Chapter 3

Environment, Natural Hazards and Climate Change

3.1 Natural Hazards as an Environmental Phenomenon

Natural hazards are typically extreme and uncommon events that are part of continuing environmental processes – the climatic-hydrological cycle and geophysical processes. It is beyond the scope of this study to consider these processes in detail. There are, however, three aspects of natural disasters *as an environmental phenomenon* to which attention should be given, because of their economic and financial implications.

First, environmental resources, in the sense of visible land, sea, flora and fauna, are important economic assets. The environment, in the sense of an amenity, has value to the people of Dominica, which in principle could be quantified.[5] These resources, beaches, forests and specific fauna, such as the Imperial parrot, the national emblem, are vulnerable to natural hazards.

The increasingly important eco-tourism sector is closely tied to Dominica's image as a 'nature island'. There is, as discussed below (Section 5.3) qualitative evidence that the level of activity and viability of that sector is linked to the actual or perceived status of key environmental resources, including the extensive forests, inland beauty spots and the very few coral reefs as well as the sand beaches with which tourist facilities are closely tied.

A second and related issue is the environmental damage that may be caused by global climatic change. Rising air and water temperatures may increase the intensity and incidence of tropical storms, bringing wind damage, severe coastal sea conditions and flooding, as well as changes in the hydrological cycle that could lead to both longer drought periods and more intense rainfall.

Third, there is the critical issue of scientific assessment and monitoring. The incidence and measurement of the physical features of hazard events, indications of potential hazards, risk mapping and prediction are all essential inputs into disaster mitigation and preparedness.

The first two of these issues are briefly considered in this chapter. Evidence is examined on the effects of natural disasters on environmental resources that are perceived as an amenity or social good, focusing on forestry, for which there is more evidence. Then hazard issues are identified that are raised by climatic change. Hazard monitoring and associated problems and costs for a small middle-income country are considered separately, in Chapter 13.

3.2 Forests and Other Amenity Resources

Dominica's reputation and image as the 'Nature Isle of the Caribbean' are based on the island's natural resource endowments - its flora, fauna and the biodiversity in the terrestrial and marine environments. These are closely associated with the surface manifestations of its volcanic origin and history, and also its exceptionally large surviving forest area.[6]

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[5] For example, Middlesex University Flood Hazard Centre has quantified experimentally the value of some environmental resources that are vulnerable to natural hazards in the UK.

[6] 'Dominica is fortunate in having the greatest expanse of relatively undisturbed tropical forest remaining in the Caribbean. This is due, in the main, to a combination of sustained conservation efforts dating back to the 1940s' strong enforcement of forestry legislation and topographical and climatic factors, which discouraged forest exploitation and the wholesale conversion of forests to non-forest use. Dominica's natural vegetation covers 65% of the total land area . 60% is privately owned' (Zamore, 1999)

Forest Impacts

Hurricanes have negative impacts on Dominica's forests and associated fauna, but very few recorded storms have had a devastating impact. The storm impact depends on the nature of the hurricane (strength and direction of winds and rainfall producing capacity), its duration and direction of approach.[7] Hurricane David resulted in extensive damage: an estimated 5 million trees were damaged and perhaps 35-40% of the basal wood negatively affected. Hurricane Allen the following year set back regrowth by causing extensive defoliation of the soft, less resistant regrowth. No other subsequent hurricane sequence has done comparative damage. However, the comparative frequency of peripheral or direct impacts means that forests have continued to be negatively affected by tropical storms. There has been a significant storm event at least once every 3 years on average. Experts are of the view that forest gaps and adjoining forests suffer greater hurricane impact than undisturbed natural forests. In one locale, Woodford Hill, Hurricane Luis was observed to have done much more damage than the stronger, generally more devastating Hurricane David. Logging in the intervening period is thought to be the major factor predisposing the forests to storm vulnerability.

Estimates of the time it takes for the forest to recover vary Some experts (Lugo and others, 1983) regard Dominica's forest as relatively resilient and suggest that intense damage may be virtually undetectable thirty years after the event Certainly informants confirm that this has proved true from an eco-tourist, if not purely scientific perspective.

Five factors are identified by Zamore (1999) as major contributors to vulnerability: forest structure, species composition, reforestation, forest gaps and logging damage Human activities such as shifting cultivation and erratic logging upset the structural balance. Reforestation with less resistant species, the opening of the canopy, damage to individual trees and collateral damage as a consequence of logging operations are also thought to have increased vulnerability

The implication is that more extensive damage to forests occurs where human activity directly impacts natural forest ecosystems. In a largely rural society with high levels of self-provisioning and local sourcing even on estates, the demand for timber for shelter, fuel, and other support activities has been high. That a comparatively large proportion of forested lands is not owned by the state also exacerbates the problems of control and protection.[8]

Taking these factors into account, Zamore has proposed a two-pronged approach to reducing vulnerability that involves both leaving most existing forests undisturbed and elsewhere developing and maintaining appropriate management systems. This would require appropriate legislation, institutional arrangements, public education and techniques that both minimize the negative impacts of species extraction and vigorously promote 'sustainable' approaches to forest management.

