge-sharing systems, including traditional knowledge, are in place at the global, regional, sub-[regional and national levels to support policymakers and end users, including through the identification and sharing of best practices and success stories.

Although there has been significant improvement in drought monitoring, reporting and management, since the 2005 Draft NAP, coupled with an overall improvement of meteorological reporting, other issues under land degradation and desertification have not been as fortunate. It was recognized that there was a glaring lack of real-time data and technical information relating to many aspects of land degradation. If the management of land degradation is to be significantly improved, it will be necessary to expand the geographical coverage and to increase the types of data collected. It will also be necessary to analyze this data and to prepare reports that can provide useful guidance to crop and livestock farmers, horticulturalists, agricultural marketing persons and others. It should include:

Data on Water Resources:

Reporting on precipitation has been the most improved with regard to meteorological data. However, it is noted that there still remains only one rain gauge reported for Barbuda. Ensuring a comprehensive suite of meteorological data is therefore a key area which needs to be developed.

There also needs to be greater reporting on the status of water storage facilities such as reservoirs, well and dams. It should be noted that the Water Division of APUA only monitors the water facilities it uses, therefore a system of monitoring and reporting of other water resources needs to be established to feed into the national GIS database. It has been reported that APUA has no rainfall collection system, so is not able to monitor potential surface catchment inflows. Rainfall intensity is not measured at any station except at the CARDI Field Station. Again, these records do not feed into any central system. Pan evaporation is also not measured anywhere except at the CARDI field station. Soil moisture levels are not measured at any of these stations or even at the agricultural stations.

The plan recommends that additional meteorological data should be collected by the establishment of additional stations to form a comprehensive network of sites including important watersheds and that the feasibility of using automatic solar powered stations should be examined to reduce costs and increase reliability and ease of data collection and handling. Evapotranspiration, wind speed and soil moisture data need to be collected at a few, well chosen, representative locations to provide additional data for agricultural and drought monitoring purposes.

Hydrological information:

The situation with respect to information on surface and ground water supply is that very little information is publicly available. The Water Division of APUA collects limited data on reservoir levels and extrapolates available volumes and may record drawdown levels in some of the wells it operates. Generally, the salinity of water extracted and absence of bacterial contamination are the major concerns of the authority. It does not make public this information so it can not currently be used to provide information on the extent of depletion of groundwater resources in the event of a drought situation. This information would be useful in determining particular stages of a drought event. The plan will recommend the regular monitoring of and inclusion into the national database the status of the surface and ground water status as part of its drought monitoring function.

Barbuda

Barbuda constitutes approximately 30% of the nation's land mass but represent less than 5% of the total population. This disparity of human and by extension technical resources has resulted in data collection and analysis specific to Barbuda remaining a key weakness in the national system. The BRC offers an opportunity for improved data collection however a memoranda of understanding addressing issues of capacity building, data collection and data sharing would have to be pursued so as to make them able and responsible for gathering, reporting and sharing the data.

Geographical Information Systems (GIS) capability:

Monitoring and reporting on the status of land degradation effectively requires the use of geographical information system technology and hardware. GIS enables the handling of spatial information (maps) and location specific data, such as details of soil

status in a particular parcel of land, in a digitized system that can be used to store and process large amounts of information accurately and with great flexibility. Maps of a variety of features and with specific data attached to particular objects on the map can be easily constructed once the information is available in digitized form. Relationships between various spatial parameters can be investigated and demarcation of areas with specific combinations of characteristics can be easily identified and displayed. It is therefore a very important tool for management of land and for identifying trends not so easily observable on the ground or from tables of data.

There is significant capability for using GIS technology residing in the various agencies that may have responsibilities for managing land degradation. The systems are not integrated and much of the basic data required is not yet in digitized form, or is absent altogether. Some aspects of the data which is needed have been mentioned already. The effective management of land degradation will require a more fully integrated and functional GIS capability within the major agencies with responsibility for land degradation. The NAP will recommend some measures that can be taken to establish such a capability at minimum cost and taking into account current equipment and human resource skills that are already available.

