Annex A.

Natural Hazards and Natural Disasters: Definitions, Chronology, Storm Frequency and Reported Impacts of Recent Disasters on Dominica

This annex provides more detailed information on natural hazards as background to the discussion of these issues in the Main Report, especially Chapters 2, 3, 4, 7 and 14. The definitions of natural hazards employed in the report are explained in Section A.1 Sections A.2 and A.3 bring together complementary sources of evidence on the incidence of major tropical storms and hurricanes from historical written sources covering the period since 1763 and meteorological statistical evidence for the period 1886-1996 from the US National Center for Atmospheric Research. The findings of these two approaches are consistent and provide an extremely useful basis for assessing the probabilities of extreme storms and their likely associated characteristics. The impacts of the most serious natural disasters affecting Dominica since independence in 1978 as reported in immediate post-disaster assessments are summarized in Section A.4. Attention is drawn to some of the inconsistencies in assessments and in particular the incomplete assessment for Hurricane Lenny.

A.1 Definitions: Natural Hazards, Disasters, Risks and Vulnerability

In considering natural hazards in Dominica, it is useful to briefly clarify the related and inter-connected terms of natural hazards, disaster, risk and vulnerability used in this study. These terms are modified from United Nations definitions to focus on economic dimensions of hazards and their consequences (UNDP, 1992).

Natural Hazard - A rare or extreme event in the natural environment that adversely affects human life, physical or human capital or activity to the extent of causing disaster.

Disaster – A serious disruption of the functioning of a society, causing widespread human, material, or environmental losses. These may exceed the ability of the affected society to cope, using only its own resources.

Risks - The expected number of lives lost, persons injured, damage to capital stock and disruption of economic activity due to a particular natural hazard and these expected losses are consequently the product of a specific risk and the elements (lives, etc.) at risk

Uncertainty- A situation in which there are insufficient data to estimate 'risk' in terms of mathematical probability.

Vulnerability – The degree of loss to a given element at risk, or set of such elements, resulting from the occurrence of a natural phenomenon of a given magnitude. For capital stock this is expressed on a percentage scale from zero (no damage) to one (total loss) In the case of activities then the effect is in terms of a reduction below expected levels in the period of impact or afterwards. *Resilience* provides a complementary concept of how quickly the level of activity recovers to either pre-disaster or expected trend level.

Natural Hazards generally arise from sources that may be described according to the forcing mechanisms, which are meteorological-climatic or geological. Major meteorological hazards include Tropical Storms and Hurricanes as categorized in the Saffir/Simpson Scale (Table A3 1). Hydrological hazards, which include floods, and, on coasts, storm surges, are likely to result from extreme meteorological conditions, and drought from abnormally low precipitation. Geological hazards include earthquakes, volcanic activity and landslides. Tsunamis are a product of a geological event. Natural phenomena tend to interact such that the hazards and their effects represent a complex interplay of forces For example, a hurricane has very strong winds but also produces intense, high rainfall that can give rise to floods and landslides. It may produce huge waves and a storm surge that can lead to coastal flooding.

A.2 Hurricane impacts on Dominica, 1764-1999: a chronology and historical note[88]

There is much informal speculation about the frequency of hurricanes that have impacted severely on human activity on Dominica. For example, Hurricane David is sometimes referred to as a one in a hundred year event, or an even more rare occurrence, whereas the historical data summarized below suggest that it is approximately a one in fifty year event. In the design and assessment of infrastructure investments, the expected frequency of specific levels of extreme conditions such as windspeeds and wave height is also critical to the determination of appropriate levels of mitigation (Chapter 7). It is appropriate, therefore, to look at the historical record and attempt to construct a chronology of severe storms, and what this suggests for the frequency and pattern of these events.

A history of storms is presented in this annex in two ways. In this section a historical approach is adopted drawing on available published and unpublished sources. This approach is an elaboration of that contained in Honychurch's history of Dominica (1995). Second, Section A.3 reproduces the results of statistical analysis, HURSTAT, showing the incidence and frequency of tropical storms which have passed sufficiently close to Dominica to have had tropical storm or hurricane category effects. This analysis uses data from the US National Center for Atmospheric Research and was originally published in the CDMP Wave Hazard Assessment Study by Wagenseil and Watson (1996). The findings of these two approaches are consistent and provide an extremely useful basis for assessing the probabilities of extreme storms and their likely associated characteristics.

A visual analysis of the list also provides valuable evidence on the issue of the formation of expectations and apparently changing subjective assessments of risk within the island society. The long period without a major event between 1930 and 1979 is frequently commented upon as a reason for lack of preparedness in the late 1970s. There is apparent marked bunching of severe events in three periods – from the mid 1760s to 1780 (6 years out of 16), from 1813 to 1834 (8 years out of 21), and from 1876 to 1893 (5 years out of 17). These periods are reported officially as periods of economic difficulty, depressed agriculture and trade. The third of these periods provided the impetus to successful official efforts to establish commercial insurance by the Administrator, Hesketh Bell, between 1900 and 1905. In between these periods of more intensive hurricane impacts there were lengthy periods in which there were few storms, and suggestions of a more relaxed attitude to mitigation measures, most recently after 1930. For example, the practice of protective windbreaks, common on estates was given up from the 1950s. With the expansion of banana cultivation and break up of larger holdings, windbreaks were cut down and not actively replanted (Lennox Honychurch, personal communication). There were also probably lower design standards in much of the more recent urban construction in Roseau and other West coast settlements, so that the destruction of housing in these areas by Hurricane David was apparently more widespread than in traditionally constructed older buildings in some rural localities such as the Carib Reserve. We are possibly in a fourth period of relatively more frequent storms affecting Dominica, but this may be more apparent than real, because of wider communications, combined with the increased awareness of hurricane hazard since 1979.

