Chapter 6.

Infrastructure and Buildings

6.1 Vulnerability, Design Standards and Costs

The vulnerability of key infrastructure to natural hazard was highlighted in Dominica by the devastating effects of Hurricane David. Almost all public utilities, water, electricity, telephones and other essential transport infrastructure, ports, roads and airports, were out of action, at least briefly. Hospitals, clinics and schools too were wrecked. The regional devastation caused by this and subsequent storms such as Hurricanes Allan and Hugo stimulated wider interest in reducing vulnerability through incorporating more effective mitigation into design and construction during reconstruction and new investments. It is also widely recognized that there are other pervasive reasons for the precarious state of key infrastructure in most of the small independent Caribbean island states. There is a lack of maintenance and repair, shortage of skilled personnel and poor fiscal performance that starves systems of funding for adequate levels of recurrent expenditure. Investment is heavily dependent on and constrained by external grant aid and official lending.

All these interrelated issues have received growing attention during the past decade, and been the subject of technical investigation and policy analysis. For example, the regional infrastructure review in 1996 by the Caribbean Development Bank (CDB) and Inter-American Development Bank (IADB) focused on financing and structural issues of organization, according recognition to the issue of disaster mitigation. These issues are now accorded priority in the documentation for the Consultative Group for the Caribbean (World Bank, 1998b). Hazard vulnerability in particular has been investigated extensively by the Caribbean Disaster Mitigation Project (CDMP), implemented by OAS and USAID funded This program has included several insightful case studies for Dominica, including on the more general problem of wave hazard to coastal infrastructure (Wagenseil and Watson, 1996), the original design of the deep-water port (Wason, 1998) and minimizing the threat to the expanded hydro-electric system from landslide (OAS, 1996b). The GoCD, wanting to reduce the vulnerability of its coastal road network (see Section 6 5), has, with UK government (ODA-DFID) assistance, commissioned studies on mitigation investment (Mouchel, 1991, 1997).

It is beyond the scope of this study to provide further in-depth analysis on these often highly technical issues of design and construction standards. Nevertheless, evidence has continued to accumulate that there has been limited success to date in reducing the hazard vulnerability of key infrastructure, particularly as indicated by assessments of the effects of Hurricane Lenny. The issue of the considerable damage inflicted by the major storms on the island's infrastructure is not in question. However, there are issues that require elaboration and explanation. First, why was it that Dominica proved to be so vulnerable to the catastrophic Hurricane David? Was this virtually inevitable, or, as is suggested in Section 6.2, did the economy's development trajectory contribute to vulnerability? Second, the links between the damage to infrastructure and the effects that major natural disasters were found to have had on Dominica's economic performance at an economy-wide (Chapter 4) and sectoral level (Chapter 5) need to be examined. Section 6.3. seeks to complement evidence of the negative economic impacts of the major disaster shocks of 1979-80, 1989, 1995 and 1999, with approximate estimates of the rehabilitation costs resulting from these storm events. Third, the CDMP case studies have suggested that failures of infrastructure can be traced to under-investment in mitigation during design and excessive cost-minimization during construction (Vermeiren, Stichter, and Wason, 1999). These findings as they concern Dominica are restated and re-examined in sections 6.4-6.6 in the light of developments subsequent to these studies, particularly Hurricane Lenny

6.2 Modernization and Investment in Infrastructure, 1950-1978

Dominica was transformed between 1950 and 1978 from an underdeveloped plantation cum subsistence colony into an independent middle-income economy with a GDP per capita of EC$3,960 (US$1,470) in 1998 prices. By 1978 there were relatively good human development indicators for health and education that reflected investments in schools, hospitals and housing, combined with key economic infrastructure.[39] The key lifeline infrastructure included an all-weather road network, largely coastal around almost the whole island, linking all important centers of population (Map 1). The completion of a deep-water port on the northern edge of Roseau, as well as facilities at Portsmouth, combined with the road system allowed relatively easy export of bananas, the highly perishable major crop. The two airports, although only suitable for smaller planes, and port facilities made access easy for visitors. There was a near island wide public electricity network by 1974, partially supplied by hydroelectric power, and a telecommunications system.

A critical issue in the provision of island wide lifeline infrastructure was that it was put in place relatively quickly, largely funded by UK colonial aid plus some CDB lending and Canadian aid. There were severe financial constraints because of the competition for colonial grant and highly concessional funding and those responsible for design were under pressure to maintain the lowest possible construction costs (Honychurch, 1995). Moreover, these investments occurred after a lengthy period during which the island had not experienced any direct impacts from hurricane force storms. Because of these two factors, inadequate consideration was given to disaster mitigation, as subsequently and cruelly exposed by Hurricane David.

The high costs of rehabilitation after Hurricane David and subsequent major storms have led to careful investigation into the technical sources of vulnerability. These investigations demonstrate notably in the case of the coastal road system that hazard mitigation was not sufficiently seriously considered under the pressures to provide infrastructure quickly at low initial investment cost (Section 6.4). In addition, infrastructure has been located in especially vulnerable sites where there are no protective physical features. One example is the deep-water port at Woodbridge Bay. The port facilities project out into deep water where the dock has to bear the full force of the waves. The evidence from 1995 confirms that many sites are vulnerable to a direct hit from a Category 1 hurricane, such as Marilyn, which Wagenseil and Watson (1996) estimate to be a 10-year event (see Annex A.3). Virtually all coastal infrastructure is extremely vulnerable to a direct hit such as Hurricane David, estimated as a 50-year event. Hurricane Lenny is difficult to place in this categorization of risk, because it caused 6-meter waves that would normally be associated with the center of a Category 4 hurricane close to the island in a 50 year event.[40]

6.3 Major Storm Damage and Rehabilitation Costs

An attempt is made in this section to provide an approximate order of magnitude of the overall cost of damage and related rehabilitation caused by the most severe storms since Independence.[41] Such estimates are necessarily approximate given the incomplete and uncertain data, based largely on immediate post-storm assessments combined with some retrospective estimates of actual rehabilitation.[42] The results of these calculations are shown in Table 6.1 in current prices for the years of impact. These costs also leave out the damage from less severe storms, as in 1984 and 1994, and landslips that are not directly associated with storms, including the 1997 Layou River event, and higher costs of construction for the expanded hydro-electricity project.

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[39] The transformation is documented by Honychurch (1995). A qualitative sense of what this transformation in transport achieved is provided by contrasting post-independence conditions with those described by Patrick Leigh Fermor in the late 1940s – landing in Roseau from an inter-island vessel, traveling on by boat to the second center, Portsmouth, and then by mule and on foot to the east coast Carib Territory and back across the central forests to the capital (Fermor, 1950).

[40] During the period November 17-19,1999, when affecting Dominica, Hurricane Lenny reached Category 4 in the Leeward Islands (Map 3). In Dominica, there were visual reports and photographic evidence of very high seas, on verbal evidence of up to 20 ft or 6 meters, but there was no scientific monitoring of wave sizes. (Annex A contains a description of the Hurricane Categories and historical information on their frequency, reflecting a combination of proximity and wind strength) .