Specific actions for upgrading the national GIS database were identified under the GCCA/OECS SLM-CCA project:

- A full transfer to a digital environment based on the systematic land registration done between 1976 and 1980, keeping paper records only for archival purposes. Filling the technology gap therefore is inextricably linked to filling the staffing gap.
- Conduct an inventory of the relevant tools and technologies required for upgrading the technological capacity of Antigua to facilitate the development of funding proposals;
- Develop national standards, policies and protocols for electronic data collection, storage, sharing and purchase of software and licences;
- Develop a list of hardware and software to be acquired to update and link all land and climate related data and information in the various Departments into standardized GIS-based formats that help agencies to organise their data to allow real time and quick electronic access by all the agencies involved in land management and administration together with the establishment of a data storage and business continuity system.
- Update the natural hazards map in relation to land settlements;

Promotion of Academic Research

The EPMA makes provision for environmental research and training. This can partly be accomplished by getting the Environment Department accredited as a research institution, providing internships, research support and supervision for university students and other researchers.

Desalination

The nation's most recent drought (which began in 2013 and has been ongoing through the elaboration of this NAP) has forced the Government to invest in desalination so that it can be relied upon to meet all the potable water resource needs. This however is done with the knowledge that it is the most expensive and preferably the 'last resort' option. However, this is being pursued for potable water meaning that due to the uncertainty of the availability of the natural water supply it is being ignored as the low cost option most available to support agrarian communities and other sustainable livelihoods. To increase reliance on desalination to meet industrial and agricultural needs has long been considered economically very unfavourable, particularly as energy prices, of which Antigua and Barbuda is heavily reliant on fossil fuels, are unstable.

It should also be noted that by increasing the ability of desalination to support 100% of potable water demand can allow the natural systems the opportunity to recharge when the current and future droughts abate.

Repairing Municipal Catchment Systems

Although the GOAB has made the decision to increase installed desalination capacity, desalination will remain an energy intensive option. Additionally, desalination plants have a life span far less that properly managed reservoirs. It should therefore be considered that while desalination will ease pressures on rain-fed systems, allowing those system to recharge and ensuring that they are fully functional will mean less expense and better water management in the future.

Community Reservoirs

The Public Utilities Act of 1973 not only gives the APUA the authority to distribute and sell potable water but it also gives the Authority the exclusive right, through the responsible Minister, to declare the corresponding catchment areas for protection and prepare regulations toward their management.

However, this leaves the remaining reservoirs, dams, wells, ponds and seasonal streams which exist on Antigua and Barbuda in need of a clear management system. Prior to 2005, the Ministry of Agriculture housed a Soil and Water Conservation Unit which provided the technical oversight for those features (particularly if they were utilized by agricultural holdings). Unfortunately, the Soil and Water Conservation Unit is currently no longer in operation and as a result this source of technical and financial support is no longer available.

The unavailability of water has been so stressful in recent years that a number of communities have seen fit to ensure the availability of community reservoirs to reduce the vulnerability to drought episodes. However establishing functioning community reservoirs only addresses one aspect of the problem since improperly managed watershed areas which feed into said reservoirs can result in their contamination, disrepair and eventual destruction.

The move to establish functioning community reservoirs should be encouraged as it will achieve several cross-sectoral benefits.

- Community reservoirs will provide greater control to local communities to support sustainable livelihoods;
- Water from community reservoirs is less energy intensive to harvest than desalinated water thereby having the potential as a climate change mitigation action.
- Community reservoirs offer cheaper source of water than desalination.
- Communities which participate in active reservoir management will have greater appreciation of drought and land degradation issues.

Operational Objective 4: Capacity-building

To identify and address capacity-building needs to prevent and reverse desertification/land degradation and mitigate the effects of drought.

Outcome 4.1: Countries which have carried out the national capacity self-assessment (NCSA) implement the resulting action plans to develop the necessary capacity at the individual, institutional and systemic levels to tackle desertification/land degradation and drought issues at the national and local levels.