Enhanced environmental monitoring is required to measure the precise ecological impacts of natural hazards on forests and fauna and thus to provide the impetus for measures to reduce vulnerability. Hurricane David, in particular, prompted interest in this area. However, such investigations depended substantially on external funding and human resources, posing problems of sustainability and of how to ensure that longer-term ecological effects are monitored (see below Chapter 13).

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[7] Forestry experts such as Arlington James and Zamore (1999) report that damage includes defoliation, breaking of stems, breaking of branches and crowns and uprooting and toppling of trees. In the longer term, as forests recover, changes occur in species composition and dominance relationships. Indeed, adaptation to occasional catastrophic storm damage is presumably reflected in the evolution of Dominica's forests. The Bois Cote (*Tapura Latifolia*) has been identified as a resistant species that rapidly grows to dominate gaps created in the canopy of the rain forests However, Zamore reports that tree fall gaps created by hurricanes increase the vulnerability of these forests to future hurricanes. (Personal communication, Arlington James, Senior Forestry Officer)

[8] Zamore (1999) reports 'The rate of forest loss in Dominica has been significantly increased by the sale of unallocated state lands. Subdivision and sale have continued in an ad hoc manner, largely in response to squatter pressures and without land capability studies to determine crop suitability.'

Other Environmental Impacts of Tropical Storms

Hurricanes can cause accelerated erosion to coastlines, damaging physical structures that have amenity value such as beaches and reefs. Informants drew attention to several examples of such damage on the island's west coast after Hurricane Lenny. The flooding that frequently accompanies hurricanes results in accelerated soil erosion and increased turbidity of the near shore waters. This contributes to further degradation of watersheds and a concomitant increase in vulnerability.

Hurricanes have had negative impacts on wildlife and marine life. For example, scientific studies of Imperial and Red-necked Parrot populations indicate that species numbers have taken twenty years to recover from the impact of Hurricane David.[9] However, it is often difficult to obtain accurate information and statistical evidence and to disentangle the impacts of extreme events from other longer-term ecological factors.

The impact of hurricanes on the marine environment is accepted, but to a large extent remains poorly described, assessed and quantified. This is understandable It is extremely difficult to establish benchmark data such as species composition, population totals and measurements of coral reefs in a small island developing state like Dominica (see above and Chapter 13).[10]

Other Hazards and the Environment

Landslips have environmental effects, such as damage to forests and riverine and estuarine siltation These have only begun to be monitored since the Layou River event in 1997 (Appendix A.3.6).

The other potential source of massive environmental damage is a volcanic eruption – ash deposits, pyroclastic flows and lahars can, as the effects of the persistent Soufriere Hills eruption since 1995 on the nearby island of Montserrat demonstrate, have catastrophic impacts and preclude access to environmental assets for extended periods (Clay and others, 1999). The only possible response to an eruption is withdrawal. The only available risk reduction measure is portfolio diversification – ensuring that environment-linked developments are geographically spread and preferably, to the extent economically viable, sited in lower risk areas.

Human intervention could also become a potential source of longer term damage to environmental assets – excavation of deltaic silts for building material, pollution from human habitation and industrial activity could affect coastal marine resources, but these are longer term rather than disaster-related issues

3.3 Climatic Change

The United Nations Global Conference on the Sustainable Development of Small Island States, in its Programme of Action, recognized inter alia, the potential hazards that climate change and environmental change may present for small island developing states such as Dominica (UN-ESC, 1999)

Changes such as more general global warming and a rise in sea levels, which is apparently already occurring in the Caribbean Sea, pose additional hazards It may be difficult to predict the precise and specific effects of such developments This is due firstly to the interplay of the forces of climate and secondly, because geological forces may

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[9] The Imperial or 'Sisserou' parrot (*Amazonia imperialis*) is the 'national emblem' that appears on Dominica's flag. Following Hurricane David the numbers were drastically reduced and distribution curtailed to the Morne Diablotin National Park (Evans, 1988). However, by the late 1990s the parrots, benefiting from conservation measures, had returned to the Morne Trois Pitons National Park Eco-tourism to Dominica includes ornithological visits to view the Imperial and Red-necked parrots (*Amazona arausiaca*) in their natural habitat.