The historical record is also useful in showing that some of the more unusual phenomena of the period since Hurricane David are not unprecedented. The sequence of three storms in 1995 – Ine, Luis and Marilyn – is paralleled by the reported three storms of August 1787. ' In August all the buildings (including the barracks and hospital) on Morne Bruce, the shipping and some houses in Roseau were destroyed by three gales of wind on the 3rd, 23rd and 29th ' (Lockhart, 1879).

During the great storm of 1834 Dominica was in the eye of the storm for several hours on the night of 20-21 September, according to the testimony of the physician, Dr John Imray, which notes also the destruction of the forests. The damage and disruption to estate production and trade in all quarters of the island offers another striking parallel to the experience of Hurricanes David and Frederick in 1979. The great hurricane of 1834 followed within one month of emancipation and Hurricane David occurred within a year of Independence, both coming in periods of social turmoil that amplified problems of relief and recovery. The full measure of the severity of the 1834 storm is provided by the detailed official assessment report from the Governor, setting out the case for temporary relaxation of import duties and granting of relief to the island. The assessment covering destruction to fixed and moveable property and loss of crop production is conceptually similar to those still conventionally made up to the present. 'The annexed return contains a general statement of the losses in the several parishes, and in the town of Roseau, distinguished under the several heads of Loan and Grant, the former amounting to the sum of 90,418 pounds 16s sterling; the latter to the sum of 32,104 pounds 2s sterling' (Report of Governor, Murray McGregor, 18 February, 1835). These were agreed on 1 June 1835 and confirmed by Royal Acts on 3 July and 31 August 1835, probably too late to be fully effective.

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88 The invaluable advice of Dr Lennox Honychurch in preparing this note and chronology is gratefully acknowledged.

Table A.2.1 Chronology of Hurricanes Affecting Dominica 1764-1999

Year	Leeward Islands Almanack, 1879	CIMH	Other notes/names of TS or Hurricane
1764	X		
1766 October		X	
1769 July 26		X	
1772 August 30	X	X	
1776 September 6	X	X	
1780 October 9	X	X	
1787 August 3, 23,29	X	X	3 storms
1792 August 1		X	
1806	X		
1813 July 22	X		
1815	X		
1817 October 21	X		
1818	X		
1819	X		
1820 September 26	X		
1826	X		
1834 September 20-21	X	X	Most extreme, David-like
1876		X	
1883		X	
1889		X	
1891		X	
1893		X	
1916 August 28		X	
1928 August 30		X	
1930		X	
1955 September		X	Janet
1979 August 29, Sept 1			David, Frederick
1980 August 4			Allen
1984			Klaus
1989 August 17			Hugo
1994 September 9-10			Debbie
1995 Aug 25, Sept 5, 18			3 storms: Iris, Luis, Marilyn
1999 Nov 17-19			Lenny

Source: Lockhart, 1879; CIMH; NOAA and ECCB Quarterly Bulletins

A.3 History of Storms on Dominica: HURSTAT (adapted from Wagenseil and Watson, 1996)

As of 1996 the US National Center for Atmospheric Research had 110 years of reliable, standardized weather data for the region The HURSTAT program, developed by Charles Watson in conjunction with CDMP, extracted statistics from this data base for storms affecting Dominica, using the latitude and longitude of a point near the center of the west side of the island.

The storms are sorted by category of intensity, according to the Saffir/ Simpson hurricane scale. HURSTAT gives the storm category according to the pressure and wind strength at the longitude and latitude chosen. Many of these historical storms had higher intensities at their centers, but the centers did not pass over the chosen location, and HURSTAT compensates for that.

The numbers in the tables need to be used with caution. For instance, Table A 3.3 indicates that there would be an average or mean interval of nearly three years (2.9 years) between years in which there have been storms. But this Table also shows that the actual interval has ranged from one to twelve years. In order to relate these statistics to personal experience, it is useful to remember that Hurricane Marilyn of 1995 was a strong Category 1, and that Hurricane David of 1979 was a strong Category 4 hurricane.

Hurricane Lenny, also a Category 4 storm, was unprecedented in moving from west to east across the northern Caribbean (Map 3). Passing 150 miles to the north it caused largely coastal damage to Dominica and neighboring Guadeloupe and Martinique, but only modest wind damage. So far the assessment of hurricane risk, as reflected in HURSTAT and these tables, is based on the assumption that the severity of impact will be a function of the intensity of the storm and its proximity to the island. Lenny type events will require a re-assessment of risks to coastal infrastructure and facilities.

Personal experience offers only limited help in assessing the risk of severe storms, however. Table A.3.3 shows that there was one interval when Dominica did not experience a hurricane strength storm for twenty years. People who grew up during that calm period may have felt complacent about hurricanes, based on their experience, but they were wrong to do so.

Table A.3.1 Saffir / Simpson Hurricane Scale

Category	Pressure (millibars)	Winds (km/hr)	Storm Surge (meters)	Damage
0 Tropical storm	> = 995	61 - 119	0 5 - 1.2	Some
1 Hurricane	980 - 995	120 - 153	1.2 - 1.5	Minimal
2 "	965 - 979	154 - 177	1.6 - 2.4	Moderate
3 "	945 - 964	178 - 209	2.5 - 3.6	Extensive
4 "	920 - 944	210 - 250	3.7 - 5.4	Extreme
5 "	< 920	> 250	> 5.4	Catastrophic

Table A.3.2. General Tropical Storm and Hurricane Statistics for Dominica, at Lat 15.5, Lon 61.4, from 1886 to 1996

Number of storms	61
Years with storms	45
Years with multiple storms	13
Years with multiple hurricanes	1
Category 0, tropical storms	40
Category 1, hurricanes	13
Category 2 "	3
Category 3 "	3
Category 4 "	2
Category 5 "	0

Table A.3.3. Interval Analysis for Tropical Storms and Hurricanes at Lat 15.5, Lon 61.4, from 1886 to 1996

Category of storm or above	TS	C1	C2	C3
Intervals Found (number)	35	17	7	4
Average Interval (years)	2.9	5.8	13.6	23.8
Maximum Interval (years)	12	20	34	70
Minimum Interval (years)	1	1	2	2

A.4 Important Natural Disasters and Reported Impacts, 1978-1999

The most important natural disasters affecting Dominica since 1960 are reported below. Typically there were assessments of damage and other effects soon after the event. The estimates in these various assessments have been synthesized and presented in summary form. Information on damage to the fixed capital stock of infrastructure and buildings has also been used to provide the estimates of rehabilitation costs presented in Chapter 7 Some of the inconsistencies in assessments are also noted.