[41] Rehabilitation is taken to include repairs and reconstruction costs to provide broadly equivalent facilities. Some rehabilitation assessments include not only repairs but also some element of additional mitigation investment. This mitigation cost has been excluded where possible from the rehabilitation cost estimates indicated in Tables 6.1 and 6.2.

[42] For example, there was no readily available disaggregated assessment of the damage caused by Hurricane Hugo.

Table 6.1: Housing and Infrastructure Damage from Major Tropical Storms and Rehabilitation Costs 1979-1999 (EC$m current prices)

	Hurricane David 1979-80	Hurricane Hugo 1989	3 storms 1995	Hurricane Lenny 1999
1. Buildings				
Housing	27.0 (5 3)a	..	4.3	2.7
Public & Commercial	26.8 (8.8)a	..	8.6	8 9
(Sub-total)	53.8 (13 1)a	5.0	12 9	11.6
2. Utilities/Infrastructure				
Roads/sea defences	10.1	...	33.8	70.2 (124.7)b
Water	2.3	...	0.8	0 3
Electricity	5.0	..	0 7	0.2
Telecommunications	3 0	...	2 1	2.0
Port (DPA)	7.8	...	1.2	3.5
(Subtotal)	28 3	15.0	39.1	76.2 (130.7)b
3. Total	**82.1** **(44.1)a**	**20.0**	**52.0**	**87.8** **(142.3)b**

Source: ECLAC, 1979, UNDRO, 1980; Wason, 1984, Mitchell, 1994, GoCD, 1995,1999c,d, Liautaud, 2000

Notes: a. Figure in brackets includes publicly and aid funded reconstruction projects only

b Includes estimated full cost of road and sea defence, including mitigation measures (Liautaud, 2000)

. Not available separately.

Table 6.2 Hurricane Damage and Rehabilitation Costs to Infrastructure and Buildings (EC$m constant 1999 prices)

	Buildings	Utilities/ Infrastructure	Total Cost
Hurricane David, 1979/80	136.8	72.0	208.8
Hurricane Hugo, 1989	6 7	20.1	26.8
3 Storms, 1995	13 5	40.9	54.4
Hurricane Lenny, 1999			
a. Excluding full upgrading	11 6	76.2	87.8
b (Including full upgrading)	11.6	(130 7)	(142 3)
Total 1979-99 (Including upgrading)	**170.0 (347.7)b**	**210.0 (522.3)b**	**380.0**

Source: Table 6.1

Notes The estimates of damage and rehabilitation costs in current prices (Table 7.1) have been converted to 1999 constant prices using the 1990 GDP deflator. Buildings include housing, public offices, schools, hospitals, private commercial and non-commercial buildings Utilities and infrastructure includes roads and related sea defenses, electricity, water and sewage, telecommunications, DPA assets and airports.

a. Excludes full reconstruction costs of roads including upgrading sea defenses (Liautaud, 2000)
b. Includes full cost of upgrading sea defenses according to the Mouchel (1997) report modified by the Ministry of Communications, Works and Housing (GoCD, 1999d) and reassessed by Liautaud (2000).

Table 6.2 shows the major categories – building and infrastructure – in constant 1999 prices. These calculations suggest that the rehabilitation costs of major storms since 1979 amounted to around EC$380m (US$140m) in 1999 prices, equivalent to EC$18m per annum, and for key economic infrastructure alone - roads, electricity, water, telecommunications and international transport links – around EC$10m. Hurricane David, the most severe event, accounted for around 55% of total rehabilitation costs Buildings, including social infrastructure of schools and hospitals have accounted for around 45% of total costs and economic infrastructure for 55%. However, probably around 80% of the total damage to buildings over the period of analysis was caused by Hurricane David in 1979. In contrast, the levels of damage to economic infrastructure have remained high in subsequent storms, particularly to roads and related public sea defenses. Roads and public sea defenses accounted for only 36% of total estimated reconstruction costs following Hurricane David, compared to over 80% in 1995 and 90% in 1999 Dominica Port Authority (DPA) assets, including the deep-water port at Woodbridge Bay and at Portsmouth Harbor have also continued to suffer substantial damage. Telecommunications costs have remained relatively high as well. These temporal patterns of damage and the scale of reconstruction costs raise important issues for further consideration concerning building damage and the concentration of infrastructural damage after 1979 in the road system, related public sea defenses and the ports.

6.4 Deep-water Port at Woodbridge Bay

Prior to the construction of the deep-water port at Woodbridge Bay between 1974 and 1978, Dominica had no deep-water facilities either in Roseau or Portsmouth. This port was designed to facilitate banana exports and reduce handling costs of imports. The project was 80% financed by the CDB with USAID funds. The project cost was initially estimated in 1972 at EC$5.4m with a CDB contribution of EC$4.32m. A social internal rate of return of 13% was achieved by scaling down to just over half the original design The facility was completed just prior to Hurricane David at a cost of EC$13m, reflecting costs inflation over 5 years, financed through a CDB loan.

The port project involved a 500-ft wharf facility for ocean going vessels, provision of ancillary buildings and reclamation of 5 acres of land It is located on an unprotected site. but some attention was given in the design to 'inconvenient swell' of up to 6ft (2 meters) in the absence of robust wave data.[43] The sea defenses were based on the 1971 preliminary design and feasibility study, but further modified to reduce costs This was despite a separate ODA-funded Delft study of wave conditions made available in June 1972, which indicated the risk of a maximum significant wave of 16ft (5 meters) every 10 years. At the time of construction there had not been any major hurricane impact in Dominica for more than 20 years.

Hurricane David in 1979 extensively damaged the newly completed facilities. Trestles were damaged and the fender system lost Half of the transit shed and the banana store were put out of commission. However, the port was only unable to operate for 2/3 days The total rehabilitation cost of damage to all the facilities was estimated at EC$10.6m, equivalent to 41% of the initial investment cost in constant price terms (Table 6.3). In comparison, had the original structure been designed and built to withstand Hurricane David (Category 4) winds and wave action, the initial investment cost would have been only 11% higher (Wason, 1998).

Enhanced facilities were incorporated into the restoration works. In particular, an improved fendering system was installed and concrete dolos were incorporated as sea defense works. These enhanced facilities worked well and the port was unaffected by Hurricane Hugo.

Extension to the port was undertaken in 1990-91, adding a further 300 ft to the south. The extension was Government funded, financed through local bank lending at a commercial 10% rate of interest. The DPA also took on 2 5 acres (1 ha) for expansion in container storage. The cost of the works was EC$18.5m, which is still being repaid.

Hurricane Marilyn in 1995 caused damage to the ferry terminal and the fendering system on the western side of both the original wharf and the new extension. Overall damage assessment to all port facilities was EC$1.4m.

