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

BARBADOS COUNTRY REPORT

THE CARIBBEAN DISASTER EMERGENCY RESPONSE AGENCY (CDERA)

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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; 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.

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Status of Hazard Maps, Vulnerability Assessments and Digital Maps in the Caribbean: Barbados

1.0 Introduction

1.1 Physical and socio-economic background

Barbados is located in the Caribbean – in the North Atlantic Ocean, to the northeast of Venezuela. Its geographic coordinates are 13° 10‘ N, 59° 32‘W. The highest point in the island is Mount Hillaby at 336 m. Barbados, with a total area of 430 square km, is the most windward (easternmost) in the chain of islands. It is a small coral and limestone island. These materials are used particularly in the construction industry. The limestone formation presents itself as terraces, scarps and slopes. The island's climate is tropical with a rainy season in the period June to October. The island is relatively flat; rising gently to a central highland region.

The natural resources that are particularly recognized are petroleum, natural gas and fish. The land is utilized primarily in three ways. Arable land accounts for 37.21%, permanent crops use 2.33% while 60.46% of the land is used for other purposes. The economy previously depended on the sugar cane industry. The country has since diversified into tourism and manufacturing. Other industries include sugar, light manufacturing, and component assembly for export. Offshore finance and information services, and to some extent light manufacturing are the most important foreign exchange earners to date. The estimates for the year 2000 have shown that the services sector contributes 78% of the Gross Domestic Product (GDP). This is closely followed by industry (16%) and agriculture (6%) respectively.

The estimate of the size of the Barbadian population is expected to be 277,264 persons in the year 2003. This figure would represent an increase of 0.38% in the same year.

Approximately 128,500 persons were actively part of the labour force in 2001. Employment in the services sector was highest at 75%, followed by industry, 15% and agriculture 10%. http://www.cia.gov/cia/publications/factbook/geos/bb.html

1.2 Major Disaster Issues Confronting the Country

Barbados is exposed to few natural hazards. The island is located in the southern portion of the Caribbean and hurricanes are not a great threat. However, Barbados is brushed by a tropical depression, tropical storm or hurricane every 3.07 years. Huricane Lily was the most recent in September 2002 that passed to the south of the island blowing the roofs off some 135 houses. During the last century, Barbados has been hit by five systems, the most devastating being Hurricane Janet in 1955, which killed 35 people, destroyed 8,100 homes and left 20,000 homeless.

However, the effects of hurricanes and tropical storms such as wind damage, inland flooding and coastal surge are still of concern. Some areas of the island are prone to landslides. In addition, Barbados has experienced periods of drought and soil erosion is an issue. Fresh water shortage and sea level rise are also of concern to the country.

The island is also prone to manmade hazards such as hazardous waste. Illegal solid waste disposal threatens to contaminate aquifers. The pollution of coastal waters from waste disposal by ships is an issue. Oil spills are considered to be a major threat because of the importance of the environment to tourism and the economy.

The active submarine volcano, Kick 'em Jenny, located 9 km northeast of Grenada, and about 260 km (100 miles) southwest of Barbados poses a threat of tsunamis, which is of great concern to Barbados.

For an overview of hazards in Barbados see
www.oas.org/en/cdmp/hazmap/present/barbados.ppt -

2.0 Hazard Mapping Initiatives

Table 1 shows the details of hazard maps in Barbados.