[10] For example, the natural resources sector assessment after Hurricane Lenny includes a detailed fisheries report which for the first time provides an estimate of the cost of damage to coral reefs and sea grass beds, totaling EC$ 2.2 million (GoCD, 1999c).

be acting independently on any given land area where observations and research are being conducted. For example, sea level rise may be occurring at the same time as coastal subsidence or elevation due to geological forces acting on a small island. In such a situation, it may be impossible to ascribe the environmental changes exclusively to climate change and sea level rise.[11]

There is considerable concern among meteorologists that a rise in global air and sea temperatures in the Caribbean basin could give rise to more frequent and more powerful hurricanes. This, of course, would pose a potentially increased hazard for Dominica. The marine environment could also be affected by climatic change. A rise in mean sea levels could make the entire coastal eco-system and shore base facilities more vulnerable to hurricane damage, especially damage by sea waves and storm surges. Even without an increase in frequency or intensity, because of higher sea levels storms could be potentially more destructive to existing societal capital stock and activity. Environmental and climatic changes would occur in a very complex milieu of natural and human settings, interacting in a dynamic manner. Environmental changes as a direct result of human activity in Dominica could make hazards such as hurricanes, drought and floods even more potentially devastating than they have been in the recent past. From a policy perspective, this is a difficult issue to address. Properly researched scientific evidence is lacking on the consequences of human intervention, but robust data may only become available retrospectively after anticipated harmful effects have already occurred. If such changes occur incrementally, then the change in an environment experiencing considerable climatic variability in the short term may be so small as to be virtually imperceptible. Over a period of several decades, the cumulative effect on Dominica could be considerable.

Against the background outlined above, it is possible to identify some of the potential effects of climatic changes and the likely hazard implications of such changes through the elaboration of scenarios based on some of the changes that are now anticipated, such as rising sea temperature and sea level. To address these widespread concerns, as for example the World Bank's Environmental Policy paper indicates (World Bank, 2000c), will require greater expenditure on scientific research and monitoring to provide robust baselines for measuring change and to make possible investigations into processes and their consequences. This issue is considered in Chapter 13.

[11] The Caribbean Planning for Adaptation to Global Climate Change (CPACC) Project was established to support Caribbean countries in preparing to cope with the adverse effects of global climatic change, particularly sea level rise. It includes a sea level network to measure more precisely sea level changes indicated by the small number of US and South American coastal measuring stations (www.cpacc.org). See also Chapter 13.

Chapter 4.

The Macroeconomy

4.1 Economic Performance and Natural Hazards

Dominica has a small, open economy, still heavily reliant on a single export crop, bananas, but diversifying into service activity. Agriculture and agro-processing combined continue to be the major productive sector, although agriculture's share in GDP has declined from an average of 37% in 1977-78 to 20% in 1997-98. Bananas have been the principal agricultural crop, exported to the UK under a preferential access agreement which is being phased out. There has been some limited diversification out of bananas, which still accounted for a third of total merchandise export earnings in 1997 (see Section 5.1). The agricultural sector also accounted for close to one-third of employment, according to the 1991 population census, and is an important secondary source of income.

In contrast, other private sector activity remains small, although experiencing some growth since the mid 1970s. Manufacturing output rose from 3.9% to 8.2% of GDP between 1977 and 1998. Soap products emerged as the island's largest single merchandise export (in value terms) in 1996. In the 1990s, promising growth has been observed in the island's burgeoning offshore services industry, although the sector is still small.

The economy is very open, with imports equivalent to 65% and exports to 25% of GDP in 1997.[12] Dominica has consistently run a deficit on its external visible trade account. This deficit has been partly met through tourism earnings. Tourism's contribution to GDP remains relatively low, but by the late 1990s accounted for an estimated 35% of external earnings (GoCD, 2000) (see Section 5.3).

As a small island economy with a narrow resource base and high degree of openness, Dominica is highly sensitive to changes in its external environment and exogenous shocks and faces particular challenges in achieving sustainable development. The GoCD (2000) identified two key external factors of particular concern: international developments, especially implementation of the WTO trade regime, and natural disasters. Indeed, the vulnerability of small island developing states more generally, both to natural hazards and other external shocks, is widely recognized and the challenges posed to sustainable development acknowledged. Research has demonstrated that small island developing states experience greater vulnerability than developing countries as a whole, and also that Dominica is one of the most vulnerable countries in the world, both to natural disasters and other external shocks (see Box 4.1). Thus, as the UN Economic and Social Council states, 'it is vitally important for small island developing States to undergo the transition, at the national and regional levels, towards a culture of risk reduction. Risk reduction plans should not be a mechanical process, in which a natural disaster leads to emergency response and then to remedy, but part of integrated policies to achieve social and economic stability and low risk' (UN-ESC, 1999: para 10).