Extreme sea swell problems were re-examined in a 1994 climatic vulnerability study of OECS ports, undertaken with CIDA funding. The study indicated that in more extreme wave conditions the originally 500-ft jetty would have problems withstanding uplift pressure. In response to the study, concrete overlay work was done to reinforce the 500ft deck in 1995/6, with similar work undertaken to the Portsmouth port The upgrade cost US$1.3m, of which $1m was funded commercially and $0.3m from local funding. At the time it was believed that the 1990 extension to the jetty was adequate to meet all but most extreme wave pressure However, Hurricane Lenny in 1999 is thought to have produced swell and wave conditions equivalent to or exceeding the 5-meter level first identified in the 1972 Delft study. The upgraded original jetty was unaffected, but the storm caused extensive damage mostly to the 1990 extension, estimated at US$1.3m.[44]

This case highlights the issue of mitigation against storm damage and the returns to infrastructure investment. The original investment had an estimated return of 13% (CDB, 1972). However, the immediate damage incurred in 1979 added 41% to investment costs. Damage from Hurricane Marilyn and Lenny have also added over EC$4.8m to the cost of the port facility. These impacts and costs of repair and further mitigation measures suggest under-investment

[43] The west coast of Dominica is exposed to the Caribbean Sea and relatively minor sea-swell occurs during most of the year. While there were no statistical data available as to the frequency of 'inconvenient swell', it was believed that for Woodbridge Bay, on average, the number of days when vessels would not be able to use the proposed wharf facilities would be not more than 15-20 days per year (Wason, 1998).

[44] The main damage to the port was the destruction of approximately 13,000 ft^2 section of reinforced concrete deck to the main wharf by wave forces on the underside of the deck Other damage included the collapse of a 530-ft section of chainlink fence and three 33-ft high electrical poles There was also some damage to the fender system. The asphalt concrete top course to the area around the banana shed also needs to be restored. The specific reason for failure appears to be composite deck design involving precast concrete slab units instead of an extended single section with overlay.

in mitigation of around 25% of capital costs in the original design and of around 20% in failing to reinforce the extension to the same level as the original facility in 1996. These additional costs also cast doubt on the original internal rate of return calculations.

The impacts have been largely in terms of damage to capital structure, with limited impacts on business. The most severe hurricane, David, did not prevent movement of goods, as services were quickly being restored within days of the hurricane. The recent Hurricane Lenny affected the port operations largely in terms of rescheduling. One week's banana exports were lost and the cruise ship sector disrupted for about four or five weeks.

Table 6.3: Deep-water Port, Woodbridge Bay: Investment, Rehabilitation and Mitigation Costs

Cost Item	Date	Cost in EC$ million	
		Current prices	Constant 1999 prices
1. Original Facility	1976-79	13.1	57.7
2. Post-David rehabilitation	1979-81	10.6	22.1
3. Port Extension	1990/91	10.5	22.5
4. Post-Marilyn rehabilitation	1995/96	1.2	1.2
5. Reinforcement of original facility	1995/96	3.5	3.5
6. Post-Lenny rehabilitation	on-going	3.5	3.6

Source: DPA, CDB, Wason (1998)

This case also raises an awkward issue of economic analysis. The port was regarded as lifeline or 'necessary' infrastructure for a modern economy – sustaining exports of highly perishable top quality bananas (although now in decline) and minimizing handling costs. Economic calculations taking into account anticipated additional export volumes and cost savings indicated that the initial design (1972) was not viable. The designers, under pressure to maintain the lowest possible construction costs, therefore almost halved the scale of the facility and did not take into account a further assessment of hazards (Wason, 1998). Underestimation of hazard risk appears to have reoccurred under continued financial pressure in designing the subsequent 1990–91 extension and in failing to make the extension more hazard resistant in 1996. In contrast, the re-assessment of hazard risks and retrofitting of the original facility in 1981 and 1996 were fully vindicated in 1999. After Hurricane Lenny had put other berthing facilities out of action, the original Woodbridge Bay wharf, because of reinforcement in 1996, acted as the sole lifeline link. It served banana exports, Dominica Coconut Products (the only significant industrial unit which had lost the use of its own jetty) and other importers, and without it there would have been economy-wide disruption (Map 2).

6.5 Sea Defenses and Storm Hazards : the Road System

The greater part of Dominica's road system is located on the narrow coastal strip of the island very near to the shoreline and so is subject to extensive damage during storms. The damage results from a combination of direct sea erosion of sea defenses and the road, plus floods and landslips.[45] The only important exception is the cross-island road linking the capital and the main airport, Melville Hall, and the rest of the north coast (Map 1). The disruption caused by storm-related damage has direct consequences for economic and social activity. Other key infrastructure - electricity, telecommunications and water transmission and distribution networks - accompany the road along the

[45] The CDMP Wave Hazard Assessment (Wagenseil and Watson, 1996) highlights the vulnerability of the Western shore to heavy storms. The shore is open, with no distinct bays; it is steep with narrow under-water shelving and talus slope. Steepness means that coastal flooding will not penetrate far inland, but it has also forced the construction of the main coastal road and other important infrastructure into precarious sites right on the shore. The repeated damage from storms since 1979 has highlighted this exposure. The potential scale of storm hazard is indicated by the CDMP study, which was undertaken in the absence of regular and reliable monitoring of waves and water levels. The study concludes that storm damage is directly related to local construction practices, which reflect the uneven distribution of risks.

narrow coastal strip and are also likely to be disrupted, as after Hurricane Lenny (Map 2). The repeated need to repair and rebuild roads and rehabilitate other key infrastructure also exerts pressure on public finances and those of separately financed utilities – an issue considered more fully below in Chapter 10

The sea defense/road issue was highlighted by the damage caused by Hurricanes David and Allen (Table 6.1) Post-disaster assessments following these storms also exposed the difficulties of separating storm damage from the effects of poor maintenance. Moreover, subsequent storm damage showed that the post-David and Allen program of rehabilitation of EC$10m, begun in 1980/81 failed to address seriously the problem of vulnerability of the road system. Further extensive damage was sustained in 1989, 1995 and 1999, with more localized damage also experienced as a consequence of other storms. The assessed damage from Hurricane Lenny to the roads and other key infrastructure again highlighted the inevitable damage that follows on any major storm and provides a measure of the outstanding problems of highly vulnerable sea defenses.

The record of investment in sea defenses and more robust standards for roads is in fact patchy. There have been some exemplary investments to high levels of robustness, notably the sea wall in Roseau, some of the new sections of coastal road built to higher storm resistant specifications towards Pointe Michel and the trans-island road from Roseau to Melville Hall. However, because of financing and other constraints on major public works, subsequent studies and reviews suggest that broadly the GoCD has adopted a strategy of minimum necessary repairs in the aftermath of each storm to allow resumption of normal use (see Section 10.4). In particular, the standard use of gabions as sea defense structures is good enough for ordinary weather, but they are not designed to withstand hurricane force sea conditions.[46]

Damage assessments for the major hurricanes since 1979 give some approximate indication of the likely level of damage to the road system in the absence of substantial mitigation measures. The estimated total rehabilitation cost over 30 years has been around EC$145m at current (1999) prices. In addition, as the review of utilities and buildings considered below indicates, much of the other infrastructural damage is also associated with the poor sea defenses for the coastal road network. Meanwhile, the Mouchel 1997 study estimated the cost of mitigation measures to protect against storms of up to category 3 with a return period of 10-15 years as EC$93m. The West Coast element of the coastal protection strategy has been re-estimated at more than EC$100m in the Ministry of Communications, Works and Housing's damage assessment for Hurricane Lenny (GoCD, 1999d) and over EC$ 120m by the World Bank's assessment mission.