A.4.1 Hurricane David –August 29, 1979

Prior to 1979 Dominica had not been devastated by a hurricane for several decades Hurricane David has been described as the most devastating hurricane in more than 150 years and is regarded as one of the most powerful hurricanes to have affected the Eastern Caribbean up to that time. It achieved at least a category 4 status with winds in excess of 130mph (180km/hr) (Map 3).

Dominica took the full brunt of the onslaught of the hurricane, which can be described as the single most destructive disaster in the island's recorded history, in terms of its impact on the fixed capital stock and natural resources sectors. The direct effects lasted approximately 12 hours, but the impact was to be felt for many years afterwards. There is general agreement that Dominica was not well prepared for this hurricane either politically or operationally. The island had achieved political independence only one year before and was in the throes of a political crisis that had seen the installation of an Interim Government.

Socio-economic impact

- 42 persons killed.
- 75,000 persons made homeless.
- 95% of buildings damaged or destroyed.
- 66% of the population initially left without food, water or electricity
- 12% of houses completely destroyed – i e , 2,000 units.
- 50% of houses severely damaged – i.e., 8,000 units.
- 3,000 persons treated for injuries.
- Almost all schools damaged or destroyed.
- The total estimated damage to fixed capital was over EC$ 53.8m.
- Massive social dislocation including emigration

Agriculture, forestry and fisheries impact

- Entire banana crop damaged or destroyed.
- Entire citrus crop affected.
- Damage to other crops estimated at EC$ 6.6m.
- Overall damage to the agricultural sector estimated at EC$ 33m
- More than 75% of forests damaged or destroyed.
- 40% of forest wood volume lost, about 5 million trees damaged or destroyed
- There were extensive landslides but the area affected was not quantified, many hundreds were observed.
- Extensive damage to agricultural and forestry feeder roads.
- Significant localized erosion as more than 50 mm (20 inches) of rain accompanied the hurricane.
- 472 or 75% of fishing boats destroyed
- A further 157 of the remaining 25% lost engines.
- Damage was exacerbated one week later with hurricane Frederick. Twelve inches of rainfall at Melville Hall on September 4, 1979 resulted in flooding.
- There was extensive coastal erosion that was largely unassessed and unquantified. Frederick did not produce direct wind damage but disrupted relief activities after David and led to the loss through flood damage of some relief supplies in storage .

A.4.2 Hurricane Hugo – September 17, 1989

Hurricane Hugo also reached category 4 status in the eastern Caribbean The islands of Antigua, Barbuda, St. Kitts and Montserrat were devastated. Dominica did not receive a direct hit but the hurricane had a serious impact

Socio-economic impact

- Damage estimates to capital stock were put at EC$20m.
- Government savings were reduced by EC$11m as emergency response activities were undertaken.
- Tourist arrivals fell by 27% in the next year, 1990.

Agriculture, forestry and fisheries impact

- Damage to the sector overall estimated at EC$ 49m. This included EC$ 48m direct damage and a further EC$ 1m in agricultural infrastructure.
- Agricultural output in general declined by 18%
- Banana output, at record levels in 1988 of 79,000 tonnes, fell to 58,000 tonnes in 1989.
- Banana exports fell by 30%.

A.4.3 Three Storms: Iris, Luis and Marilyn - 1995

Three storms affected the Eastern Caribbean in rapid succession – Tropical Storm Iris on August 27, Hurricane Marilyn on September 5 and Hurricane Luis on September 18 both of Category 1 strength. Since the three events occurred within 3

weeks, it is almost impossible to separate the effects of each on any of the affected countries. Most of the available literature describes the effects of these storms together. Dominica was not as severely impacted as Antigua, Barbuda, Montserrat, St. Kitts and Nevis, however the economic impact and the effects on the natural resource sectors were significant

Socio-economic impact

- One person killed.
- A projected economic growth rate of 4.5% converted into a decline of 2%.
- Discernible rise in food prices.
- CDB initially suggested a national rehabilitation estimate of EC$ 174m.

Agriculture, forestry and fisheries impact

- Crops affected severely: 98% of bananas, 90% of plantains, 85% of vegetables, 71% of citrus trees, 55% of tree crops in general, 50% of root crops, and 33% of coconut trees
- Banana losses valued at EC$ 64m.
- Root crop losses valued at EC$ 14.5m.
- Reduction in export revenues by EC$ 72m
- There was a 25% decline in crop production and 20% decline in agricultural output.
- Forestry was damaged but no accurate estimates available – estimate of EC$ 8.8m suggested by some authorities
- Hurricane Luis alone destroyed 10 fishing boats and set back completion of the Roseau Fisheries Complex by six months at an additional cost of EC$ 2m.
- Fishery landing sites, boat houses, boats and engines lost, to an estimated value of EC$ 3.5m.
- The total damage to the agricultural sector was estimated at EC$ 192m. An agricultural rehabilitation program of EC$ 88m was proposed.

A.4.4 Hurricane Lenny – November 18-19, 1999

This very unusual eastward-tracking and late-season storm developed in the Caribbean Sea in mid-November reaching strong Category 4 by November 17-19 when it stalled within the Leeward Islands in the Anguilla-St Maarten area (Map 3). It caused high seas and storm damage on western coastal areas of Dominica that are commonly less vulnerable, being on the leeward side of the island. As it was not expected to cause high winds in the Windward Islands, there was no hurricane warning in Dominica. Consequently, Hurricane Lenny caught many unawares with minimal opportunities to protect vulnerable property, such as fishing boats and equipment and hotels exposed to the West. There were, however, high sea alerts on the Internet and at least one hotel owner took mitigation action by moving vessels to the lee of St Lucia. The hurricane warning system appears not to have been geared to anticipating and indicating consequences of such an unusual event, being focused primarily on wind speed based measures of hazard. In the absence of wave monitoring, the sea surge, wave height and swell can only be inferred from observer reports.

