CDERA
The Caribbean Disaster Emergency Response Agency
Managing Disasters with Preparedness

Japan International Cooperation Agency

Agence canadienne de développement international
Canadian International Development Agency

Organization of American States

STATUS OF HAZARD MAPS VULNERABILITY ASSESSMENTS AND DIGITAL MAPS

ANTIGUA & BARBUDA COUNTRY REPORT

THE CARIBBEAN DISASTER EMERGENCY RESPONSE AGENCY (CDERA)

October 2003

Table of Contents

Preface

From 2002 – 2005, the Caribbean Disaster Emergency Response Agency (CDERA) is implementing two major regional initiatives which are designed to reduce vulnerability to natural and technological hazards. These are the Japanese International Cooperation Agency (JICA) supported Caribbean Disaster Management (CADM) Project and the Canadian International Development Agency (CIDA) supported and Organization of American States executed Caribbean Hazard Mitigation Capacity Building Programme (CHAMP). The hazard mitigation planning component of the latter is being implemented in close collaboration with the Caribbean Development Bank's Disaster Mitigation Facility for the Caribbean. Hazard maps, vulnerability assessment studies, and digital maps are critical inputs to both initiatives.

This survey reviewed the status of these thematic activities in sixteen (16) CDERA Participating States, Haiti, Martinique, Suriname and Puerto Rico over the period August – October 2003. The objectives of the Survey were as follows:

1. To determine the status of hazard maps and vulnerability assessment studies and their use in the socio-economic planning and management of the Caribbean.
2. To determine critical success factors, gaps and best practices in the preparation and use of hazard maps and vulnerability assessment studies in the Caribbean.
3. To compile a database of hazard maps, vulnerability assessment reports, and digital maps available in the Caribbean.

Hazards considered under the survey included natural hazards such as floods, hurricanes, landslides, coastal disasters (surge, wave, and erosion), earthquakes, and volcanic eruptions as well as technological hazards. The types of vulnerability assessment considered were structural, economic, and human assessments.

This report was prepared by Jacob Opadeyi, Shahiba Ali, and Eva Chin of the Centre for Geospatial Studies, Faculty of Engineering, The University of the West Indies, St. Augustine, Trinidad and Tobago.

Status of Hazard Map, Vulnerability Assessments and Digital Maps in the Caribbean: Antigua and Barbuda

1.0 Introduction

1.1 Physical and socio-economic background

Antigua is the largest of the Leeward Islands with an area of 280 sq. km. It differs from neighbouring islands in that it does not have a mountainous landscape and lush green vegetation. The island is relatively flat with approximately 70% of the island less than 30m above sea level. The coastline is undulating and characterized by bays and rocky headlands. The island is surrounded by a number of coral reefs.

Antigua contains both volcanic and limestone geological formations and can be divided into three topographic regions each of which comprises approximately one-third of the island's area. The volcanic region is hilly and rises to 402m in the southwest at Boggy Peak. The central plain separates the volcanic and limestone regions and consists of gently rolling hills. The limestone region includes the northern and eastern third of Antigua.

The population was 59,355 in 1991. During the period 1960 to 1991, the population of Antigua grew at a low rate of 0.6% per year. Before the 1970's the birth rates were relatively high and this resulted in a high proportion of the 1991 population being of working age. 60% of the population is concentrated in and around the capital city of St. John's and along All Saints Road which connects St. John's to Falmouth. Most of the other population is distributed in small villages strung out along roads.

A central feature of the economic development of Antigua is its transformation over the last two decades from an agricultural to a service economy. Agriculture has declined in relative importance and in 1994 agriculture accounted for only 4% of GDP compared with 20% in 1960. The service, construction and transportation sectors have increased their share of GDP because of "spin-off" from expansion in the tourism sector, which is one of the major sectors in the economy. Construction of residential and commercial buildings has also contributed to economic development.

1.2 Major disaster issues confronting the country

Antigua is at risk from damage caused by hurricanes, earthquakes, volcanic eruptions, drought and man-made disasters. Given the small size of its population and land area, its capacity to absorb and recover from the physical, economic and financial losses sustained during hazard events is low.

Homes, hotel facilities and other physical infrastructure in coastal locations are particularly vulnerable to hurricanes and its associated storm surge. In the past 10 years, the country has been affected by five major hurricanes that caused extensive damage to the environment, physical infrastructure, homes, tourism facilities and the economy. These included hurricanes Hugo in 1989, Luis in 1995, Georges in 1998 and Jose and Lenny in 1999. Earlier hurricanes also caused severe damage in 1928 and 1960.