The apparent slow progress in providing sea defenses partly reflects the scale of investment financing required (Mouchel 1997 and Map 2). Other factors have also slowed the rate of action on a now widely acknowledged problem of vulnerability. There is a lack of donor coherence in addressing the vulnerability of the whole network, rather than a series of separable local problems. Reflecting this, in practice sea defense mitigation investment is being taken up piecemeal by individual donors as separate projects for specific sections of road - for example, by the CDB and DFID, or as a component of a broader disaster management project by the World Bank (See Box 13.1) The choice of road sections to be upgraded and protected may then reflect different donor priorities, such as contributing to overall economic development or targeting poorer geographical areas. The process of design and construction is also subject to the procedures of different organizations, for example for tendering for services and procurement

6.6 Public Utilities: Telecommunications, Electricity and Water

The three key utilities were rapidly expanded in the final pre-independence era. In the case of electricity and water this expansion was undertaken through monopoly public bodies Telecommunications was provided by the then UK government-owned Cable and Wireless Company (C & W). All three systems suffered devastation during Hurricane David, which caused almost complete short-term disruption to services. Between 1979 and 1980 both electricity

[46] Many coastal structures are built on wire gabions, baskets filled with stones. The foundation under the gabions may be concrete common casting placed over rounded cobblestones, or there may be no foundation at all. Gabions get much of their strength from friction amongst stones in the basket. The lubrication and buoyancy of storm floodwaters weaken these structures.

generation and the number of connected telephones declined by over half, reflecting both physical impacts on the networks and weakened demand due to commercial disruption. The costs of rehabilitation were considerable, as shown in Table 6.1. Repair and reconstruction were hampered by Hurricane Allan a year later (CDB, 1980). Potable water, electricity generation and distribution and telephone connections only recovered to pre-devastation levels by 1982-83. Post-storm assessments drew attention to poor maintenance, linked to weak cost recovery in supply, during the 1970s which had contributed to increased vulnerability. In the process of rehabilitation, efforts were made to reduce future vulnerability by the introduction of mitigation measures.

Telecommunications

In the case of telecommunications, the ruined network of overhead wires was extensively replaced by underground cable. The C & W headquarters and main depot in Roseau were also rebuilt according to hurricane resistant designs. The relative success of this mitigation effort is reflected in the reported cost of damage in 1995 and 1999, set beside the considerable expansion of the network from 3,120 to 19,424 connected telephones between 1978 and 1998. The overall growth of the network, both residential and commercial, shows no impact from subsequent shocks comparable to those caused by Hurricane David. The substantial damage to the network caused by Hurricane Lenny in 1999 occurred where underground and overhead cables had been installed alongside sections of coastal road damaged by the storm.

Rehabilitation and expansion with a high level of disaster mitigation have been internally financed by an international company that has been the monopoly provider of telecommunications services in Dominica and other former British colonies. Some cell phone communications are now being installed. Currently the tariffs for telecommunications are widely perceived in Dominica as high compared with North America, raising issues of competition and deregulation. From a disaster mitigation perspective, this poses a challenge of ensuring that possible technical and organizational change in the network – the introduction of cell phones or entry of additional service providers – does not jeopardize safety standards.

Electricity Supply

The power system was not restored in size and capacity to pre-David levels until mid 1983 (CCA, 1991). However, the high cost of installing the island's ring main and other critical components underground was regarded as impracticably high because of the mountainous, rocky terrain and wide dispersal of the small customer base – only 22,000 by the mid 1990s, already providing access to electricity to 93% of the population. The transmission and distribution network therefore remain highly vulnerable and require high maintenance standards.[47] The impact of Hurricane Lenny appears to exemplify the continuing problem of vulnerability of a distribution system that supplies a largely coastal population with overhead transmission following the coastal roads. The damage was comprised of a combination of broken local lines, where the road and utility distribution run together, and disrupted supply to houses also destroyed or damaged.

Nevertheless, although storms after Hurricane David have done damage to transmission and distribution, this damage has been localized and overall growth in the supply of electric power has been sustained. The main source of variability in generation has been associated with the expansion of hydroelectric capacity rather than storms.

To reduce the structural import deficit and vulnerability to price shocks, the longer-term power supply strategy has been to increase the hydro-electricity capacity.[48] After immediate post-David rehabilitation was completed that strategy was realized through the Dominica Hydro-Electricity Expansion Project, which more than doubled hydropower generation after completion in 1991/92.

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[47] According to the CDB and IADB (1996) infrastructure report, maintenance is a continuing area of weakness associated with high transmission losses (about 17%) and poor financial performance.

[48] The Prime Minister stated in 1979 'I am proposing to do all in my power not only to see the electricity supply restored, but the hydro-electricity supply in particular. Dominica has ... a natural advantage which it must now exploit'(GoCD, 1979: 6).

However, hydro-systems are potentially vulnerable to landslides and flood hazards [49] A CDMP study found that problems encountered in construction and re-assessment of landslide and flood hazard delayed the completion of the hydro-power extension project and resulted in identifiable additional costs of over EC$1m (OAS, 1996b). Soon after completion landslide related repairs cost in excess of EC$100,000, plus loss of revenue from reduced power generation. The original 1984 design criteria failed to reflect best available information on landslide hazard, resulting in additional costs.

The CDMP study also draws attention to the scope for hazard damage reduction and improving operational performance by regularly re-evaluating retrofitting (additional investment) as against repair options and by re-assessing maintenance schedules.[50] These are, as the ports, roads and sea defense cases have already shown, policy issues of more general relevance (see Chapter 13).

Water Supply

The Dominica Water and Sewerage Company (DOWASCO) is singled out in the CDB and IADB's (1996) infrastructure report as 'a unique publicly owned private corporation', that underwent a successful restructuring to overcome problems of debt and poor cost recovery, whilst providing near universal provision of potable water and public sewage disposal where viable.

Like the rest of Dominica's public infrastructure, its predecessor had been in dire financial straits by the mid 1970s. The water and sewage system then suffered severe damage and temporary disruption as a consequence of Hurricane David, with considerable rehabilitation costs (Table 7.1). Despite the introduction of a new tariff also in 1979, the water authority was unable to collect sufficient revenue to cover capital and recurrent costs and 'fell into a chronically dilapidated, deficit-ridden state'.

After the formation of DOWASCO in 1989 the company was turned round with revenue collection sufficient to cover both capital and recurrent expense by 1995. By the same year, the system provided some 90% of the population with access to potable water, although 45% of these use standpipes It now has over 12,000 customers, almost all metered, with enforced monthly payment.

Domestic, industrial and commercial consumption has steadily expanded while severe tropical storms have had no significant impact on levels of use since 1980. The effects of Hurricane Lenny are consistent with the wider pattern of localized damage to infrastructure, concentrated along the route of the west coast road and includes installed facilities on exposed west coast properties. DOWASCO's detailed estimate of rehabilitation costs totaled EC$342,000, equivalent to just under 5% of its annual revenue. This is still a significant cost to a public corporation operating under very tight financial constraints, but is much less than the massive post-David and Allen rehabilitation costs, which were equivalent to 140% of annual revenue in 1982, the first year in which more normal cost recovery had been re-established .