[12] Comparable figures for 1978 were 72% and 40% respectively.

Box 4.1: Quantifying Vulnerability to External Shocks

Small states face a number of special disadvantages associated with size, insularity and remoteness, which in turn result in potential economic sub-optimality, a high degree of openness and limited diversification. These factors render small states particularly exposed and vulnerable to a range of external shocks, including natural hazards, causing high volatility in national incomes. Although the range of per capita incomes and rates of growth of small and large developing countries are not significantly different, the standard deviation of real per capita growth is about 25% higher amongst the former (Commonwealth Secretariat/World Bank, 2000).

There has been considerable recent interest in attempting to measure the extent of vulnerability of individual nations to external shocks. This interest has been fuelled by the fact that many small states have relatively high levels of per capita GNP, suggesting economic strength rather than - as is often, in fact, the case – frailty. This limits their access to concessional aid resources. Efforts in measurement have focused on structural vulnerability, defined as being caused by 'factors which are not under the control of national authorities when the shocks occur' (Atkins, Mazzi and Easter, 2000: 3).

As a result, various indices of vulnerability have been developed, based on a (sometimes weighted) range of components capturing different aspects of vulnerability, including that relating to natural hazards/disasters. The way in which disaster or hazard vulnerability has been measured has varied between studies, basically reflecting poor data on the impacts of disasters as well as the complexity of factors determining hazard vulnerability. The relative ranking of different studies has also varied, highlighting the very approximate nature of the results. Nevertheless, they suggest that Dominica is highly hazard prone.

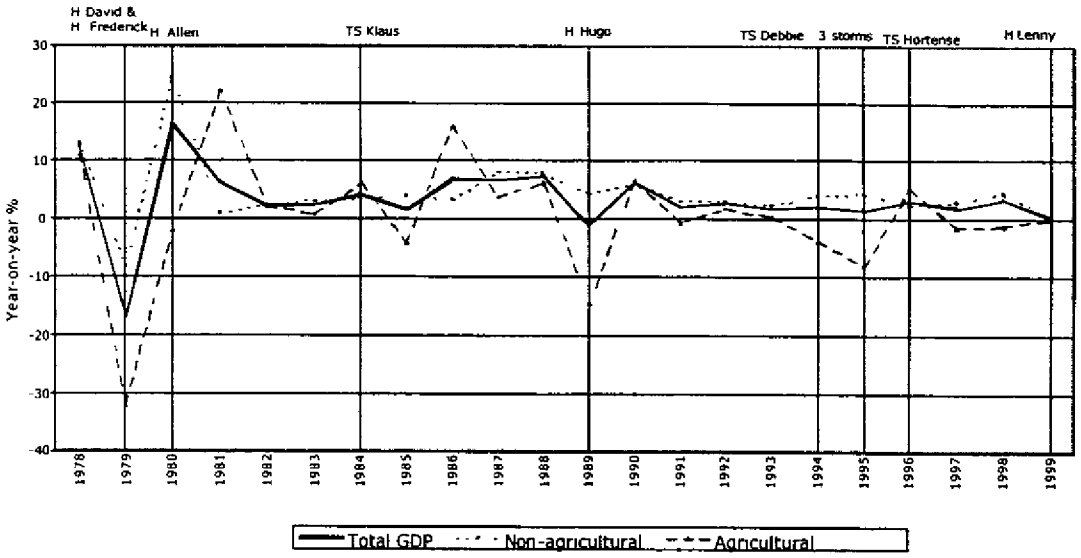
For example, one of the earliest vulnerability indices was developed by Briguglio (1995), based on size (proxied by openness to trade), insularity or remoteness (proxied by transport costs), proneness to natural disasters and environmental fragility. Proneness to natural disasters was proxied by total damage from significant disaster events (defined as exceeding 1% of GNP) occurring over the period 1970 and 1989. According to Briguglio's index, Dominica was the second most disaster-prone of the 114 countries analyzed, and the 18th most vulnerable country overall.

The Commonwealth Secretariat has also developed a model, based on three dependent variables: susceptibility to natural disasters (defined as the percentage of population affected by natural disasters cumulatively over the period 1970 to 1996), export dependence, UNCTAD's merchandise export diversification index and the overall size of GDP of a particular country. According to this index, Dominica was ranked 6th out of the 100 countries analyzed in terms of the overall Commonwealth Vulnerability Index, also making it the most vulnerable state in the Caribbean overall. In terms of vulnerability to natural disasters, it was ranked in 13th place, behind only Antigua and Barbuda in the Caribbean.