Outcome 4.2: Those countries which have not previously undertaken capacity needs assessments engage in relevant assessments processes to identify capacity needs for tackling desertification/land degradation and drought at the national and local levels.

One of the most important and varied areas which needs to be addressed in improving Antigua and Barbuda's ability to effectively address DLDD is to achieve capacity building. This will include specific agency upgrades as well as the revising of multisector programmes and approaches. In some cases, capacity building can require the reorganization or establishment of entire units or agencies.

Reconvening of the National Coordinating Mechanism

One of the key provisions of the EMPA, is the convening of a multi-stakeholder consultative body to guide the management and implementation of multilateral environmental agreements as well as settle any environment related disputes that may from time to time be referred to them.

This Committee, titled the National Coordinating Mechanism (NCM) for The Implementation of Multilateral Environment Agreements (MEAs) shall comprise:

(a) four members appointed by Cabinet one of which shall be a representative of the Ministry of Foreign Affairs who shall chair the Committee and of the remaining three at least one of whom shall be from a non-Governmental organisation with expertise in environment matters and one of whom shall be from the business community;
(b) the Director of the Environment Department, who shall be the Secretary to the Committee;
(c) five other members of the Committee, appointed from the public service, who have expertise in health, fisheries, agriculture, forestry and public works; and
(d) a representative of the Public Utilities Authority.

The Cabinet of Antigua and Barbuda initially convened the NCM in 1999, in an effort to encourage a participatory process towards sustainable development. The Environment Division was made the secretariat of the NCM as it already served as is the National Focal Point for the majority of MEAs. The Ministry of Foreign Affairs, as Political Focal Point, chairs the NCM. Other line ministries, departments, agencies and NGOs which have sector specific authority or interest may also be serving as Operational Focal Point or equivalent designation and hence also sat at the coordinating table.

As a small island developing state, Antigua and Barbuda has limited resources to support robust delegations to participate in international conferences. It is therefore imperative that concerned agencies and key stakeholders coordinate not only to ensure effective representation but to develop negotiating positions that balance the needs of all national stakeholders.

Upgrading of the DCA

With the endorsement and approval of the SIRMZP by the parliament of Antigua and Barbuda, the next step is to ensure the ability of the DCA to prepare and enforce local area plans. The SIRMZP has already indicated the required restructuring and technical assistance needs which is provided below.

Technical assistance needed to upgrade the DCA include:

- one medium format printer 13x19 inch
- two (2) regular printers
- one (1) server with Xeon processor coupled with wiring for networking
- one (1) graphics computer with large monitor 19 or 21 inches
- ten (10) desktop computer systems
- broad-band internet system to facilitate and integrate national GIS database
- five (5) auxiliary power sources
- AutoCAD software license