6.7 Buildings and Housing

Unfortunately, a detailed investigation into the impacts of storm damage and mitigation measures in this economically and socially important area is beyond the scope of this study. There is a lack of readily available satisfactory data other than some for public buildings, making it difficult to explore what has been happening. However, a few issues require attention because they relate to other aspects of this economic study. The social implications of disaster impacts on housing are discussed in Chapter 12.

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[49] This was dramatically demonstrated by the effects of landslides triggered by Tropical Storm Danielle in 1986 on St Vincent, which reduced generating capacity on the island by 36%.

[50] The first example cited is the choice between repair and more costly redesign or installation of protective measures. The second example is where turbine blades are being replaced regularly earlier than their design life, due to sediment, and it may be more cost-effective to increase maintenance of intakes and other points where sediment can be removed.

There appears to have been relatively limited damage, or at least assessed damage, to the housing stock other than that incurred as a consequence of Hurricane David. However, localized damage can still be substantial and severe, as demonstrated by Hurricane Lenny in coastal and relatively poorer fishing communities. The publicly funded share of rehabilitation costs has also been relatively limited – actual public projects of EC$5 3m after the storms in 1979 and 1980 were spread over several years . These projects in current prices for 1980 and 1981 were equivalent to only 18% of the initially assessed damage in 1979 (Table 6.1). That implies that 82% of costs were met privately by those affected.[51] There was also very limited insurance cover (see Chapter 8). The apparent reduced scale of damage in subsequent storms could be accounted for by several factors. Most housing is only vulnerable to the most extreme storms (Hurricane Category 3 and above). There has been some successful investment in mitigation since 1979. Nevertheless, some communities remain highly exposed to direct sea damage.

Building standards in Dominica may have also fallen in the immediate wake of Hurricane David as construction boomed and unskilled people set up as builders. A research project funded by PAHO (Lechat and others, 1981) found that a high proportion of temporary repairs undertaken in the immediate aftermath of the hurricane were becoming semi-permanent due to lack of funding, building material and skilled labor shortages, potentially implying a long-term deterioration in the housing stock.

More positively, there is reported to have been a general increase in awareness of the importance of hurricane-proofing since Hurricane David which, coupled with a general improvement in the quality of housing stock, including greater use of imported materials, has increased the strength of newer buildings against hurricanes. The quality of public buildings is also reported to have improved in recent years, in part because of the increased use of private consultants such as engineers.

Dominica is also in the process of adopting the OECS Model Building Code as its national code. The only remaining step (which has been pending for some time) before the code becomes law is approval by the Cabinet of the related legislation and placing this before the Assembly. This development has been supported by Habitat and the CDMP.

There has also been at least one project specifically intended to reduce the vulnerability of housing to strong winds In 1994, the National Development Foundation of Dominica (NDFD) launched a Retrofit Program, with financial support from CDMP and the Community Housing Foundation of Washington. This program, which is still on going, has three components. to provide information on retrofitting measures; to provide training to builders and artisans, and to provide seed funds for retrofitting, including in the informal sector The first loans were made in late 1994, with increased interest in the scheme after the 1995 hurricanes demonstrated the benefits of retrofitting.

6.8 Overall Assessment

Under-investment in mitigation is a problem of multiple design failures. This is sometimes due to lack of hazard information, but also caused by the failure to utilize available information on, for example, storm hazard risk and landslide risk. Another contributory factor is excessive cost-minimization in initial investment in the public provision of modern infrastructure. The scarcity of investment funding has frequently resulted in minimal post-disaster repairs, aimed at facilitating a rapid return to normal activity rather than incorporating mitigation into rehabilitation.

The damage in different areas of key infrastructure is linked, particularly by the lack of sea protection to the road system, along which other utility networks are also located. As discussed in Section 10.4 frequent and extensive repairs to the roads place a considerable strain on the public finances.

[51] The rate of inflation was highest between 1979 and 1981. As most of the rebuilding and repair was done privately in 1979-80, the share financed in public projects is substantially less than the implied 18% of rehabilitation costs, say 12-15%. Without a detailed breakdown of costs and reliable data on construction sector inflation, more precise calculations are not possible

There has been substantial but uneven progress in reducing hazard risk in all areas of infrastructure and building. As discussed further in Chapter 13, progress has been hampered by a weak risk assessment information base, a lack of donor coherence, failures of land use planning and a reluctance to adopt and enforce adequate building codes

Chapter 7.

External Account

In this Chapter there is a brief review of the inter-relationships between natural disaster shocks and the external account, considering first the current trade account and, second, the capital account There are clear and direct links between disaster shocks and export earnings, that have largely come historically from primary commodities, whereas the links are more inferential for imports and especially for capital movements, relying on the interpretation by those involved in these events.

7.1 The Trade Account

The overall levels of exports and imports since 1977 in constant price terms are shown in Figure 7.1. Dominica typically has had a real trade deficit in excess of EC$50m in constant 1990 price terms, equivalent to 12-13 % of GDP. However there have been years of substantially greater deficit associated with the considerable variability in export levels, with post-disaster surges in imports, especially in 1979-80 The components of the export account - banana earnings, non-banana exports of goods and non-factor services (NFS) are shown in Figure 7.2.

Figure 7.1 Dominica - Exports and imports of goods and services, 1977-1998 (constant 1990 Prices)