The hurricane caused considerable structural and equipment damage on the western side of the island. There were also some limited reported agricultural losses reflected in the loss in storage of one week's banana exports by DBMC of EC$730,000 and WINCROP payouts.[89]

The Ministry of Communications, Works and Housing (GoCD, 1999d)) damage assessment focuses on roads and associated infrastructure on the West Coast and associated service infrastructure (Map 2). Much of the damage was to previously 'inadequately' protected or unprotected structures Most badly affected were road connections from Soufrière to Scott's Head, which were interrupted, along with power lines and telecommunications.

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[89] There were 1560 claims, 1474 payments with a total value of EC$1.106m, with an average payout of EC$750 (Table 6 1 3)

The MCWH assessed cost of repair restoration to roads and sea defense works was EC$3.4m and building damage EC$7.8m. In addition the MCWH estimated the cost of permanent works to protect road infrastructure as EC$109.6m This estimate is closely related to the sea defense strategy capital investment of EC$96 1m in the 1997 Review of Capital Defence strategy (Mouchel, 1997). The costs of rehabilitation, including mitigation measures, was re-estimated as EC$125m. (Liautaud. 2000).

By June 2000 no overall assessment of the direct damage caused by Hurricane Lenny had been undertaken comparable to that, for example, made by the government with CDB/IADB assistance following Hurricanes Luis and Marilyn in 1995 (GoCD, 1995). Other reported direct damage was as follows. WINCROP's payout of EC$1.1m implies total producer losses in the 1999-2000 season of around EC$5 5m (Table A 6.1.3). The Ministry of Agriculture estimated total losses in the rest of the crop sector as EC$3 9m, including EC$1.8m for plantains and EC$0 9m for 'ground provisions' or root crops The absence ofvery high winds or heavy rain associated with Hurricane Lenny makes this 'provisional' assessment appear somewhat high. In fact, the Ministry's assessment had already been adjusted downwards from an implausible initial EC$18.6m for the non-banana sector (GoCD, 1999e) Independent observers pointed to the potentially sensitive situation in late 1999 prior to the General Election as a possible factor influencing assessments for the rural sector

Other assessments of direct losses or costs included:	EC$ million
DOWASCO (water and sewage)	0.34
DOMLEC (electricity)	0.15
Port Authority	1.3
Fisheries	
Roseau complex	3.4
Other private sites and equipment	1 4
Hoteliers	0.67[90]
Residential Property	2.73
DCP	2 8

There are also various estimates of other damage and indirect costs For example, the Ministry of Agriculture estimated potential damage to coral reefs and seagrass beds on the basis of beach level assessments as EC$2 2m. The estimated cost of business disruption in terms of unemployment in the fishery sector was EC$0.5m (GoCD, 1999c) As for damage to residential property provisional estimates were of 174 affected households, including 602 people, whilst 69 houses were destroyed and 104 reported damaged. The largest number affected was in Loubiere, south of Roseau (GoCD 1999d). Private sector informants indicated substantial losses in terms of business disruption, especially in the tourism related sector, and temporarily higher transport costs

A.4.5 Other Hurricane Events

Hurricanes Frederick and Allen are noted in Dominica's history not for the scale of destruction but for the timing of their impact (Table A.2.1). Hurricane Frederick occurred *only one week after* Hurricane David in 1979. It brought prolonged torrential rainfall and exacerbated the damage done to the natural resources sector by Hurricane David Quantification was almost impossible. Hurricane Allen, which severely affected St Lucia, hit Dominica a glancing blow on August 4 1980. It disrupted and interrupted the recovery and rehabilitation efforts that were underway from Hurricane David the year before (Walsh, 1982)

Tropical Storm Debbie generated winds of about 40 mph. over Dominica on September 9 and 10 in 1994 The winds were accompanied by persistent rains. This storm followed an extended dry period that many local people regarded as a drought. At the time, approximately 5,000 acres were under banana cultivation, of which 2,800 were affected by the storm. 143 acres of plantains, 355 acres of root crops and 355 acres equivalent of tree crops were also damaged. Losses in banana production were initially estimated at EC$25m, but this is not confirmed by WINCROP payouts (Table A.6.1.3). Losses in fisheries and non-banana agriculture amounted to EC$5m The forestry and environmental losses were not quantified.

A.4.6 The Layou Valley Landslide

The Layou-Carholm Landslides represent a complex series of landslides that achieved climactic proportions in 1997 and remain a hazard today (Map 2). The Layou River is one of the largest watersheds in Dominica and drains about 10% of the land.

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90 The hoteliers estimated themselves that total losses including business disruption might amount to around EC$5.0m.

Landslides were common in the area, with specific reports occurring between 1987 and 1997. There is an eyewitness account of a slide following Hurricane Hugo in 1989 and also following Hurricanes Iris, Luis and Marilyn in 1995. There was a major change to the pattern of small landslides. Dramatic slumping occurred between November 18 and 25, 1997. Two major slides blocked the river and created a natural dam. The dam was breached on November 21 with mudflows reaching the sea accompanied by extensive flooding of the lower river valley A wall of material estimated at 50 feet high was washed downstream. An estimated 300 million gallons of water had collected behind the natural dam wall, at a depth of 60 feet and ¾ of a mile in extent. The riverbed rose dramatically in its lower reaches This elevation was estimated at 30 feet at the location of the swing bridge. The river had dried up between November 18-20 1997 and then flooded on November 21. Further landslides occurred on November 25, 1997 and October 8 and 11, 1998 with subsequent dam breaks being significant events.