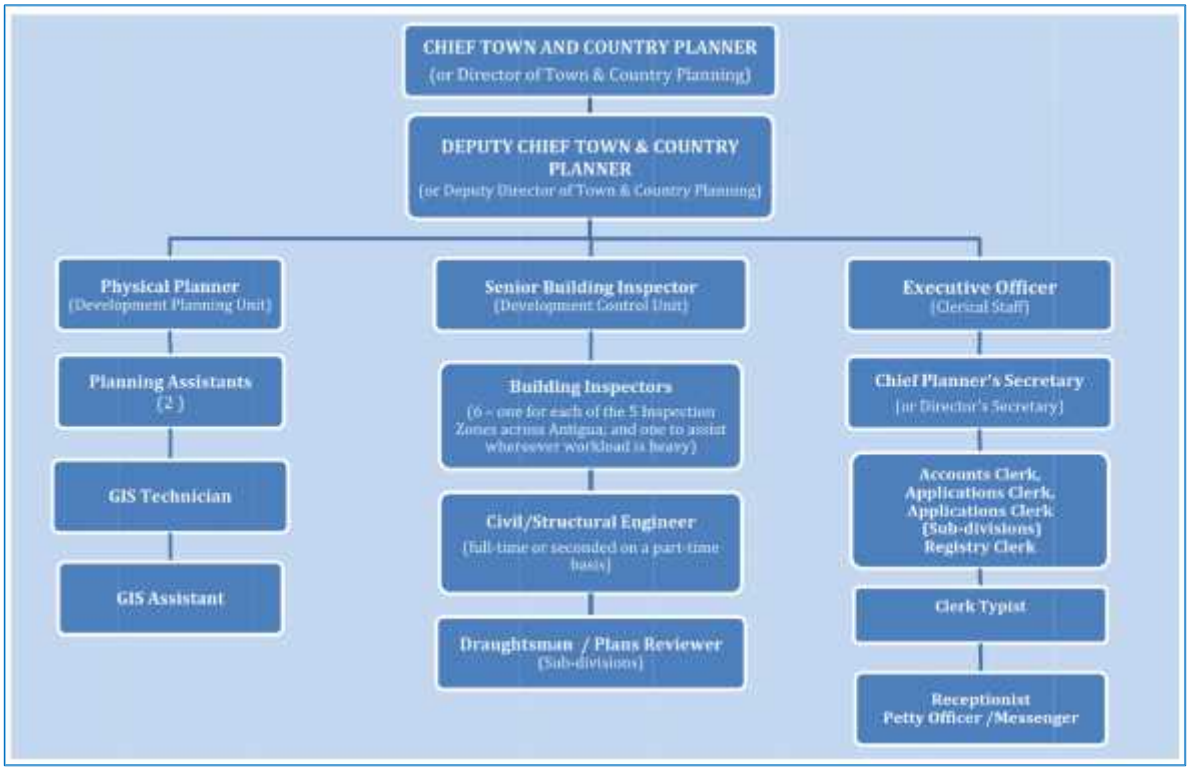


Figure 22 Propose Organisational Structure for the DCA[31]

Capacity Assessment of the Department of Meteorological Services

The DMS does not have its own governing legislation. As such, although a number of agencies like the National Office of Disaster Services, Antigua Public Utilities Authority, and the Environment Division as well as sectors, like agriculture and fishing all rely heavily on the services that the DMS provides, technically, it only has one official purpose; to support aviation.

The DMS need a full capacity assessment to be conducted to ensure that the policy expectations and functions can be properly defined and then ensure that the appropriate staffing and infrastructure are identified.

Establishment of the Watershed and Wetland Management Committee

The EPMA 2015, calls for the establishment of a Watersheds and wetlands committee under section 45 (1)-(3). This body is to be comprised of representatives from the following agencies:

a. Director of Agriculture,

[31] GENIVAR (2012) Sustainable Island Resource Management Zoning Plan

b. forest officer,

c. fisheries officer,

d. APUA,

e. Lands Division,

f. Pesticide Board; and

g. Any others as deemed relevant (by Director and Minister of Environment)

Reviving the Soil and Water Conservation Unit

With the core duties of the Watersheds and Wetlands Committee to make recommendations on adoption and implementation of watershed and wetlands management plans it is also recommended that the Soil and Water Conservation Unit, which used to provide technical assistance to the management of watersheds and reservoirs be revitalized, repurposed and repositioned within the Environment Department so as to ensure that there is an identifiable human resource to implement and enforce the plans of the committee. However as Antigua and Barbuda has changed over the last 50 years from a majority agrarian to a service oriented economy, the reconstituted Soil And Water Unit should not be limited to agricultural support but should be focused on all watersheds and their uses.

Establishment of a Coastal Zone Management Unit

As a long term goal, the GOAB needs to invest into the establishment of a Coastal Zone Management Unit. Just as it is recommended that the Soil and Water Conservation Unit be reconstituted to ensure the effective implementation of the watershed plans proposed by the committee, a Coastal Zone Management Unit will be responsible for providing the technical and enforcement support for wetland and other coastal plans.