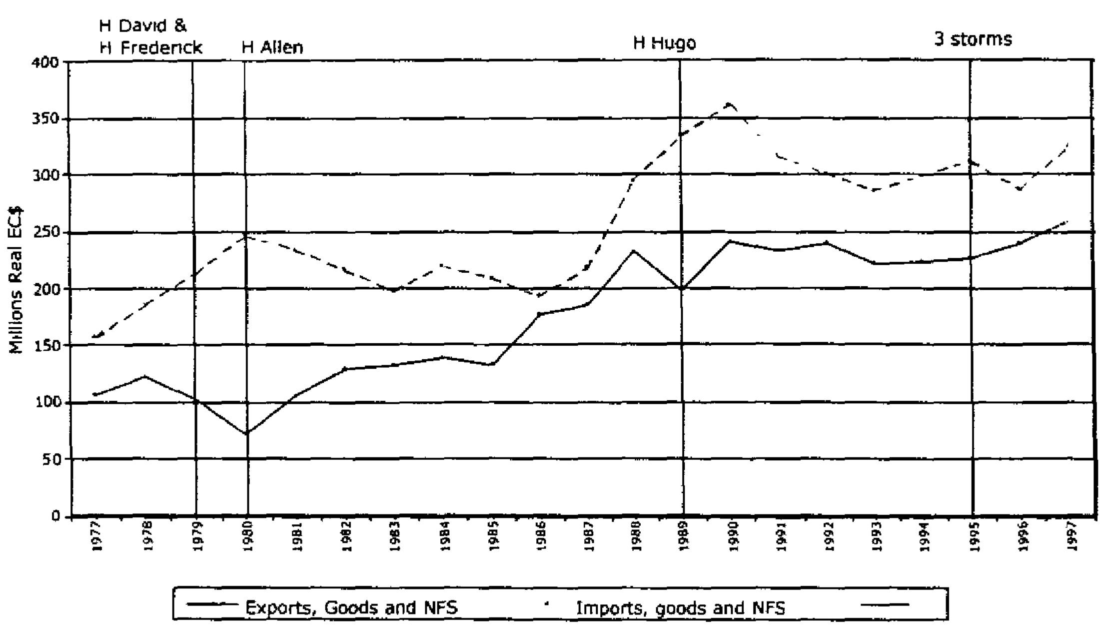
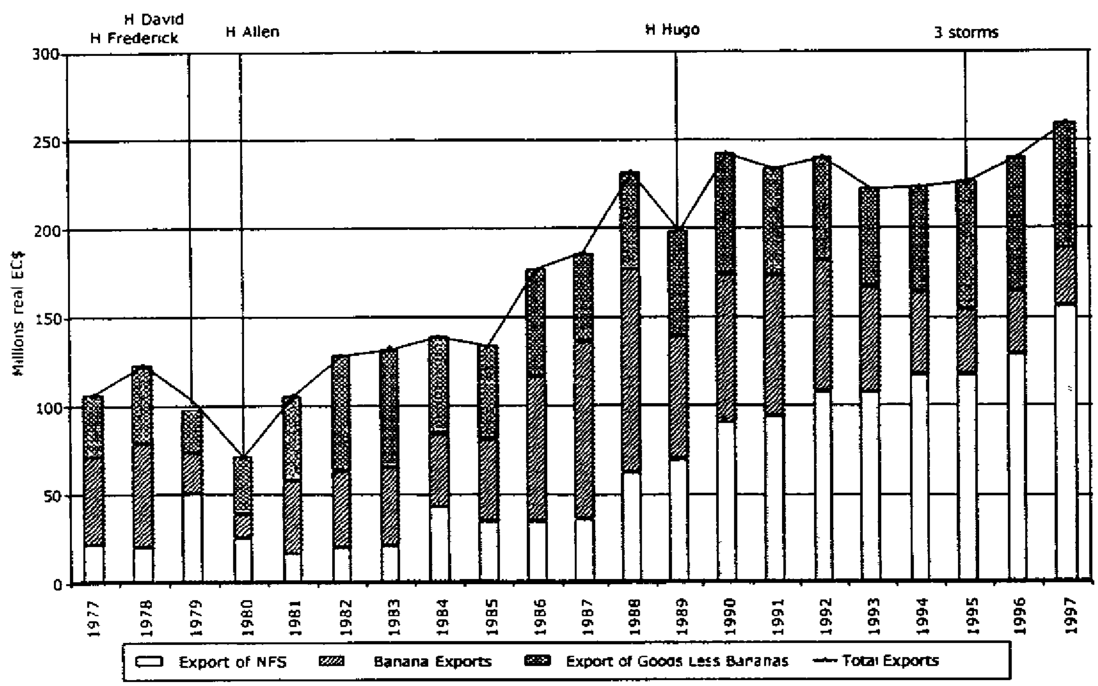


Figure 7.2: Dominica - Export earnings by category, 1977-1997 (constant 1990 prices)



During the 1979 and 1980 hurricane years there was a widening of the trade deficit which was largely due to a 50% decline in the export of goods, although NFS more than doubled in 1979. The further reduction in total exports in 1980 was largely due to a fall back to EC$25m in NFS exports. In contrast, imports increased over the two impact years due to the import of materials and equipment to rehabilitate infrastructure and housing after the hurricanes. Food imports also rose to compensate for lower domestic production This import surge also coincided with an oil price shock There is a similar but less marked increase in imports after each of the subsequent major storms in 1989 and 1995.

Between 1981 and 1983 the trade deficit narrowed and this trend continued despite Hurricane Klaus in 1984 up until 1986. Total exports grew because of the rapid recovery in banana exports followed by wider recovery in exports of goods and also an increase in the export of NFS. Import totals remained fairly static over the period, possibly reflecting the end of the post-David reconstruction boom.

Between 1987 and 1990, the trade deficit increased dramatically, with only the tail end of the increase partly due to Hurricane Hugo in 1989 Overall exports increased with a rapid expansion of bananas earning to record levels until checked by Hurricane Hugo and what proved to be a reversal of the trend in prices. There was also a massive growth in NFS exports which between 1986 and 1991 increased more than three fold to EC$84m (in constant prices). Imports increased considerably between 1987 and 1990 due to the growth in NFS imports and a consumer domestic building boom fuelled by banana earnings.

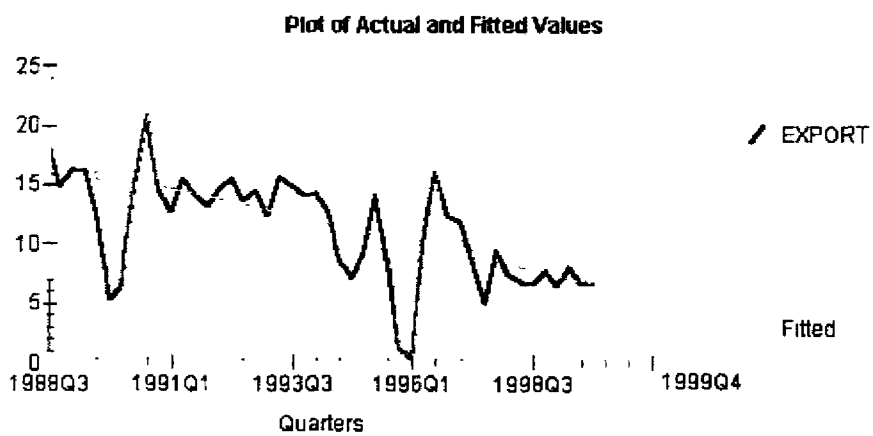
During the 1990s, a period of relatively slow overall growth, there is no clear trend in overall exports, although the value of goods dropped by 30% between 1991 and 1997. The decline in export of goods is largely explained by the depressed banana sector These impacts are largely the result of reduced volumes of banana exports. First, Dominica is a price taker, with US$/UK£ exchange rate movements and changes in the EU banana regime having a direct effect on export prices and profitability. Second, there have been the impacts of hurricane damage on the production and exports, as is shown in more detail in Section 7.2.

The decline in commodity earnings in the 1990s has been partially offset by some increase in other export categories, but especially by a substantial rise in NFS (Figure 7.2). From 1990 NFS exceeded banana earnings, marking a new phase of reduced sensitivity in total exports to hurricanes. The NFS, which includes tourism and international financial services, is a relatively opaque category of the external account and some of its behavior is difficult to explain. For example, there was a surge in NFS exports in 1979, perhaps suggesting that some of the relief activity was being funded as NFS payments. The import of both goods and NFS has been comparatively stable over the same period reflecting the slow growth in this extremely open economy in which imports have a high share of consumption and investment.