Separate work by the Commonwealth Secretariat on the development of a composite environmental index, again using natural disasters as one of a number of indicators but this time based on the total number of natural disasters over the period 1970-96 expressed relative to total land area, ranked Dominica as the 5th most disaster vulnerable country, with four smaller Caribbean states in the top five (the others being Saint Vincent, Saint Kitts and Nevis and Saint Lucia).

In the case of Dominica, natural disasters have clearly had a major impact on economic performance since 1978 (Figure 4.1).[13] The combined impact of Hurricane David in 1979, followed closely by Hurricane Frederick and then by Hurricane Allen in 1980, was particularly devastating, reflecting both the scale of physical damage and disruption caused as well as an already weak economy. During the 1970s, economic performance had been relatively poor, in part the consequence of the world oil crisis of 1973-4 and escalating import prices. A further oil crisis occurred in 1979, and there were also mounting political difficulties in the immediate post-Independence period. As a consequence, real GDP plummeted by 17% in 1979, whilst agricultural GDP alone fell by 32% and non-agricultural GDP declined by 8.3%. Despite some recovery in non-agricultural sectors, agricultural GDP fell by a further 2.1% in 1980, so that overall GDP remained 3.3% lower than in 1978 and the visible trade deficit increased to 71% of GDP. Poor economic performance in 1980 reflected the further impact of Hurricane Allen. Hurricane David also resulted in the temporary exodus of almost 20,000 people, equivalent to about a quarter of the pre-disaster (1978) population.[14] This exodus included many school-aged children and there is anecdotal evidence of skill shortages hampering reconstruction (see Section 12.1). Twenty years later the population had still not recovered to its 1978 level. These severe multiple shocks also brought intensified budgetary pressures from increasing recurrent expenditure on relief and capital costs of reconstruction (see Chapter 10 and Annex C).

Figure 4.1: Dominica - Annual fluctuations in agricultural, non-agricultural and total GDP, 1978-1999 (%)



Hurricane David is generally considered to have been a significant factor in forcing the country into a subsequent Structural Adjustment Program (SAP) In FY 1986/87 the GoCD adopted a SAP, supported by an arrangement under the IMF Structural Adjustment Facility (SAF) and an IDA Structural Adjustment Credit (SAC) The overall SAP was aimed at achieving a sustainable rate of economic growth, reduced unemployment, improved living standards and strengthened fiscal and balance of payments positions. [15]

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[13] Historical records dating back to 1763 also provide some evidence of the cumulative adverse impacts of earlier hurricanes. There was a bunching of severe hurricane events during 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 were officially reported as ones of economic difficulty, depressed agriculture and trade (see Annex A.2).

[14] The combined impacts of Hurricanes David, Frederick and Allen are discussed in more detail in subsequent chapters of this study

[15] The SAF, whose targets included increasing government savings to 2-3% of GDP and reducing the current account deficit (excluding official transfers), to 4% of GDP, was fully disbursed by November 1989. Almost all macroeconomic targets were

Relatively high rates of growth were experienced between 1986 and 1988, averaging 7 0% per annum in real terms, in part reflecting the success of the SAP as well as rapid increases in the price and volume of bananas and high levels of aid flows.[15] Under its 1989/90 budget, the GoCD forecast that the economy would grow by 5% in 1989, although the agricultural sector was expected to decline by around 5% due to a fall in banana prices and a reduction in output during the banana-replanting program. Then Hurricane Hugo in September 1989 destroyed some 70% of banana production. Economic performance for the year was also adversely affected by unfavorable exchange rate movement between the EC dollar and pound sterling, resulting in a fall in the EC$ unit price of banana exports In consequence, overall GDP fell by 1.1% year-on-year and agricultural GDP alone by 14.6% whilst the visible trade deficit increased to EC$130m (equivalent to 38.5% of GDP for the same year). However, non-agricultural GDP increased by 4.4%.

During the 1990s, the GDP growth rate was lower, averaging 2.4% (in real terms) between 1990 and 1998. To some extent the weaker performance reflected difficulties in the banana industry and its implications for the balance of trade deficit (particularly in the latter part of the decade) as well as a decline in concessionary financial flows. There was a 20% fall in unit banana earnings in 1993 due to changes in the EU banana regime The 1997 WTO ruling against the EU system of issuing preferential licenses to certain banana producing countries is expected to exacerbate difficulties in the future.