Operational Objective 5: Financing and technology transfer

To mobilize and improve the targeting and coordination of national, bilateral and multilateral financial and technological resources in order to increase their impact and effectiveness.

Outcome 5.1: Affected country Parties develop integrated investment frameworks for leveraging national, bilateral and multilateral resources with a view to increasing the effectiveness and impact of interventions.

Outcome 5.2: Developed country Parties provide substantial, adequate, timely and predictable financial resources to support domestic initiatives to reverse and prevent desertification/land degradation and mitigate the effects of drought.

Outcome 5.3: Parties increase their efforts to mobilize financial resources from international financial institutions, facilities and funds, including the GEF, by promoting the UNCCD/Sustainable land management (SLM) agenda within the governing bodies of these institutions.

Outcome 5.4: Innovative sources of finance and financing mechanisms are identified to combat desertification/land degradation and mitigate the effects of drought, including from the private sector, market-based mechanisms, trade, foundations and CSOs, and other financing mechanisms for climate change adaptation and mitigation, biodiversity conservation and sustainable use and for hunger and poverty reduction.

Outcome 5.5: Access to technology by affected country Parties is facilitated through adequate financing, effective economic and policy incentives and technical support, notably within the framework of South-South and North-South cooperation.

In conformity with the United Nations Convention to Combat Desertification, countries in the Latin America and Caribbean Grouping are individually and jointly obligated to adopt measures to strengthen mechanisms to supply funds through public and private investments to achieve results in combating desertification and mitigating the effects of drought. Desertification along with climate change and the loss of biodiversity were identified as the greatest challenges to sustainable development during the 1992 Rio Earth Summit. Antigua and Barbuda is obligated to maintain and restore land and soil productivity and develop mitigation strategies for drought and climate change.

Sustainable Island Resource Framework Fund (SIRF Fund)

The Sustainable Island Resource Framework Fund (SIRF Fund) is a national fund established by the passing of the Environmental Protection and Management Act under section 84. The SIRF Fund is an output of the first GEF Full-sized national-scale project in Antigua and Barbuda, the Sustainable Island Resource Management Mechanism and its components. It was created in response to the lack of funding made available to finance adaptation and mitigation to drought and to the improvement of management of watershed areas.

The Fund was established to finance activities and projects intended to protect and manage the environment; programmes for the establishment or management of wetlands and watersheds; for adaptation and mitigation of climate change and necessary expenses incurred in the negotiation, monitoring or audit of any code of environmental practice. The SIRF Fund, in essence, would fund the work that the legislation governs and provide non-governmental organizations (NGOs) and the private sector with the means necessary to implement the legislation. The SIRF Fund is a

revolving fund meaning that the money will remain available to finance continuing operations by organizations without any fiscal year limitation.

Access to the Adaptation Fund

The GOAB realizes that a key factor in attracting and maintaining the levels of funding required for this mechanism is the strong adherence to meeting international fiduciary standards. In August 2015, the Environment Division completed the first step in this process when it became the OECS's first internationally accredited agency to the Adaptation Fund. This will allow Antigua and Barbuda to secure up to USD$10 million dollars to be placed in the SIRF Fund. Funding would also come from revenues from protected areas and ecotourism user fees. The Fund will be able to own assets, negotiate Debt for Nature swaps and will reforest watersheds to assist with water production and dam construction and protection.

National Allocation

The Government of Antigua and Barbuda has pledged to develop the country in an environmentally sustainable manner where the rule of law is paramount, social justice is achieved, and the nation state becomes the economic powerhouse of the region and in doing so has allocated EC$74,116,668 (US $27,450,618) to the Ministry of Health and the Environment for the fiscal year.

Technology Transfer

The most important aspect of technology transfer for Antigua and Barbuda to address DLDD issues is through the ability to improve the amount and quality of data. There are two types of technology which will assist the national system greatly. Firstly will be the acquiring of at least two aerial drones which will not only save time in monitoring but will provide data where satellite images have left gaps. The second technology would be remote weather stations. As was pointed out earlier there is only one data point for weather in Barbuda and if a more detailed description and assessment is desired at least three more points are required.