A monitoring program by the Forestry Department was introduced and remains in place because of the continuing hazard of flooding of the valley that is traversed by a main road connecting northern west coast villages with Roseau (GoCD, 1997b, James, undated; Rodgers and others, 1997)

Socio-economic impact

- Temporary evacuation of 600 residents
- Loss of an access road to banana producing areas.
- Closure of Layou Valley Hotel.
- Loss of Swing Bridge
- Loss of income through fisheries and tourism related sales.
- Severe disruption of traffic

Agriculture, forestry and fisheries impact

- Loss of approximately 40 acres of land.
- Loss of natural vegetation
- Loss of bananas and tree crops especially citrus and cocoa.
- Destruction of cocoa drying shed and banana boxing plant.
- Siltation of river and build up of sediment offshore.
- Pot fishery has been destroyed in the area.
- Fish sales have fallen away dramatically.
- Fishermen have been dislocated many must now use other landing sites.
- Reefs located two miles offshore are covered with mud.
- Aquatic life in the river was obliterated.
- Loss of streamside vegetation.

Annex B.

Regression Analysis Methodology

This Annex describes the methodology employed in undertaking more formal regression analysis of the impact of storms on certain aspects of the Dominica economy Regression analysis was undertaken in four key areas: broad economic performance (as defined by GDP), banana sector activity, tourism and external aid flows.

The results of the analysis are discussed in relevant sections of the main report. A more detailed account of the regression analysis, including tables of results, is available upon request from the authors.

B.1 Storm Dummy Series

For the purposes of the analysis, the impact of the storms was captured using a dummy series. Two types of dummy variable were tested, with a variant of the second type used in the analysis of quarterly banana production :-

i) *a weighted composite series* – a dummy series assuming a positive value for storm years and 0 for non-storm years reflecting the record of storms since 1976 (Table A 2.1). The weights were constructed partially on the basis of data on WINCROP insurance payments during 1988-99 (Table A 6.1.3). The full dummy series was as follows

1976 – 0	1988 – 0
1977 – 0	1989 – 5
1978 – 0	1990 – 0
1979 – 7	1991 – 0
1980 – 1	1992 – 0
1981 – 0	1993 – 0
1982 – 0	1994 – 1
1983 – 0	1995 – 5
1984 – 1	1996 – 0
1985 – 0	1997 – 0
1986 – 0	1998 – 0
1987 – 0	1999 – 1

ii) *a series of discrete independent dummy series* – a separate dummy series for each storm year (see Annex A), assuming a value of 1 for the year of impact and 0 for all other years.

B.2 Gross Domestic Product

The impact of hurricanes on annual GDP, agricultural GDP and non-agricultural GDP was explored Initially simple models were developed, regressing the various components of GDP (in real EC$ terms) against a constant and the composite and independent dummy series Regressions were undertaken in both linear and logarithmic form, whilst the explanatory power of the dummy series lagged one period were also tested. Initial regression runs with the independent dummy series indicated that some of the hurricane events had had very little impact on the Dominica economy and so subsequent analysis included only three discrete dummy variables - for 1979, 1989 and 1995.

Several other explanatory variables were also tested to control for their effect on GDP: government consumption, private consumption, total investment[91] and the average banana unit price

[91] Disaggregated investment data was not available.

To further tighten the econometric methods, regressions were re-run based on rates of growth of all the non-dummy variables. Growth rates were computed in two ways: firstly, as (var-var(t-1))/var(-1) and then as log(var)-log(var(-1))

B.3 Banana Production and Export Earnings

A variety of techniques were used to determine – separately - the role of natural disasters, banana producer prices on banana production and export earnings The analysis was based on quarterly data reported by the ECCB over the period 1988Q3 to 1999Q4

Simple ordinary least squares (OLS) techniques were used to explore the impact of the 1989 and 1995 storms on banana production (expressed in volume terms) and also export earnings in real 1990 prices. Discrete dummy variables were tested, assuming a value of 1 for the quarter in which the relevant storm struck and 0 for other quarters. An additional dummy series was included to control for seasonality

B.4 Tourism

Analysis was undertaken to assess the impact of storms on annual visitor arrivals, expressed in terms of the rate of growth of numbers of visitors, over the period 1976 to 1998 Analysis was undertaken on data disaggregated by type of visitor - stopover, cruise and excursion – as well as on total number of visitors. Visitor expenditure was also assessed but the results were found to be inconsistent.

Again, both the composite and discrete storm dummy variables were tested. In the latter case, a general to specific approach was adopted, such that the least significant variables were removed one at a time in a stepwise fashion. All equations were run on a constant and the dummies. The explanatory power of the storm dummies lagged one period were also tested.

B.5 External Assistance

It had originally been hoped to undertake an in-depth analysis of aid flows to Dominica. However, inconsistencies in the data arose that were insurmountable, and so a more simplified approach was adopted

The impact of hurricane events on annual aid flows was analyzed using a variety of OLS methods and dummy series. Both composite and independent dummy series were run as explanatory variables against commitments and gross and net disbursements. The dummies were lagged for up to 2 periods. As before, general to specific methods were adopted. In later stages of the analysis, the effects oftotal value of exports and banana market value were also controlled for (separately)

Annex C

Public Finance

This annex considers the impact of Hurricane David, Hurricane Hugo and the 1995 storms on Dominica's public finances in more detail. As already noted, overall data on public expenditure and revenue suggest that disasters have little impact on this aspect of the economy. However, this apparent insensitivity reflects post-disaster reallocation of resources, rather than a sharp increase in public expenditure, combined with protracted – rather than rapid - reconstruction investment over a number of years.

A careful examination of the budgetary impact of individual disaster events is important because, by providing a more accurate assessment of their full public cost, it emphasizes the importance of integrating hazard risk reduction concerns into medium- and long-term economic and financial planning. It also helps facilitate a more rational response to natural hazard risk and disasters, both in allocating public resources and external assistance and in determining appropriate standards for Dominica's infrastructure.

This annex also includes an examination of the level of public investment in hazard mitigation and preparedness, noting particularly the difficulties in measuring this form of expenditure in Dominica – a problem also observed elsewhere.