Adverse weather conditions also contributed to slow growth. In 1994, real agricultural GDP declined by 3.7%, in part due to the impact of Tropical Storm Debbie in September on the banana sector as well as to deterioration in the EC$ banana export price. Overall GDP increased by 2 2%, however, reflecting a 4.0% expansion in non-agricultural GDP. For 1995 GDP growth had initially been projected at 4.5%, reflecting the banana sector's recovery from the 1994 storm. In the event, the island experienced three damaging storms and achieved real growth of only 1.6%. The decline in agricultural production was expected to have a significant impact on the level of unemployment, increasing to as much as 30% (GoCD, 1995). Moreover, the situation was expected to be exacerbated by lack of availability of jobs in neighboring islands, which had also been affected by the storms Nevertheless – and most significantly - in contrast to an actual decline in 1979 and 1980, there was still GDP growth because the already reduced sectoral share of agriculture meant that the economy-wide impact of crop damage was relatively less severe. There was also compensating m anufacturing and service sector expansion

Most recently in 1999 Hurricane Lenny caused considerable damage to coastal infrastructure. But, without hurricane force winds or intensified rainfall, it had relatively limited impact on agricultural production or aggregate economic performance (see Chapter 2 and Annex A.4). According to provisional GoCD estimates, GDP marginally increased by 0.4% year-on-year, with agricultural product unchanged and non-agricultural product 0 5% higher.

Regression analysis

The sensitivity of sectoral economic performance to hurricanes over the period 1978–98 has also been subjected to more formal examination using regression analysis. The purpose of this analysis was not to prove that storms affect overall economic performance – a point already demonstrated by the qualitative examination of economic performance presented above – but, rather, to quantify their impacts. This exercise is useful in trying to further understanding of the nature of impact of disasters and to draw out any implications for disaster reduction.

Using ordinary least squares techniques, annual growth rates of each of GDP, agricultural GDP and non-agricultural GDP were regressed, in turn, against several forms of a storm dummy variable series constructed to represent the possible downward impact of tropical storms and hurricanes in the year in which these occurred (See Annex B) The dummy variables were also lagged one year to examine whether storms generate prolonged economic downturns or,

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achieved during the course of the SAP and a series of broad policy and institutional changes undertaken that created an improved environment for supporting economic growth (World Bank, 1992)

[15] A further hurricane, Klaus, occurred in July 1984, damaging an estimated 20-25% of the 1984 banana crop (ECCB, *Quarterly Bulletin*, 1984 , 2(3)). However, overall GDP for the year increased by 4.3% and agricultural GDP alone by 6 2%.

alternatively, subsequent booms. Several other explanatory variables were also tested, in part to take account of the other major form of external shock to which the Dominica economy has been exposed – namely, banana price movements.[17]

Certain methodological problems were encountered in identifying and quantifying an appropriate storm dummy series, immediately pointing to an important distinction between two broad categories of storm affecting Dominica. Storms have differed not only in their wind strength but also in terms of their precise path and associated levels of rainfall and sea surge. As such, their impact can be categorized either as principally affecting banana sector output or as also causing significant infrastructure damage. The 1979, 1995 and 1999 storms fall into the latter category, although Hurricane Lenny was also unusual in causing relatively little damage to the banana crop. Other tropical storms and hurricanes have principally affected the banana sub-sector. As such, they have been followed by relatively rapid economic recovery, basically linked to the rehabilitation of banana production, although the agricultural impact of Hurricane Hugo (1989) was particularly severe, also causing substantial infrastructure damage (see Chapter 6).

After establishing that other storms did not have immediate, measurable sectoral or macroeconomic impacts, the storm dummy series eventually selected only took into account the three major disaster years over the period of analysis – 1979, 1989 and 1995. Two forms of disaster dummy were tested – a composite series, with varying weight accorded to each disaster. and a series of dummy series for each of the three years, each of which was set at 1 for the relevant disaster year and 0 for other years (see Annex B)

Regressions were initially run simply with only the disaster dummies as independent variables. The best fits taking each of total GDP, agricultural GDP and non-agricultural GDP annual growth rates as the dependent variable were found in the logarithmic regressions against the individual dummy series (Table A.4.2). However, in the regressions taking GDP and non-agricultural GDP annual growth rates as the dependent variables, only the 1979 dummy series was found to be significant, with the relevant independent variable negatively correlated with the dummy variable in the current year and positively correlated with the lagged dummy variable. In the regressions taking agricultural GDP annual growth rates as the dependent variable, growth was also found to be negatively correlated with the current year dummy variable for 1989 , as would be expected given the sharp fall in agricultural GDP in that year.

When additional explanatory variables were included in the analysis, the best results in the regressions for GDP and non-agricultural GDP annual growth rates (with R^2 =0 99 and R^2 =0.96 respectively) were again found in a logarithmic form using the individual dummy series for 1979, 1989 and 1995 together with the consumption, investment and banana export price as independent variables. The dummy series for 1989 and 1995, in both their current and lagged forms, as well as for 1979, were found to be significantly correlated with GDP annual growth rates in this revised form. In contrast, only the severe 1979 hurricane had significant implications for the performance of non-agricultural GDP. In the regressions for agricultural GDP annual growth rates, the best results (with R^2 =0.87) were found in a logarithmic form using the composite dummy series, but again with consumption, investment and banana export price as additional explanatory variables. Both the current and lagged composite disaster dummy series were found to be significant in this specification.