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Annex 1: Hydro-Geological Baseline Data Capacity[32]

	Available in map form							% of coverage	Source	Available but not in map form
	Hardcopy		Digital							
	Scale	Year	Scale[33]	Year (created and last update)	Rate of update (Daily, Monthly, Yearly)	Format (CAD, GIS)	Has Database Attributes (if yes, specify the DB)			
Administrative Boundaries Data										
Coastline	5K, 25K & 50K		1:50,000 [34]	Created 1970, updated 2004		GIS	Attribute table *Errors in data	100%	Environment Division	
Parishes/Districts			1:50,000	1970		GIS	Attribute table *Errors in data	100%	Environment Division	
Geographic Place Names	1:50,000	Last updated 1980							NODS	
Community boundaries										No
Natural Resources Related Data										
Geology			Unknown	2010		GIS	Attribute table *Errors in data	Antigua only	Environment Division	
Elevation contours			1:125,000[35]	1970		GIS	Attribute table *Errors in data	70%	Environment Division	

[32] OECS (2014) Comprehensive gap analysis to assess the OECS's secretariat and member states status in terms of land management institutional, technical and human capacity, "Data Collection Tool for Gap Analysis in Sustainable Land Management in the OECS MS and Secretariat"

[33] Interpreted as referring to "Scale of source" for GIS data. Scales from Surveys Division cadastral maps are in three scales: 1 : 1,250 and 1 : 2,500 and 1 : 5,000

[34] The Devine coastline (2010) was mapped from the LandFolio 2004 aerial images (approx. 1 pixel /m Can be used for drawing vector objects at about 1:1000 before pixcellation

[35] Uncertainty of source 1:25K DOSmaps (2 for ANU and 2 for BBQ - that has the lower elevations at 25ft intervals then 100 ft.

	Available in map form							% of coverage	Source	Available but not in map form
	Hardcopy		Digital							
	Scale	Year	Scale[33]	Year (created and last update)	Rate of update (Daily, Monthly, Yearly)	Format (CAD, GIS)	Has Database Attributes (if yes, specify the DB)			
Elevation points[36]				1978	Last updated 2010	GIS, CAD	Attribute table	50%	Surveys Division	
Digital Elevation Model			1:50,000	1970		GIS	Attribute table *Errors in data	Antigua only	Environment Division	
Soils	UWI – scale unknown	1966		1992		GIS	Map was digitized but does not fit other layers properly	Antigua only	Organization of American States (OAS)	
Rivers/Streams/Watercourses	1:10,000	1960	1:50,000	Created 1970, updated 2004		GIS	Attribute table *Sig. errors in data	90%	Environment Division	
Water bodies: Lakes/Lagoons	1:10,000	1960		2004		GIS	Attribute table *Errors in data	90%	Environment Division	
Roads – Major and minor				2010	Lands & Surveys is in the process of updating	GIS	Attribute table *Errors in data	90% of Antigua, none for Barbuda	Environment Division, Lands & Surveys	
Land Cover Map				2010		GIS	Attribute table *Errors in data	75%	Environment Division	
Rainfall data									Antigua & Barbuda Meteorological Services	Available not as maps
Locations of Rain Gauges									Antigua & Barbuda Meteorological Services	Available not as maps

[36] Many trigonometrical stations have been destroyed – grid coordinates, few have heights on them

	Available in map form							% of coverage	Source	Available but not in map form
	Hardcopy		Digital							
	Scale	Year	Scale[33]	Year (created and last update)	Rate of update (Daily, Monthly, Yearly)	Format (CAD, GIS)	Has Database Attributes (if yes, specify the DB)			
Beaches		1970 Tourism cadastral maps (L&S)[37]		1999 2010		GIS	Attribute table *Errors in data	10%	Environment Division	
Environmentally Sensitive Sites	1:40,000	2012		2012		GIS	Attribute table		Environment Division	
Wind direction data									Antigua & Barbuda Meteorological Services	Available not as maps