C.1 Hurricane David

In the immediate run up to Independence, the GoCD already faced considerable budgetary difficulties and was operating a process of monthly cash budgeting in an attempt to contain expenditure. The GoCD was also receiving considerable budgetary support from the British Government, totaling an average 24.1% of total recurrent revenue in 1977/78 and 1978/79. The 1978/79 *Budget Address* noted how the persistent liquidity problems had made it 'virtually impossible to put into effect long term programs for budgetary expenditures, and made it extremely difficult to implement development projects without interruptions and delays' (GoCD, 1978 6)

Although a draft budget for 1979/80 was drawn up before the end of fiscal year 1978/79, internal problems following Independence in November 1998 led to the dissolution of the country's parliament and the establishment of a provisional government in June 1979. The new government set about revising the draft budget. It had almost completed its task when Hurricane David struck, causing estimated damage of EC$64.3m (US$23.8m) (see Annex A). In terms of damage to public assets alone, an initial reconstruction mission undertaken in October 1979 estimated the cost of repairs to public buildings at US$500,000, to hospitals and health centers at US$630,000; to school buildings and equipment at US$3.6m; to roads at US$3m; and to the power system at US$4m (UNDRO, 1980). In recognition of the severe budgetary implications of the disaster, a second 'comprehensive and detailed review involving every attempt to cut back upon expenditure and a detailed recasting of the anticipated revenue picture' was therefore undertaken (GoCD, 1979: 2), with the final draft Budget Statement eventually introduced on December 10, 1979.

The first draft budget drawn up by the new administration had indicated total expenditure of EC$35.7m, including EC$18m for the remuneration of civil servants. Various tax adjustments were expected to increase revenues over the previous year, together with UK budgetary support of EC$2m resulting in a balanced recurrent budget. In comparison, the final 1979/80 budget, as announced in December 1979, detailed estimated recurrent expenditure of EC$37.8m, only 5.9% higher than the original figure. Of this, EC$16m was earmarked for the remuneration of civil servants implying a 23% increase in recurrent expenditure on other items. The estimate for budgetary support remained at EC$2m. Revenues were now expected to be 32% lower than in 1978/79, in part reflecting an anticipated fall in employment as well as a one-year waiver on duties on a wide range of building materials in order to help facilitate the rehabilitation process. Meanwhile, a previously planned change in the nature of taxation on gasoline, which was expected to lead to a rise in tax on the product, and an intended doubling of the monthly allowance for destitute people were also deferred (GoCD, 1979).

In the event, total recurrent expenditure increased by 31% in real terms between 1978/79 and 1979/80 to EC$51.9m – that is, to a level 37% higher than had been estimated. However, this rise in part reflected an addendum to the 1979/80 budget that was introduced in January 1980 following industrial action by public servants. Under this addendum, public sector wage increases were announced bringing planned total recurrent expenditure up to EC$45.2. Public sector salaries accounted for 61% of this

new total To counteract the wage-push inflationary spiral that the GoCD anticipated as a consequence of this increase, the pauper allowance was also doubled.

Thus, total actual recurrent expenditure exceeded the final planned figure by only 14.9%. However, non-wage related expenditure alone was 59%, or EC$10.4m, higher (based on actual expenditure of EC$23 9m on wages and salaries, as reported by the World Bank (1985)). Nevertheless, it is difficult to identify any recurrent expenditure specifically made in response to Hurricane David other than a small amount expended through a special recurrent budget line, entitled Hurricane David Relief, which was created in 1979/80 to provide support to the disaster victims. This budget line received an initial allocation of EC$2m, with a small supplementary allocation in 1980/81. Actual expenditure totaled an estimated EC$2.2m over the two years, equivalent to only 1 9% of total recurrent expenditure over the same period, almost half of which was spent on supplies and materials However, available evidence suggests a considerable increase in expenditure under certain existing budget lines. For example, the budgetary allocation for casual labor in the Plant Propagation Division of the Ministry of Agriculture, Lands, Fisheries and Marketing was 76% higher than in 1978/79, reflecting the fact that it was 'a vital key to the rehabilitation program in the agricultural sector' (GoCD, 1979: 28). Similarly, the cost of casual labor for the maintenance of roads and bridges alone increased fom EC$0.74m in 1978/79 to EC$1.88m in 1979/80 However, the cost of supplies and materials under the same budget subhead fell 34%, to only EC$0.26m Subsidies were also paid to Statutory Boards whose finances had been seriously adversely affected by the dislocation caused by Hurricane David although, unfortunately, detailed information on the amounts involved are not readily available.

Capital expenditure had been set at EC$27.1m in the final 1979/80 budget, compared to actual nominal capital expenditure of EC$1.6m in 1978/79. Despite this substantial year-on-year increase, further rises were expected in subsequent years. As the 1979/80 Budget noted, 'much of the reconstruction work will be reflected in subsequent budgets spread over the next five years . as we have had to rethink our priorities and redesign projects that were already in the pipeline to take account of the new post David situation' (GoCD, 1979: 38). For example, capital estimates for the Ministry of Communications, Works and Tourism were much lower than in previous years due to the fact that many new projects were still being designed and therefore that accurate costings were not yet possible, although they were expected to be substantial. Indeed, as it turned out, actual capital expenditure was very low across the board, totaling only EC$10.3m.

Although, as already indicated (see Chapter 11), it is not possible to identify precisely which items of capital expenditure related to post-disaster rehabilitation, a large proportion of the total estimated capital budget was allocated to the agricultural sector, with particular emphasis placed on emergency food production, rehabilitation of banana cultivation, early restoration of facilities for boxing fruit and rehabilitation of plant propagation facilities for replanting of tree crops. In the event, this sector received 57% of total capital expenditure for the year Other clearly disaster-related activities included a pilot logging and sawmill project, aimed at salvaging fallen timber for use in housing reconstruction, and a building materials pilot project.