The effects of seismic activity have been less severe and the last major earthquake experienced in Antigua was in 1974. No volcanic activity has occurred in Antigua. However, volcanic eruptions on neighbouring Montserrat produce ash clouds over Antigua. Despite the low incidence of volcanic and seismic activity, the island is located in an active seismic zone and it is at risk from such hazards.

Severe drought affected the islands between 1964 and 1968 and in 1983-84. Ivor Jackson Associates[1] indicates that drought is a recurrent feature of Antigua's climate. It occurs when there is an extended period of deficiency in precipitation. The trigger for Antigua appears to be the occurrence of less than 30.74 inches per year or 80% of the annual rainfall. Between 1960 and 2000 there were eight years in which these conditions were experienced. The most severe drought occurred during the 1983-84 period. During this period damage to crops and death of livestock resulted in major income losses to farmers. The population was without pipe-borne water for months and the country had to resort to importing water from Dominica. Largely as a result of this, water desalination plants were developed and they now supply 62% of Antigua's water requirements. Although the population is less vulnerable to drought, agriculture remains very vulnerable because of its heavy reliance on rainfall for irrigation.

2.0 Hazard Mapping Initiatives

Antigua has had one major hazard mapping initiative conducted as part of the Post Georges Disaster Mitigation (PGDM) Project. The PGDM project produced categorized hazard zone maps for wind, waves, storm surge, coastal erosion, inland erosion, flooding and drought.

The goal of the PGDM project was to reduce the vulnerability of population, economic activities and resources to natural hazard through enhanced capacity for hazard mitigation. The project was developed as a response to Hurricane Georges. The United States Agency for International Development-Jamaica/Caribbean Regional Program (USAID-J/CAR), established a program entitled Hurricane Georges Reconstruction and Recovery and the Organization

[1] Jackson, I. 2001. Antigua and Barbuda Drought Assessment Mapping Summary Report. Organization of American States, Unit of Sustainable Development and Environment, Washington DC. http://www.oas.org/pgdm

of American States' Unit for Sustainable Development and Environment (OAS/USDE), implemented the disaster mitigation capacity building component for USAID-J/CAR, under the PGDM project. The project extended from January 2000 to July 2001.

Table 1 summarises the hazard maps that exist for the island of Antigua. The maps were produced from the 1:50,000 map base dated 1970. All the hazard maps, with the exception of coastal erosion, cover the entire island. The coastal erosion map dealt with beach erosion on specific beaches monitored by the Fisheries Department. The base map datum is UNHO Astro 1943 Clarke 1880 modified and the projection is Transverse Mercator British West Indies.

Table 1 – Hazard Mapping

Type	Purpose	Coverage	Date Produced	Primary Sources	Author
Wind	Hazard mitigation plan development	Entire island	2001	National office of Disaster Services	OAS (USDE)
Waves	Hazard mitigation plan development	Entire island			
Storm surge	Hazard mitigation plan development	Entire island			
Coastal erosion	Hazard mitigation plan development	Monitored beaches			
Inland erosion	Hazard mitigation plan development	Entire island			
Flooding	Hazard mitigation plan development	Entire island			
Drought	Hazard mitigation plan development	Entire island			

2.1 Methods of preparation and distribution

The PGDM project provided consultants for each of the hazards and geographic information system (GIS) to improve the capacity of the Government of Antigua. Base maps were digitized by the Development Control Agency (DCA). The hazard specialists prepared digital maps for each of the hazards, which were then integrated into a GIS by the GIS consultant. Specific details for the preparation of each hazard map can be accessed in the OAS consultant reports on PGDM web site www.oas.org/pgdm.

Wind, storm surge and waves are caused by hurricane and tropical storm activity and are closely related. The Arbiter of Storms (TAOS) model was used to generate a series of hazard maps for wind, storm surge and waves by return period. The maps were prepared for 10, 25, 50 and 100 year return periods at a cost of approximately US$11,500 for Antigua.[2]

Table 2 provides the categories used for the wind, surge, and wave hazard maps.

Table 2: Categories used for the wind, surge, and wave hazard maps

Hazard level	Description	Wind speed in metres/sec		Surge height in metres		Wave height in metres	
		Lower bound	*Upper bound*	*Lower bound*	*Upper bound*	*Lower bound*	*Upper bound*
0	None	0	17	0.0	0.1	0.0	0.1
1	Low	17	43	0.1	0.5	0.1	1.0
2	Moderate	43	50	0.5	1.5	1.0	1.5
3	High	50	59	1.5	3.0	1.5	2.0
4	Very high	59	100	3.0	100.0	2.0	100.0

The identification of flood hazard zones considered factors such as slopes, drainage, the ratio of watershed area to flood plain, run-off rates and potential. The Hurricane Lenny rainfall event (1999) was used as the basis for classification of flooding. The flood hazard map cost approximately US$12,000.