7.2 Storm Shocks and Banana Export Earnings

The full, immediate extent of the direct impacts on banana export earnings is partially obscured by the timing of hurricanes shocks in the third or fourth quarter of the year, August-November, and almost immediate impact on bananas exports. The reduction in exports may also be increased by problems in shipping out the perishable crop. Thus in November 1999 a week's exports already in store were lost because of the disruption to shipping. Because of the capacity of producers to replant and recover production in 6 to 9 months, direct impacts are spread over the end of one and the beginning of the next calendar year. This pattern of rapid decline in exports and recovery is illustrated in Figure 7.3 for the effects of Hurricane Hugo and the triple shock in 1995. The dominant share of banana in exports accounts for the extent to which a hurricane impacting on agriculture but causing little structural damage, such as Hurricane Hugo, impacted severely on exports and the wider economy.

Figure 7.3 Banana export earnings (EC$m) and disaster shocks, 1988-1998



Source Table A.7.2

The relationship between banana export earnings and extreme storm shocks has been quantified employing regression analysis in a similar way to that already adopted in Chapter 4 and 5 and described in Annex B, introducing individual dummy variables to represent major disaster events. But in this case quarterly data on export earnings were available from 1988 to 1998, and, as Figure 7.3 shows, most of the short-term variability in export earnings around a downward trend is linked with the major storms in 1989 and 1995.

The downward trend is also associated with a decline in real EC$ export prices and a related fall in grower profitability This declining trend in real banana earnings since about 1989 has had implications too for the sensitivity of the trade account to disaster shocks. In 1995-96, despite the temporary loss of banana earnings, there was actually a small increase in total export earnings because of growth in DCP exports and resilient NFS earnings This is an instructive example, showing how the nature of an economy's sensitivity to natural disaster shocks may change quickly. It implies that vulnerability and appropriate policy response need to be regularly re-assessed. Both regional and to some extent international arrangements for buffering the effects of natural disaster shocks have been geared to compensating for primary commodity export earnings - as with the complementary EC's STABEX for government or for producer revenue, in WINCROP (Box 5.2). There are no comparable easily accessible mechanisms for counteracting shocks in other sectors.

7.3 The Trade Balance and the Capital Account

Figure 7.4 shows both the current trade and the capital account balances As would be expected, these tend to follow each other's pattern inversely: an increase in the trade deficit is associated with a positive movement in the capital account balance. However, the capital account has varied considerably over the period, particularly in hurricane years and for at least one succeeding year. These increases in capital inflow typically overcompensate for current account movements. Afterwards capital inflows decline to levels that are much closer to the trade account deficit (see Figure 7 5)

Figure 7.4 Dominica - Real trade balance and capital accounts balance, 1977-1997 (constant 1990 prices)

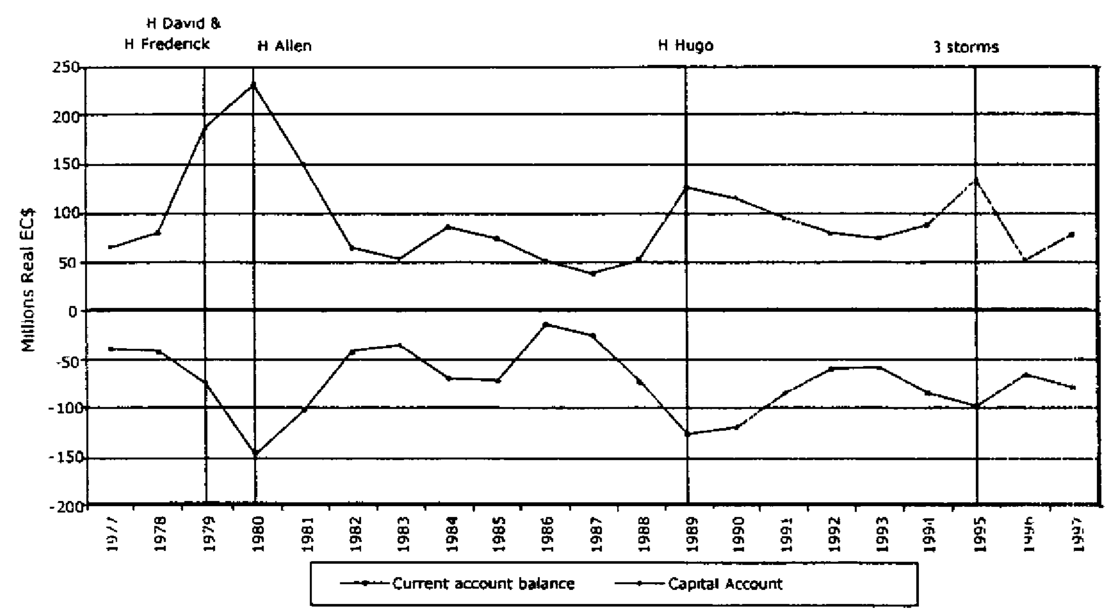
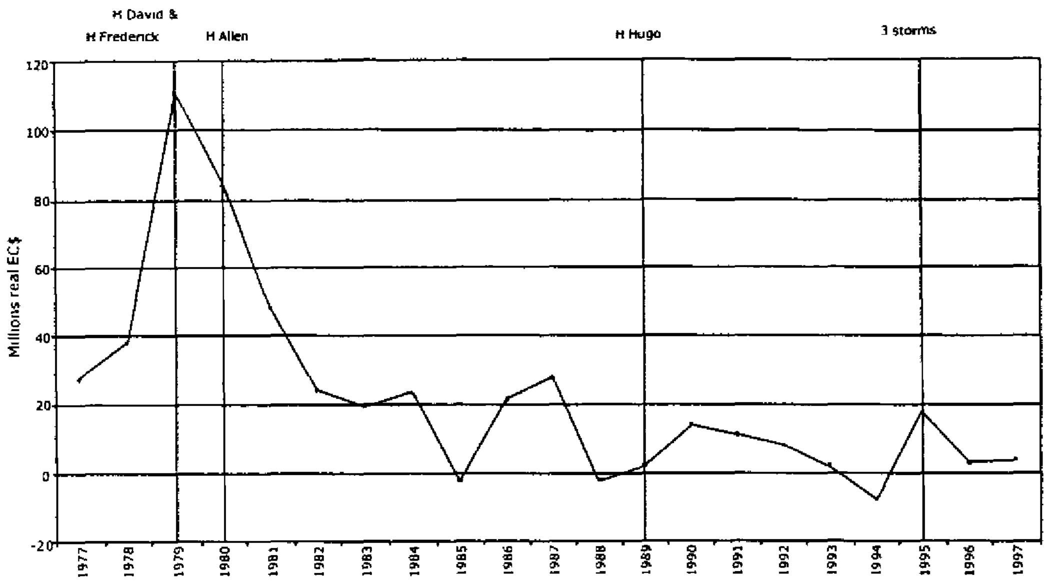


Figure 7.5 Dominica - Balance of payments, 1977-1997 (constant 1990 prices)



In earlier years the temporary increase in the capital account flows was principally due to official or public grants, comprising of budgetary grants, capital grants and relief import counterparts. Between 1978 and 1979, public grants rose by 300% to EC$54m (in current prices). Most of the increase (66%) was channeled via the import relief component. Public grants also expanded in 1984, associated more with the structural adjustment agreement and channeled as capital grants The next marked upward movement in the capital account coincided with Hurricane Hugo in 1989, to EC$126m (in current prices) from EC$52m in 1988. The account did not fall toward normal, balancing levels until 1992. Most of this effect manifested itself via increases in credit to the financial account (which doubled) and decreases in debits from this account. 'Other investment' categories and long-term public sector loans also contributed to the net increase Again the capital account surplus declined toward more normal levels in 1993 and 1994. In 1995 three storms impacted Dominica and this was associated with a further rise in the capital account surplus including capital transfers (an increase of 100%) and direct investment (increase of 150%).