In summary, the results of the regression analysis confirm the negative impact that major hurricanes have had on overall short-term economic performance and, particularly, on agriculture. Each of the three major storm events tested was found to have a statistically significant negative impact on both total and agricultural GDP In fact the agricultural sector impacts may even be under-estimated As the analysis of banana exports reported below in Chapter 7 shows, the full extent of the sensitivity of agriculture to storm impacts requires analysis on a quarterly rather than the annual basis on which national accounting data are only available for most developing economies.

[17] Other explanatory variables tested were gross domestic investment, private consumption, government consumption and the average annual unit banana export price (measured in EC$).

The results indicate that in the short-term non-agricultural GDP is less vulnerable to storms, other than the most severe events. The regression analysis also supports the finding that the impacts of hurricanes have become relatively less severe as agricultural sector product has declined as a share of GDP. But it should be borne in mind that the particular strength and path of Hurricane David made it especially devastating.

It should be noted that the above analysis has focused on the more easily measured short-term impact of disasters, relating to performance over only a few years at most. Longer-term analysis would probably indicate that the cumulative impact of disasters on non-agricultural GDP has been substantially greater, via their impact on such factors as the pace of capital accumulation. It would be naïve to conclude, based on an analysis of flow effects alone, that the non-agricultural sector is largely insensitive to natural hazards

4.2 Economic Development Strategies

Since before Independence, the GoCD has placed a continuing, central emphasis on economic diversification, both away from banana production within the agricultural sector and also, more broadly, into non-agricultural sectors.[18] This commitment to diversification has been prompted by concerns to develop a more resilient economic structure and also, more recently, by the decline in guaranteed preferential access to the European market for banana exports. As the Caribbean Conservation Association report explains (CCA, 1991: 73), diversification within the agricultural sector has additionally been predicated in part on the fact that 'emphasis upon a single crop leaves the country's agricultural sector vulnerable to natural disasters'. However, natural hazard vulnerability reduction concerns have apparently not been factored into plans for diversification more generally nor, at least in earlier years, into diversification within the agricultural sector [19] Indeed, there has apparently been little deliberate effort to reduce the overall hazard vulnerability of Dominica's economy.

Much play has been made of the opportunities created, as well as the challenges posed, by Hurricane David. For example, in the 1979 budget address it is stated that '(Dominica) has, unfortunately, since its Independence been savagely scarred by the ferocity of hurricane David. This however has, perhaps, provided the opportunity – and possibly the capital – for us to build a new nation and to achieve a greater standard of living for our people than would otherwise have been possible' (GoCD, 1979: 8). Hurricane David also offered the opportunity to advance the GoCD's diversification policy - and underlined the necessity for such a policy. The 1980/81 *Budget Address* explicitly acknowledged this opportunity, at least in the context of the agricultural sector, stating 'in the past we have given no more than lip service to the policy of diversification. Now that we have seen the dangers of a one-crop economy we need to move rapidly to implement in a meaningful way the program for diversification in agriculture... Our efforts at diversification must include crops which are not susceptible to destruction by adverse weather, and which can be used for expansion in agro-industry' (GoCD, 1980: 9)

Despite such statements of intent, Hurricane David in fact provided further impetus to the shift into banana production. Bananas offered the quickest, low investment way to restore agricultural production and export income whilst the GoCD failed to actively promote diversification into other crops - for example , through the provision of incentives Meanwhile, the potential for development of the services sector was not then recognized and the government felt that there was little scope for diversification in the manufacturing sector. [20]

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[18] Agricultural diversification is reported to have been on Dominica's agenda since the Royal Commission of 1893 (World Bank, 1992)

[19] The same report also comments that in the longer-term 'agriculture in Dominica has traditionally been characterized by 'boom and bust' patterns of development, with emphasis upon a single crop until a natural disaster, disease, or a change in the export market have compelled farmers to switch to another crop' (CCA, 1991: 71).

[20] The ECCB (*Quarterly Bulletin*, 1980: 13), in considering the impact of Hurricane Allen both on Dominica and also Saint Lucia and Saint Vincent, similarly noted the merits of banana production, writing that 'it is perhaps fortunate that bananas are a crop which can be rehabilitated in twelve months; there are some agricultural commodities that require a much longer period for the crop to come to fruition ' However, at the same time it also recognized the merits of diversification: 'in the interest of balanced economic growth it is prudent for territories such as these to take steps to broaden their economic base and move away from concentration solely on primary production to the fostering of secondary and tertiary industries' .