Inland erosion examined sheet and rill erosion, gullying and landslides. Simple empirical models were used to produce hazard scores for each land unit. Each unit was defined on the basis of geology, soils and environmental factors. The models integrated the estimated effects of the elements and produced a score, which represents the likelihood of the hazard at the unit. Composite maps for

[2] Costs of hazard maps were estimated by apportioning the cost of the relevant consultancy to each island for which the map was prepared.

combined hazards were produced. The approximate cost of map production was US $6,300.

Coastal erosion considered only those beaches that are monitored by The Fisheries Division of Antigua. Beach change was based on data collected over an 8-year period in Antigua and the Coastal and Beach Stability in the Lesser Antilles(COSALC) model was used. The map cost approximately US $2,600 to produce.

The drought hazard map considered the factors of rainfall, wind, marine influence, soil type, slope, vegetation, water supply and land use. Criteria were applied to each of these factors and the data integrated to produce the final map. The map was produced at a cost of approximately US$6,500.

All hazard maps exist in ArcView shapefile digital format. Maps are available on the PGDM web site for free download www.oas.org/pgdm. The government of Antigua has adopted the policy of providing the maps free of charge on the condition that that they will not be used for monetary gain.

2.2 Users and uses

The hurricane related hazard maps of wind, storm surge and waves are the most heavily used maps. They are used by the National Office of Disaster Services (NODS), Antigua Power and Utility Agency (APUA), Banks, Insurance agencies, the Health Ministry, Public Works, Police and Military. Their primary uses are to identify vulnerable facilities and provide warnings for hurricanes. They are also being used to review insurance premiums and as an input to Environmental Impact Assessments required for CDB loans.

The Ministry of Agriculture, Tourism, APUA and the Meteorological Office use the drought map. It is used to identify areas at risk and is currently informing the review of agricultural policy. The Ministry of Agriculture also uses the inland erosion map for site-specific analysis of landslide potential. One example of this is its use in the Crabbs Hill area. The flood hazard map is used by DCA and Public Works for development planning and infrastructure development. The coastal erosion map is also used by DCA for development planning and the Environmental Division as an input to the revision of environmental laws.

2.3 Current condition and limitations

None of the hazard maps have been updated and there are no immediate plans to do so. The preparation of several hazard maps suffered from a lack of current digital data. The absence of settlement data, a current road network, current land use, limited elevation data and rainfall data were some of the data issues indicated. There is a need for a more extensive system of rain gauges in Antigua to provide additional rainfall data. The coarse contour intervals and limited data on flood heights were indicated as a limitation to the production of the flood hazard map. Variations in georeferencing accuracy between input data layers affected the quality of the inland erosion product. These data issues impacted on the models used and quality of the results. The models used to predict flooding and beach erosion were forced to make assumptions and use mean values. The length of data collection periods also limited the amount of data available for analysis and the quality of the map produced.

2.4 Critical Success factors

Respondents indicated that the mapping of hazards and vulnerability facilitates dissemination of the hazard information. The composition of the PGDM project team and collaboration with local agencies, especially NODS and DCA contributed to the success of the preparation of the maps.

2.5 Respondents

Formatted: Bullets and Numbering

Two interviews were conducted in Antigua on August 11th 2003. The interviews were with representatives of the National Office of Disaster Services (NODS) and the Environment Division. Personal and contact information is listed below:

a. Philmore Mullin, Deputy Director, National Office of Disaster Services, American Road, Antigua. Telephone: 1-268-562-2144; email: nods@candw.ag

b. Ato Lewis, Environment Officer, Environment Division, Antigua. Telephone: 1-268-462-4625; Fax: 1-268-462-6398; email: environment@antiguabarbuda.net

In addition, information was sourced from the DCA[3], APUA[4] and the Organization of American States (OAS) Unit for Sustainable Development and Environment (USDE)[5], to complete the data required on the hazard mapping and vulnerability assessment studies executed in Antigua.