Economic assessments of the performance of the Dominican economy such as World Bank Economic Memoranda have typically concluded that performance in the external account is largely determined in the short term by banana export earnings and capital movements. The overwhelming importance of the former at least up to the mid 1990s is confirmed. The role of capital account movements is also confirmed From the viewpoint of this study the most important issues appear to be overcompensating immediate reactions to disaster-related downward pressures on the trade account. In particular, there was considerable inflow of capital from 1979 and into the early 1980s that contributed to funding reconstruction investment. Many in Dominica's public and private sectors referred to this massive capital inflow as an opportunity that considerably counterbalanced the damage from Hurricane David. (The external assistance component of these capital account flows is considered further in Chapter 12).

Chapter 8.

Domestic Absorption

Disasters have potentially significant implications for levels of consumption and investment. The impact of a disaster on private consumption is determined by a number of factors, including the effects on levels of employment; the ability and willingness of households to dis-save; the availability of goods for sale; the extent of any insurance payouts; and the scale and nature of various relief efforts, and the extent to which they utilize domestic resources and create local job opportunities.

8.1 Investment Levels

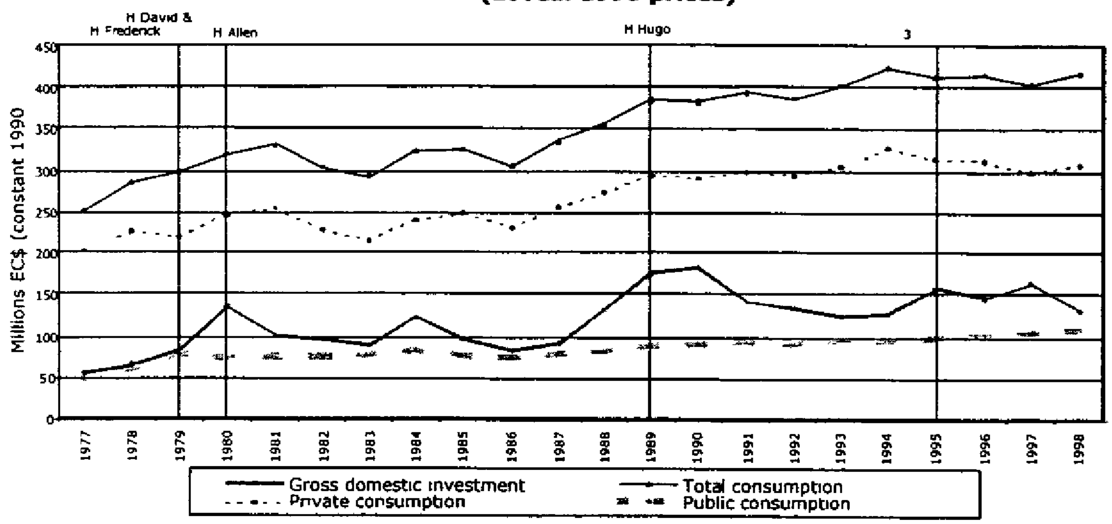
Sudden-impact disasters damage and destroy productive and non-productive assets and infrastructure Overall rates of investment may rise as lost infrastructure is replaced, but only to the extent that investment resources are additional and do not involve the diversion of resources away from other potential areas of investment. The economic impact of this investment is then dependent on the ratio of non-productive to productive investment. However, disasters may also act as a deterrent to prospective new investors. The impact of disasters on public investment and consumption is explored in more depth below (Chapter 9).

The GoCD (2000) identifies the capital formation effort as critical to Dominica's medium-term growth prospects. It has actively and continually sought foreign private investment to supplement scarce domestic capital, facilitate technology transfer and provide the thrust of economic growth (World Bank, 1992). Various fiscal incentives are offered to promote private sector investment.

It is difficult to discern much evidence of the impact of natural disasters on total investment or consumption in Dominica, other than in the aftermath of Hurricane David in 1979 (Figure 8.1). Hurricane David resulted in a massive infusion of investment funds, initially primarily in the form of private investment and afterwards in the form of public investment. The scale of both losses and reconstruction funds created a significant opportunity to replace and update much of the island's infrastructure and commercial, productive capital, following years of inadequate maintenance and limited investment. Gross domestic investment increased by 24.9% year-on-year in real terms in 1979, with a further 65.2% increase the following year. However, although remaining significantly above the 1978 level, gross domestic investment fell again by 25 2% in 1981, with further marginal declines in 1982 and 1983 The fall off in private investment from 1981 onwards was apparently particularly pronounced, based on a comparison of data on gross domestic investment with that on central government capital expenditure (unfortunately only available on a July-June fiscal year basis) (see Chapter 9).[52] Central government capital expenditure almost doubled in real terms between 1980/81 and 1984/85 to reach a figure of EC$61 1m (at real 1990 prices) Total gross domestic investment averaged EC$111.0m (at real 1990 prices) in 1984 and 1985 Thus, it would appear that private investment fell significantly once repairs were undertaken to existing capital, with the hurricane possibly having played a role in deterring new investment. Moreover, a significant part of the private investment that did occur may have been in the form of non-productive capital. Subsequent hurricanes have caused only partial dislocation and have not resulted in any comparable infusion of capital for reconstruction.

[52] Data disaggregating between public and private investment are not readily available

Figure 8.1 : Dominica - Domestic absorption by component, 1977-1998 (at real 1990 prices)



8.2 Consumption

Disaggregation between public and private consumption also suggests that the former to some extent compensated for a decline in the latter in 1979 (Figure 8.1) but that fluctuations in both consumption and investment in other years have largely reflected other factors. This observation is confirmed by regression analysis of total investment and government and private consumption against both the composite and individual disaster dummy series. The regressions indicate some increase in government consumption in 1979 and a decline the following year but even then the overall power of the fitted equation is weak.

Nevertheless, natural disasters may be one of a number of factors leading to high consumption volatility both in Dominica and the Caribbean more broadly. The World Bank (2000a) reports that although Dominica has one of the lowest levels of consumption volatility within the Caribbean region, the level is still high. Although the data suggest that the GoCD may be playing some role in reducing volatility through its pattern of public consumption, as already noted in the specific context of Hurricane David, standard deviation of private consumption over the period 1960-97 was estimated at 7.46% for private consumption and 5.51% for total consumption. The World Bank attributes the relatively high level of consumption volatility in the Caribbean region generally to the fact that, in the face of high vulnerability to external shocks (see Box 4.1), countries are not diversifying their risk optimally, despite having relatively well-developed financial systems. The World Bank concludes that 'much remains to be done to foster the developments of both financial and insurance markets' (p15), including through regional harmonization of the banking and insurance systems, deepening of government and corporate securities markets, pension reforms and more efficient transfer of catastrophic risks to the international market (see Chapter 9)