The increase in recurrent expenditure was partly met through additional external support, including STABEX transfers Overseas grants in support of recurrent expenditure totaled EC$26.8m, EC$24.8m higher than had been expected. Indeed, some 82% of total external grants and loans received in 1979/80 were in the form of budgetary assistance. Additional uncosted material aid was also reported to have been received in the form of goods and services (GoCD, 1980) Meanwhile, local revenue was 84% higher than expected, in part reflecting the announced re-introduction of duty on building materials and a number of other tax changes in January 1980 to meet additional costs relating to the public sector wage increases that were announced at the same time.

External grants and loans received in support of the capital sector in FY 1979/80 were much lower than originally expected, totaling only EC$4.7m compared to original estimates of EC$28.2m. The precise factors underlying such low flows of assistance are not clear but they presumably reflected difficulties in determining priorities and designing and processing aid projects under chaotic circumstances, as created both by the hurricane and extreme political difficulties.

The Government Budget for the following fiscal year was introduced just ten days after Hurricane Allen and, as such, revenue projections were again expected to require 'considerable readjustment' although these adjustments had yet to be made (GoCD, 1980: 4). Although the Budget included no changes in taxation, it had been anticipated that there would be a substantial increase in local revenue as the economy began to recover from Hurricane David Instead, following Hurricane Allen it was now expected that local revenue would have to be reduced by an estimated EC$10 6m, leaving an EC$28.6m deficit on the recurrent budget. Various steps were identified to help reduce this deficit, including that payment of arrears to civil servants would be delayed and that indiscriminate granting of tax and duty concessions would cease immediately. STABEX compensation of EC$10-11m was also anticipated as a consequence of the hurricanes

In the event, local revenue totaled EC$47.8m, only 4.8% or EC$2.4m lower than had been initially anticipated. Local revenue was boosted, in particular, by substantial increases in personal income tax and consumption duty revenues as, despite Hurricane Allen, economic performance improved (see Section 4.1). Recurrent expenditure totaled EC$62.6m, 11.8% higher in real terms than in the previous financial year, although expenditure was partly contained through strict controls. This implied an overall improvement in Dominica's recurrent fiscal budget, but still left an EC$14.8m deficit, in part financed by an EC$9.5m draw down under an IMF Program. In view of Dominica's serious budgetary difficulties, to which Hurricane David had been a major contributing factor, the GoCD had agreed a three-year program of assistance with the IMF in November 1980. Various expenditure targets were set under the program, both on overall spending and spending within particular sectors. However, the agreement also recognized that increased expenditure was required in certain areas, such as road maintenance.

Meanwhile, external capital revenue totaled EC$36.1m during FY 1980/81, compared to an original estimate of EC$71.4m. This shortfall was in part attributed to unusually heavy rainfall, which caused severe additional damage to the road network and hampered 'work in the field' (GoCD, 1981. 5). Financing for some projects was also not forthcoming, particularly for road infrastructure and health.

As already indicated, the budgetary implications of Hurricane David and years of poor public infrastructure maintenance continued to be felt for a number of years as rehabilitation and reconstruction projects, including some major road projects, were gradually implemented. Annual capital expenditure was, on average, 61% higher in real terms in each of the years 1981/82-1985/86 than in 1980/81. Heavy rains experienced as a consequence of a further hurricane, Klaus, in 1984 also probably played a role in prolonging road reconstruction. These capital projects were met almost entirely through external grants and loans. Indeed, in large part because of Hurricane David, Dominica experienced a relatively rapid increase in its outstanding external debt, rising from US$15.2m at the end of 1979 to US$42.7m by the end of 1984, including obligations of US$10.5m to the IMF (World Bank, 1985).

C.2 Hurricane Hugo

In the 1989/90 budget estimates presented in mid-1989, the GoCD had envisaged total recurrent expenditure of EC$108.9m over the forthcoming fiscal year. A current account surplus of EC$22.6m was also forecast, which would be put towards the PSIP.

The subsequent occurrence of Hurricane Hugo in September 1989 contributed to only a marginal 2.1% rise in recurrent expenditure as compared to the original GoCD estimate, suggesting that there must have been considerable reallocation of resources within the recurrent account. Despite an improvement in efficiency of the tax system, local tax revenue was also EC$11.9m or 8.8% lower than had been expected, reflecting poor economic performance (see Section 4.1), unfavorable exchange rate movements and the suspension of the banana development levy. The latter measure was implemented to alleviate pressure on the agricultural sector, in turn caused both by the hurricane and low EC$ banana prices, and alone resulted in a EC$3.8m loss in estimated revenue, as earnings from this source fell from a projected EC$4.5m to only EC$0.7m. The overall recurrent account surplus for the year was reduced to EC$11.8m from EC$17.5m in the previous fiscal year.

Meanwhile, overall flows of external grant and loan assistance totaled EC$57.6m, including unanticipated hurricane relief of EC$7.6m, compared to the original figure of EC$27.5m contained in the 1989/90 estimates (GoCD, 1989).

Total public sector savings fell from EC$44.4m in 1988 to EC$25m at the end of 1989, in most part reflecting a draw down of DBMC reserves to assist banana farmers. Central government savings alone fell from EC$19.1m to EC$6.1m over the same period, again in part reflecting the temporary use of local funds to compensate farmers for losses sustained as a result of Hurricane Hugo in anticipation of subsequent STABEX transfers, and in part reflecting the suspension of the banana development levy.