Table 1 – Hazard Maps in Barbados

Type	Purpose	Coverage	Scale	Date produced	Primary sources	Author(s)
Landslide	Serve as a guide for agricultural, residential & recreational land management	Scotland District	1:5,000	February to April 2000	Department of Agriculture	Mr. I. F. Hodgson; Dr. G. J. Hearn; Mr. Lucas Scott Wilson, Basingstoke, UK.
Flood	Development control and planning	Speightown, Weston, Holeton, Constitution River, and Wotton	1:2,500	unknown	Ministry of Public Works	Cummings Cockburn Ltd. & Errol Clarke Assoc.
Flood	Development control and planning	South & West Coasts	1:1,000	1994	Coastal Zone Manageme nt Unit	DELCAN

Seismic	To map Horizontal Ground Acceleration; Expected Maximum Mercalli Intensity; and Horizontal Ground Velocity	Entire country	0.25º grid	1999	OAS/ CDMP http://www.oas.org/en/cdmp/hazmap.htm	Seismic Research Unit, UWI, Trinidad
Seismic	To map general level of earthquake hazard in the Caribbean in the terms of the Modified Mercalli Scale and PGA and SGA values	As part of the Windward Islands and Barbados region	0.25º grid	1999	Seismic Research Unit http://www.uwiseismic.com/SRU_Site01/Earthquakes/eq_ec_seismicity_hazmm.html	Seismic Research Unit, UWI, Trinidad

2.1 Methods of preparation and distribution

2.1.1 Landslide Hazard Map

The landslide hazard map for the Scotland District was prepared primarily from desk-study. The study made use of data on soils, geology, slope angle, drainage, groundwater, remote sensing and other secondary datasets. A GIS-based factor mapping approach was used. Furthermore, correlations between landslide occurrence and geology; slope and land use; and instability and various drainage elements were examined. The results showed that there was no significant relationship among the variables. The result is available in digital format but not freely distributed. The following levels of landslide susceptibilities were mapped: very low, low, moderate, high, and very high.

2.1.2 Floodplain Map

The map was prepared in a GIS environment. No information was provided on the actual methodology and distribution of this map.

2.1.3 Flood Water Levels Map

The floodwater hazard map showing the water levels for Barbados in 1:100 year was prepared using topographic data and coastal modeling software. No further detail on its distribution and levels of hazard was provided.

2.1.4 Seismic Hazard Maps

Two sets of seismic hazard maps were prepared for Barbados by the Seismic Research Unit, one, done in 1999, as part of the regular dissemination of information that the Unit routinely performs and the other for the Caribbean Disaster Mitigation Project (CDMP) in 1999. The first set of seismic hazard maps showed levels of ground shaking using the Modified Mercalli (MM) scale of earthquake intensities and Peak Ground Acceleration (PGA) with 10% probability of exceedance in any 50-year period and One-Second Spectral Ground Acceleration (SGA) for the same probability. Barbados falls into the Moderate Hazard category of earthquake intensity on the MM scale. The MM maps, and the PGA and SGA maps will be updated in the near future by the Seismic Research Unit.

The methodology for arriving at the *Eastern Caribbean Seismicity* seismic hazard maps for Barbados, showing PGA and SGA values, is given at URL: http://seismo.ethz.ch/gshap/northam/report.html

The second set of seismic hazard maps was prepared for the CDMP Hazard Mapping and Vulnerability Assessment workshop in 1999. These maps showed seismic hazard maps of Horizontal Ground Acceleration, Expected Maximum Mercalli Intensity and Horizontal Ground Velocity for Barbados. The maps were prepared using types and intensities of earthquakes, distribution of faults, thrusts and volcanoes in the region. Recurrence models were used to determine how future earthquakes would occur. All this information was combined to produce expected earthquake spectra that showed how amplitude would vary with frequency. Maps of ground acceleration, ground velocity and Modified Mercalli Intensities for the Windward Islands and Barbados, done at a scale of 0.1º grid resolution, are posted at:
URL: http://www.oas.org/en/cdmp/document/seismap/windward.htm

Source of this information:
URL: http://www.oas.org/en/cdmp/hazmap/Grenada/atwell.htm#Introduction

2.1.5 Storm Surge Hazard Maps

An Internet search revealed that a storm hazard assessment, that included Barbados, was done for the Caribbean basin through the Caribbean Disaster Mitigation Project (CDMP) by the Caribbean Institute for Meteorology and Hydrology (CIMH). The map for Barbados, contained in the *Atlas of Probable Storm Effects in the Caribbean,* shows the likely estimates for storm surge, wave height and wind speeds for the 10-25, 50, and 100-year return periods, associated with the passage of a hurricane. The scale of the map is approximately $1km^2$ grid of the Caribbean Basin, using the Plate Carrée projection and WGS84 datum.