3.0 Vulnerability Assessment Studies

The PGDM hazard vulnerability project is the only vulnerability assessment conducted for the island of Antigua. It is a structural, economic and human assessment of the impact of hurricanes, coastal/inland erosion, flooding and drought. It specifically assessed the elements of critical facilities and resources. The study was used as an input to the preparation of a disaster mitigation plan. It

[3] DCA contact: Alva Guishard Telephone: 1-268-462-6427
[4] APUA contact: Michael Winters Telephone: 1-268-480-7000 email: danny@apua.ag
[5] OAS/USDE contact; Steven Stichter email: SStichter@oas.org

Deleted: ph

is owned by NODS and was prepared with support from the OAS (USDE) and USAID. The DCA and Environment Division collaborated on the study, which was prepared over the period 2000 to 2001.

3.1 Methods of preparation and distribution

To assess the vulnerability of critical facilities to natural hazards, the priority categories of facilities were identified and mapped. These categories included any facilities that functioned as a shelter; hospitals and clinics; government administrative buildings; airports and seaports; power, water and telecommunication installations; oil and gas companies; protective services and the road network. Using the hazard GIS layers, those facilities that are at the highest risk to each of the mapped natural hazards were identified. For additional details please refer to Antigua and Barbuda Hazard Vulnerability Assessment on PGDM web site www.oas.org/pgdm .

The vulnerability assessment methodology consists of the following steps:

a. Identification and prioritization of hazards.
b. Creation of an inventory of critical facilities.
c. Assessment of each facility in terms of damage history, structural vulnerability and operational vulnerability for each hazard identified.
d. The creation of hazard specific vulnerability zone maps.
e. The locational assessment of facilities within hazard zones.
f. The calculation of a total facility vulnerability score (FVS) for each facility and each hazard.

The vulnerability assessment process is defined by the formula:

$$FVS = (L+V)HPS$$

Where "FVS" is the Facility Vulnerability Score, "L" is the Locational Vulnerability, "V" is the total of the damage history, structural vulnerability and operational vulnerability scores, and "HPS" is the Hazard Priority Score. A priority listing of the hazards were weighted from 1 to 6 to generate a Hazard Priority Score (HPS) as listed Table 3. These are the values utilized in this assessment.

The Vulnerability Assessment process was automated within a GIS environment to allow for the integration and analysis of data with hazard mapping. The system is designed within Microsoft Access ™ and ArcView 3.2™. It consists of a Microsoft Access ™ database and an ArcView 3.2™ project for each island. The Microsoft Access ™ database stores the facility data collected by PGDM Committee and calculates the "V" of each facility for each hazard. A table consisting of the hazard specific "V" scores is linked to each ArcView 3.2™ project. The ArcView 3.2™ project consists of digital maps and linked data tables.

Table 3 – Hazard Priority Scores (HPS)

Hazard	Hazard Priority Score (HPS)
Winds / Hurricanes	6
Drought	5
Storm Surge	4
Floods	3
Coastal Erosion	2
Earthquakes	1

Maps on the following features were integrated into the project to identify the features vulnerable to hazards:

a. Critical facilities
b. Roads
c. Settlements
d. Corals
e. Topography
f. Drainage
g. Land Use / Land Cover

The GIS facilitates the overlay of hazard maps on the location of features and critical facilities. Visual interpretation determines which features are located in the various hazard zones categorized as very low, low, moderate, high and very high. Spatial and tabular manipulations in the GIS identify facilities in each hazard zone and calculate the FVS of each facility.

3.2 Users and uses

Two agencies in Antigua have used the vulnerability assessment: the APUA and Public Works Division. Both agencies have used the assessment to identify vulnerable buildings for retrofitting or relocation of facilities.

3.3 Current condition and limitations

Deleted:

There are plans to prepare more detailed assessments at the community level. This is the objective of the community exercise of NODS at the Crabbs Hill community. The intention is to extend this exercise to all communities.

The data limitations, which affected the quality of the hazard maps, also affected the output of the vulnerability study. It was indicated that the format of the document limits the dissemination of the data to the general community.

3.4 Critical Success Factors

The structure of the project team allowed the vulnerability assessment to benefit from the input of experts with a wide range of expertise. The application of the assessment at the community level will promote the development and use of the assessment.

4.0 Digital Maps

Digital mapping and the GIS activity in Antigua are conducted in a number of agencies. These agencies include the DCA, Environment Division, Fisheries Division and APUA. The primary source for most government digital mapping is the DCA. The APUA is very advanced with regards to GIS development. They are responsible for developing and maintaining the electricity and telephone layers for Antigua. Both agencies use ArcInfo / ArcView and store their layers in shapefile format.