In relative terms, current expenditure remained unchanged in 1989/90 at about 25% of GDP. However, capital expenditure rose by some 5 percentage points to 19% of GDP, in part reflecting activities under two non-disaster related domestically financed port projects, which were completed the following year. The weakened fiscal position led to increased domestic borrowing and, in turn, to a tightening of credit markets, as the lending rate to the private sector was increased by 1% (World Bank, 1992). In FY 1990/91 there was a further decline in the current account surplus to 1.5% of GDP as certain tax reductions were introduced, in part apparently to alleviate the impact of Hugo, and a 21% retroactive civil service pay increase was implemented.[92]

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[92] Tax relief measures included a reduction in the corporation tax from 35 to 30%; tax exemption for interest income, hotel bar and restaurant sales and for distributed profits in the form of bonds; reduction of the hotel occupancy rate from 10 to

The banana development levy was reinstated in 1990/91, contributing 4.4% of total local revenue and 1.8% in 1991/92. However Hurricane Hugo was a significant underlying factor leading to a further suspension of the levy in 1992/93, in order to relieve pressure on the agricultural sector and to allow the DBMC to manage its cash flow, following a deterioration in the sterling-US dollar exchange rate and a subsequent fall in banana export earnings (GoCD, 1994).[93] In restructuring of the corporation's debt, the GoCD eventually wiped off the arrears on the levy owed by the DBMC and the levy was never reinstated, although annual Budget estimates continued to assume some revenue from this source until FY 1996/97

C.3 The 1995 Storms

In the 1995/96 Budget Address presented in mid-1995, the GoCD had indicated total recurrent expenditure of EC$182.3m and central government capital expenditure of EC$104.0m over the forthcoming fiscal year. It was anticipated that the latter would be partly met through external grants totaling EC$38.6m and concessionary loans totaling EC$28.8m with an additional EC$8m raised through a capital review, leaving an EC$28.6m financing gap.

In the event, total recurrent expenditure was 8.1% lower than planned whilst capital expenditure totaled only EC$23.9m – equivalent to a mere 23% of the GoCD's original estimate and 57.8% lower (in real terms) than the previous year - in part as a direct consequence of the 1995 hurricanes. The following year, capital expenditure remained low, at only 8.0% above the FY 1994/95 figure despite considerable post-disaster rehabilitation needs (see Annex A) The GoCD attributed low expenditure on the capital account 'to delays in the implementation of projects arising from the non-satisfaction of conditions precedent for disbursement of funds from lending agencies coupled with the utilization of government's counterpart funds for Capital Projects in order to satisfy emergency rehabilitation requirements, following the passage of hurricanes Luis and Marilyn' (GoCD, 1996b: 5) In other words, the storms themselves were in part responsible for low capital expenditure, rather than generating immediate additional external investment resources to fund rehabilitation.

Local revenue receipts were 5.1% or EC$9.1m lower than expected in FY 1995/96, again in part a consequence of the storms. Import duty on chicken was suspended from October 1995 to March 1996 in order to provide some relief to citizens in the immediate post-hurricane period. For the third year running, no revenue was also collected under the banana development levy.

In part as a consequence of the impact of the 1995 storms, the GoCD began discussions with the IMF in 1996 about a possible package of reforms, although no agreement was ever reached The GoCD decided to enter into such discussions in view of its continuing fiscal and balance of payments difficulties, in part disaster related; growing awareness on the part of the GoCD that access to external assistance could become increasingly difficult if it did not take action to correct fiscal imbalances or thus to meet its loan obligations on schedule; and donor pressures for reform. Meanwhile, the 1996/97 budget was austere, reflecting both the fact that revenues would be limited by the economic downturn following the 1995 storms and continued donor pressures to implement structural adjustment Nevertheless, the GoCD was reported to be unable to achieve its target of fiscal savings of 2.5% of GDP by FY 1996/97 due to economic difficulties relating both to changes in the banana industry and the continuing effects of the 1995 storm devastation (GoCD, 1998).

C.4 Mitigation and Preparedness

The GoCD has also invested some public resources in disaster mitigation and preparedness. However, it is not possible to estimate the full cost of such measures because some – for example, the hurricane proofing of public buildings – are not reported separately or even at all. Indeed, the only capital investment mitigation measures that the GoCD has undertaken which can be more easily quantified are those relating to sea defense and volcanic monitoring and hazard mapping. The latter totaled EC$0.6m (at real 1990 prices) between the late 1980s and early 1990s.

Sea defense works have been conducted under a number of budgetary heads, including not only the Ministry of Communications, Works and Housing but also the Ministry of Tourism, Ports and Employment (under headings of airport and harbor). There was some limited capital investment in sea defense in the 1970s but, according to a review of annual government budget statements, no further expenditure was undertaken until the 1990s. Some EC$0.8m (at real 1990 prices) was then spent

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5%, introduction of a 10% investment credit, and revision of the capital allowance in order to shorten the period over which assets could be written off (World Bank, 1992).

[93] Formally the GoCD introduced a reduced rate but in practice did not even enforce collection of the levy at this reduced rate.

on a government-financed sea defense project between 1992/93 and 1998/99 Additional expenditure was undertaken as part of an EC$15.6m British-funded bay front development project for Roseau, and under an EC$1.3m airport sea defense project A significant further increase in spending was anticipated under the 1999/2000 Budget, together with some road rehabilitation costs totaling over EC$22m, in part as work on CDB and World Bank sea defense and wave tidal protection projects was begun.

In the past, the recurrent budget also included an allocation under the Ministry of Communications, Works and Housing (General Maintenance Services) for sea walls and river damage repairs and control. However, although EC$5,000 was consistently allocated for sea wall maintenance over the period 1975/76-1978/79 and again from 1981/82-1984/85, no actual expenditure was ever made and the budget sub-head was subsequently dropped. Similarly, an allocation of EC$15,000 was made for river damage repairs and controls under the 1976/77-1978/79 budgets and again in 1980/81 but no expenditure was actually undertaken. Subsequently, between 1982/83 and 1988/89, a total EC$44,299 (at real 1990 prices) was spent under this budget line but there have been no more recent allocations specifically earmarked for river damage repairs and control.

As regards preparedness, small levels of capital expenditure have been intermittently made on supplies and materials Some recurrent resources have also been allocated to preparedness, including via the GoCD's contribution to the regional organization CDERA and, since it was created in 1995/96, the GoCD Office of Disaster Management (ODM). However, budgetary allocations remain small with, for example, only EC$145,639 approved for the ODM under the 1999/2000 budget.