The storm hazard map utilized The Arbiter Of Storms (TAOS) model to produce the maximum likely estimates of surge, wind speeds and wave height.

The map is distributed via the Internet and can be found at: http://www.oas.org/en/cdmp/document/reglstrm/index.htm

2.2 Users and uses

No information was provided on the users and uses of the landslide and floodplain hazard map.

The seismic hazard maps were intended to be used for developing earthquake resistant designs; determining how soils will react during an earthquake event; for microzonation; public education; informing disaster emergency management and land use planning

The storm hazard map is intended for use by coastal engineers, regional planners, emergency management personnel and lending and insurance agencies for vulnerability assessments.

2.3 Current condition and limitations

The floodwater hazard map suffers from the unavailability of adequate profile data and topographic data. The other limitation is that it only covers the south and west coasts of the island.

No information was provided on the current condition and limitations of the following hazard maps: landslide, floodplain, seismic and storm hazard maps. Every effort made to obtain this information from the relevant person/agency has proved futile at the time of the submission of this report. The report will be updated as soon as this information becomes available.

2.4 Critical success factors

No information was provided on the critical success factors of the landslide and floodplain hazard projects. Likewise, no information was available on the critical success factors of the seismic and storm hazard maps.

2.5 Respondents

The list of respondents is as follows:

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Ricardo Arthur
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Charles Yearwood, Senior Technical Officer
Drainage Unit
Ministry of Public Works, Barbados
Tel: 426-9695; Fax: 426-9705

3.0 Vulnerability Assessment Studies

Table 2 shows the details of vulnerability assessment studies undertaken in the country.

Table 2 – Vulnerability Assessment Studies for Barbados

Type	Purpose	Coverage	Date produced	Primary source	Author
Human and economic	To delineate the 5, 20, & 100-year floodplains	National	1996	Ministry of Public Works	Cummings Cockburn & Errol Clarke Assoc.
Bio-geophysical and socio-economic	To assess the effects of sea level rise and potential for adaptation	Coastal regions	2002	CZMU/CPACC	Antonio Rowe, CZMU, Barbados
Tsunami	To evaluate possible impacts of tsunamis	Northwest coast of Barbados	Nov, 1999	Port St. Charles Development Ltd.	Smith Warner International Ltd

CZMU: Coastal Zone Management Unit
CPACC: Caribbean Planning for Adaptation to Climate Change

3.1 Methods of preparation and distribution

The 1996 stormwater drainage study was aimed at delineating floodplains for the following flood periods: 5, 20, & 100 years. The study was based on hydrological and hydraulic analyses. The result is not widely distributed but made available on request to other Government Agencies.

The CPACC funded assessment of the effects of sea level rise was conducted using the Bruun rule concept. The project was recently completed and its results have not been distributed. The following scenarios were assessed: 0.2m, 0.5, and 1.0m rise in sea levels.

The evaluation of the possible impacts of tsunamis on the northwest coast of Barbados involved the use of a run-up model to predict wave run-up and run-down on the shoreline of Port St. Charles. Actual bathymetric survey was done to enable detailed refraction and run-up analysis. The tsunami model was calibrated with respect to the run-up value. Four scenarios of tsunami wave height were modelled and later revised to use three of the four scenarios. The maximum possible eruption scenario, the 1939 Eruption scenario and the landslide-tsunami-generated scenario were used, giving 7.9 m, 3.2m and 4.6m tsunami run-up respectively. The study also included emergency management procedures to be taken in the unlikely event of a tsunami.