The digital mapping available for Antigua is indicated in Table 4. The DCA maps were produced using the Clarke 1880 Modified datum and Transverse Mercator British West Indies projection. The base maps for most of the DCA maps are at a 1:50000 scale. The roads layer was digitized from a 1:25000 scale base map. The APUA maps were produced using the National Grid Antigua 1943 projection. These maps use the cadastral maps as base maps and the data is constantly updated by field survey. The cadastral maps exist at 1:1250, 1:2500, and 1:5000 scales.

Table 4 – Digital Mapping in Antigua

Data Theme	***Scale of input map***	***Year input map was produced***	***Area covered***	***Primary Source***	***Digital File format***	***Datum***	***Projection***
Drought	1: 50,000	1970	Entire island	NODS	Shapefile	Clarke 1880 (Mod)	TM BWI grid
Flooding	1: 50,000	1970	Entire island	NODS	Shapefile	‘’	‘’
Landslides	1: 10,000	1970	Entire island	NODS	Shapefile	‘’	‘’
Wind	Not stated	1970	Entire island	NODS	Shapefile	‘’	‘’
Waves	Not stated	1970	Entire island	NODS	Shapefile	‘’	‘’
Storm surge	Not stated	1970	Entire island	NODS	Shapefile	‘’	‘’
Beach erosion	1: 50,000	1970	Monitored beaches only	NODS	Shapefile	‘’	‘’
Contours	1:50,000	1970	Entire island	DCA	Shapefile	‘’	‘’
Land use	1:50,000	1970	Entire island	DCA	Shapefile	‘’	‘’
Roads	1:25,000	1970	Entire island	DCA	Shapefile	‘’	‘’
Water Courses	1:50,000	1970	Entire island	DCA	Shapefile	‘’	‘’
Electricity lines	1:1,250, 1:5,000 1: 5,000	Updated constantly	Not stated	APUA	Shapefile	‘’	National Grid Antigua

							1943
Telephone lines	1:1,250, 1:5,000 1:5,000	Updated constantly	Not stated	APUA	Shapefile	''	''
Population	1:50,000	1991	Entire island	DCA	Shapefile	Clarke 1880 (Mod)	TM BWI grid
Social facilities	1:50,000	1970	Entire island	DCA	Shapefile	''	''
Economic facilities	1:50,000	1970	Entire island	DCA	Shapefile	''	''
Land Capability	1:50,000	1970	Entire island	DCA	Shapefile	''	''
Parcels	Not stated	Updated constantly	Entire island	DCA / Lands and Surveys	Shapefile	''	''
Beaches	1:50000	1970	Entire island	DCA	Shapefile	''	''
Digital Elevation Model	1:50,000	1970	Entire island	NODS http://www.oas.org/pgdm/	Grid	''	''

5.0 Conclusions and Remarks

Antigua is the largest of the Leeward Islands and is relatively flat and dry when compared to its neighbours. The island contains volcanic and limestone formations and its highest elevation is 402m. The population was 59,355 in 1991 and had very low growth rate. Most of the population is concentrated on the capital city of St. John's and the surrounding area. The economy of Antigua is heavily dependent on service industries such as tourism and construction.

The island is at risk to hurricanes, earthquakes, volcanic eruptions, drought and man-made disasters. Over the last decade hurricanes have caused significant structural and economic losses. Drought has also significantly affected the economy.

Hazard mapping has been conducted for the effects of hurricanes, coastal erosion, inland erosion, flooding and drought. A vulnerability assessment has been conducted of critical facilities and resources by the PGDM project for these hazards.

The hazard maps and the Vulnerability Assessment are used by a number of agencies in Antigua. The hazard maps are used by NODS, APUA, banks, insurance agencies, the Health Ministry, Public Works, Police and Military. Their primary uses are to identify vulnerable facilities and provide warnings for hurricanes. They are used at both the national and community levels. The vulnerability assessment is used by the APUA and Public Works to identify vulnerable buildings for retrofitting or relocation.

References

Development Control Authority, Government of Antigua. National Physical Development Plan. 1999. http://www.antiguagov.com/dca/

Jackson, I. 2001. Antigua and Barbuda Drought Assessment Mapping Summary Report.
Organization of American States, Unit of Sustainable Development and Environment, Washington DC. http://www.oas.org/pgdm

Hodgkinson-Chin, E. 2001. Hazard Vulnerability Assessment, Final Report, Antigua and Barbuda. Organization of American States, Unit of Sustainable Development and Environment, Washington DC. http://www.oas.org/pgdm

Organization of American States, Unit for Sustainable Development and Environment Web page. http//:www.oas.org/pgdm