[37] Land and Surveys Division

Anthropogenic Related Data										
Buildings				2004		GIS	Attribute table	90%	Land & Surveys Division	
Census Layers									Statistics Division	Available not as maps
Political Districts				2007 (current)		GIS	Attribute table		Statistics Division	
Government Buildings									Public Works	Available not as maps
Recreational /Tourist Facilities				2011		GIS	Attribute table *Errors in data	50%	Environment Division	
Educational Facilities				2011		GIS	Attribute table *Errors in data	95%	Environment Division/NODS [38]	
Health Facilities				2011		GIS	Attribute table *Errors in data	90%	NODS	
Land Use				2010		GIS	Attribute table *Errors in data	80%	Environment Division	
Airports/airfields/airfields/runways				2011		GIS	Attribute table	100%	Environment Division	
Banks and Financial Centres									Financial Services Regulatory Commission	Available not as maps
Waste management sites	1:5,000	Unknown		2011		GIS	Attribute table *Errors in data	Only Cooks landfill is mapped	Environment Division	
Dams and Ponds				2011		GIS	Attribute table *Errors in data	85%	Environment Division	

[38] National Office of Disaster Services (NODS)

Electrical generating plants				Last updated 2012		GIS	Attribute table	100%	APUA	
Water tanks / reservoirs				1997	Updated based on consultancies	GIS	Attribute table *Errors in data	70% St. John's has not been mapped[39]	APUA	
Police stations				2011		GIS	Attribute table	90% of Antigua only	Environment Division	
Fire stations				2011		GIS	Attribute table	90% of Antigua only	Environment Division	
Prisons										No
Population centers				2011		GIS	Attribute table *Errors in data	75% of Antigua only	Statistics Division	
Seaports				2011		GIS	Attribute table *Errors in data	100%	Environment Division	
Electricity lines				1997[40]		GIS	Attribute table *Errors in data	100% but still need ground-truthing	APUA	
Water supply lines				2000		CAD	Attribute table *Errors in data	80% but still need ground-truthing	APUA	APUA would like more support
Emergency operations facilities[41]										No
Emergency Shelters				Created 2010, updated 2013	Updated annually	GIS	Attribute table	100%	NODS	
Place of worship										No

[39] Only 20% of this data has been ground-truthed
[40] 1997 was when APUA got its GIS system
[41] There is only one emergency operations facility – the National Office of Disaster Services.

Markets and shopping Centres										No
Historic /Archeological sites				2010		GIS	Attribute table *Errors in data	80%	Environment Division, National Parks	

Hazard-related Data										
Flood Hazard Zones				1999 (PGDM)[42]		GIS	Attribute table *Errors in data	90%	Environment Division, NODS	
Flood incident inventory									NODS	Available not as maps
Landslide hazard zones				1999 (PGDM)		GIS	Attribute table *Errors in data	90%	Environment Division, NODS	
Landslide incident inventory									NODS	Available not as maps
Erosion hazard map				1999 (PGDM)		GIS	Attribute table *Errors in data	90%	Environment Division, NODS	
Earthquake epicentres									UWI Seismic Research Center	
Geological Fault lines									UWI Seismic Research Center	
Volcanic centres									UWI Seismic Research Center	
Hurricane tracks									Antigua & Barbuda Meteorological Services	
Storm surge				1999 (PGDM)		GIS	Attribute table *Errors in data	90%	Environment Division, NODS	
Tsunami inundation zones				2010		GIS		Antigua only	Environment Division, NODS	
Tsunami Evacuation Zones										No
Tsunami Wave Heights										No
Building Damage History									Public Works	
Infrastructure Damage History									Public Works	

[42] Post-Georges Disaster Mitigation

Remotely Collected Data										
Aerial Photos				Created 2004, updated 2010		GIS GIS		Antigua only	Environment Division, Lands & Surveys Div	
Satellite Imageries				2000		GIS		Antigua only	Environment Division, APUA	
LiDAR										No