3.2 Users and uses

The result of the stormwater drainage study is used by the Town and Country Planning Department for development and settlement planning; by the Ministry of Environment for gully study; by the Central Emergency Relief Organization (CERO) for evacuation planning; and by the Ministry of Housing for flood damage assessment.

There is no information on the users and uses of the tsunami study. A contact person is Thomas Herbert of Port St. Charles Development Ltd. Tel: -246-419-2224 or email: therbert@portstcharles.com.bb)

3.3 Current condition and limitations

No limitation was identified for the stormwater drainage study.

The sea level rise study, however, has the following limitations: lack of data on beach profile, water level during severe storm events, and high-resolution elevation.

3.4 Critical success factors

No information was provided on the critical success factors of these projects.

3.5 Respondents

Below is the contact information of the respondents:

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4.0 Digital Maps

Table 3 shows details of digital data themes available in the country.

Table 3 – Digital Maps Available in Barbados

Theme	Input Scale	Year of input map	Coverage	Datum	Map Projection	Format	Primary source
Contours	1:10,000	1997	National	HMS Challenger Astro 1938	BNG; TM	ArcINFO	BWA
Contours	1:10,000	1986	Scotland District			AutoCAD	LSD
Land use	1:10,000	1991	National			ArcINFO ArcView	CZMU
Land use	1:10,000	1997	National				BWA/ MOA
Land use	1:10,000 1:25,000	1987	National (excluding Bridgetown)				TCPO
Soils	1:50,000	1997	National				BWA/CZMU
Roads	unknown	1997	National				BARTEL
Roads	1:1,250 1:2,500 1:5,000 1:10,000	1983-1986	National				LSD
Rainfalls	1:10,000	2000	National				BWA/CIMH
Water Pipes	1:10,000	On going	National				BWA
Vegetation	unknown	unknown	Coastal regions				CZMU
Vegetation	1:10,000	1997	National Park				NHU
Slope	1:10,000	1986					
Rivers	unknown	unknown	National				BWA/CZMU
Buildings	unknown	unknown	National				BARTEL
Active Slippage areas	1:10,000	1986	Scotland District			AutoCAD	MOA
Slippage remediation areas							

Engineered flood lines	1:10,000	1991	National		BNG; TM	ArcINFO	Drainage Unit Mr. C. Yearwood
Flood prone areas	1:10,000	1991 & 1993	National		BNG; TM	AutoCAD	
Observed flood	1:10,000	1993	East Coast		BNG; TM	ArcINFO	
Basemap	1:1,250 1:2,500 1:5,000 1:10,000	1972-1986	National		BWIG; TM BWIG; TM BNG; TM BWIG; TM	AutoCAD	LSD
Coastal Flood (100yr)	Unknown	Unknown	West & South Coasts		unknown	ArcINFO	CZMU
Geology	1:50,000	1983	National	unknown	BNG; TM	ArcINFO	CZMU/LSD
Population	unknown	unknown	National	unknown	unknown	ArcINFO	ADPP
Social Facilities	unknown	unknown	Coastal regions	unknown	unknown	ArcINFO	CZMU

List of abbreviations:

BNG: Barbados National Grid
BWIG: British West Indies Grid
TM: Transverse Mercator
BWA: Barbados Water Authority
TCPO: Town and Country Planning Office
CZMU: Coastal Zone Management Unit
BARTEL: Barbados Telephone Company
NHU: Natural Heritage Unit
ADPP: Area Development Plan Project
MOA: Ministry of Agriculture
CIMH: Caribbean Institute of Meteorology and Hydrology
LSD: Lands and Surveys Department

5.0 Conclusions and Remarks

The study found very few hazard mapping and vulnerability assessment studies have been undertaken in Barbados. This does not accurately reflect the proneness of the country to natural hazards but the increase in the awareness to undertake such studies.

The Country has a number of digital mapped data because of the increased use of GIS but the absence of a visible national GIS database is still a management challenge along with the absence of data dissemination policy.