Limitations in the country's policy and planning capacity, lack of moral authority on the part of the government and as yet less than full relations with the wider donor community contributed to the GoCD's failure to exploit the opportunities presented by Hurricane David. Poor vision may also have contributed, as historically the island had swung from one dominant crop to another and this pattern was simply repeated. Following Hurricane David, senior officials established a small committee that continued in operation for two or three years, working on a strategic plan covering agriculture, infrastructure, schools, hospitals and so forth. However, this committee's efforts were largely ignored both by the GoCD and the international community. The latter mostly responded ad hoc to specific requests for emergency aid while individual donors based their response on their own assessments. Meanwhile, the still internationally inexperienced government was not fully aware of the potential external resources available for rehabilitation. Thus, between 1979 and late 1980 little was achieved other than the rapid restoration of pre-existing facilities whilst little was effectively done to stem the outflow of human capital from the island. It was not until late 1980, when more 'sensible' planning was begun, that the GoCD could begin to convince the IMF and World Bank that the situation required stabilization.

During the 1980s, the continued high profitability of banana production emerged as a key short term factor, discouraging resources from flowing into the development of a more diversified agricultural sector. Only the declining profitability of bananas in the 1990s for a combination of reasons including the loss of previously assured preferential markets, has forced a re-examination of the composition of the agricultural sector (see Section 5.1). Infrastructure constraints, inadequate government savings and fiscal instability – themselves in part a consequence of natural disasters – have also played a role in limiting progress towards economic diversification

The continued absence of a clear-cut growth strategy has been identified by the GoCD as an additional constraint on sustainable growth. This also represents an obstacle to the fuller consideration of natural hazard risks in the broader planning process. An integrated approach to national development planning, including between economic policy and physical planning operations, has been announced as one of the government's medium-term objectives (GoCD, 2000) Nevertheless, there remained a sense, at least amongst those interviewed in mid 2000, that the island's economic opportunities are already so limited and almost all viable economic activities are hazard prone anyway that it is simply not possible to take hazard risks into account in the formulation of broad economic strategies and policy .For instance, the GoCD's 1989/90 *Budget Address* identified several factors that 'we must constantly be watchful of' – namely, political stability, the cost of labor and labor productivity, but natural hazard risk was not mentioned.

Yet this attitude may be, at least in part, defeatist. Some sectors and sub-sectors are more hazard vulnerable than others as, for example, already discussed in relation to the fact that a proportionate decline of the agricultural sector in the economy has already played a role in reducing the impact of recent storms on short-term economic performance The country's burgeoning international financial services sector could also play a significant role in reducing Dominica's economic vulnerability to future hazard events, indicating that there is scope for changing the economy's vulnerability.

A lack of attention to natural hazard risks in overall economic strategy and policy formulation is by no means confined to Dominica. For example, Colleymore (1992: 93) comments about the Caribbean region more broadly that 'where disaster management efforts exist, they can be described as myopic and reactive... (while) decision-makers give natural hazard consideration a low priority'. Similarly, Surte (1996 275) states that 'the question of disasters has not assumed as important a role as it should have, either in the national physical planning process or in the economic and development calculus of the (Caribbean) region'.

Progress in incorporating hazard risk reduction into development strategy has been in part limited by informational constraints (see Chapter 13) and also by analytical difficulties in applying probabilistic data to planning and decision-making processes.[21] Detailed long-run historical records on disasters, dating back centuries rather than decades, are

[21] For instance, in assessing medium-term growth and balance of payments prospects for Dominica the World Bank Economic Memorandum in 1992 acknowledged the existence of hazard risks. However, although their assessment took into account the possibility of a banana export price shock, it is stated that'other potentially more serious constraints which could result from non-

simply not available. Meanwhile, difficulties in the applic ation of probabilistic data have been further complicated by the marked bunching of severe hurricane events within particular periods of time in Dominica (see Annex A). This bunching has also played a major role in the formation of subjective perceptions of risk, so that the importance of effective risk management has been underestimated at certain points in time. Thus the long period without a major disaster between 1930 and 1979 is frequently cited as a reason for lack of preparedness and a relaxed attitude to mitigation in the 1970s (e.g., GoCD, 1996a).

More information and analysis is also required on the economic and financial impacts of disasters in order to integrate hazard risk reduction concerns into medium - and long-term economic and financial planning. This case study has indicated some of the gaps in knowledge and ways in which these issues could be explored.

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economic factors such as adverse weather cannot be predicted and thus are not included in the projections' (World Bank, 1992: 29).