

Historical trajectories of disaster risk in Dominica

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Abstract

The calamitous consequences of Hurricane Maria (2017) for the Caribbean island of Dominica highlighted the acute and increasing susceptibility of the region to hazard events. Despite the increasing international attention given to disaster risk reduction, recovery from hazard events can be especially lengthy and difficult for Small Island Developing States. In this paper we build on existing understandings of disaster risk as a physical and social condition, and take a novel approach showing that historical processes are fundamental to understanding not only how conditions of risk emerge, but also how societal inertia causes them to persist over time. We take an integrated approach to analyzing the historical, physical, and social and political drivers of risk accumulation, and the consequent barriers to the reduction of risk. Using the example of Dominica, we demonstrate how processes set in motion during colonial times have shaped where people and assets are located, the degree to which they might be harmed, the societal repercussions of that harm and the prospects for recovery. We develop an understanding of the historical factors that have shaped Dominica's development trajectory, focusing on the underlying economic vulnerabilities and physical exposure to hazards created by agricultural, economic, and social practices, and successive government and international responses that have constrained post-disaster recovery. We argue that uncovering these historical drivers and persistent issues elucidates lessons for pursuing a more resilient development trajectory, including through the promotion of economic restructuring and diversification.

Significance

This paper provides an integrated approach to analyzing the historical, physical, and social and political drivers of risk and the barriers to risk reduction in the Caribbean island of Dominica. We show how a historical focus on these drivers can reveal the reasons why risk has accumulated over time, and how recurrent hazards have played an important role in further generating vulnerability and exposure. This paper demonstrates how combinations of events and processes have heightened disaster risk for the island, explaining why Dominica now faces significant challenges in pursuing

social, economic and sustainable development. This work can inform similar analyses of the historical factors that have shaped the development of other small island developing states with colonial histories.

Introduction

On 18th September 2017 Hurricane Maria, a category 5 hurricane, swept across the Caribbean island of Dominica. Its passage left catastrophic destruction in its wake, with 31 people dead and 37 missing, 80% of the population affected and more than 90% of buildings damaged or destroyed (ACAPS, 2018). The impacts of this intense storm were disastrous; but as with all disaster, the drivers of risk are social, political, and cultural, as well as physical. Across the Caribbean, a series of shortsighted policy and investment decisions have led to an accumulation of exposure and vulnerability to hazards in these islands. High levels of debt and dependency on external finance, economic instability, insularity, remoteness and environmental fragility, limit their development potential, but so too do the repeated and devastating impacts of disasters (Wilkinson et al., 2016).

Hurricane Maria was one of a long succession of hazard events that have impacted Dominica, with effects that can be traced, at least in part, to actions and processes rooted in colonial and post-colonial history. An analysis of these historical drivers can help to reveal the reasons why risk has been allowed to accumulate (and where exposure has been successfully dealt with). We argue that by the time of independence on 3rd November 1978, Dominica was already fixed on a trajectory, locked into a high-exposure and vulnerability development path. Risks have accumulated over time, and hazards have played an important role in further generating vulnerability and exposure. This paper sheds light on these historical events, to help explain why Dominica now faces significant challenges in pursuing social, economic and sustainable development.

In the next section, we provide a brief overview of the physical context and history of Dominica, introducing the idea that a combination of events and processes have generated over time a heightened situation of disaster risk for the island nation. In the following three sections, we then set out the historical roots of this condition in detail, leading onto a discussion of how these historical drivers have interacted to shape past and present patterns of risk.

Dominica: the context

The Caribbean island of Dominica (capital city: Roseau) occupies around 750km² of land. The highest elevation is Morne Diabolotins (1,447m), part of a chain of rainforest-covered volcanic peaks that creates a central, steeply dissected mountain range, from which 365 rivers originate (Figure 1). This precipitous topography creates unstable slopes, strong orographic variation in rainfall and a steep marine shelf. At 15°18' N and 61°23' W, Dominica also lies under the influence of the inter-tropical convergence zone, with a shift in wind patterns and broadly increased rainfall during the July to October hurricane season.

Consequently, and in common with many other Small Island Developing States (SIDS) worldwide, Dominica is prone to a wide variety of natural hazards including hurricanes, intense rainfall, slope instability, volcanic eruptions, seismic activity, and tsunami (Wilkinson et al., 2016). Since Columbus's ship first saw the island in 1493, impacts from some 177 intense storms or hurricanes, and 4 earthquakes or earthquake swarms have been recorded (Table 1). Approximately 70% of the island's total land base is unsuitable for modern agriculture primarily due to the risk of sheet erosion or waterlogging (Burke and Lovell, 2000).

Decisions taken by colonial powers (by the French and then the British) have played a significant role in shaping population distribution and growth patterns, land-use, and recovery from hazardous events (Tables 1 and 2). Historians infer that the pre-Columbian population lived mainly in small distributed settlements, close to fertile land and relatively sheltered from hazards (Burke and Lovell, 2000). French and English occupation, however, shifted the pattern of settlement to locations with good external trading routes and strategic and defensive advantages.

Dominica officially remained a neutral territory until the Treaty of Paris in 1763, although prior to this, French settlers were already setting up small market gardens and cutting timber (Atwood, 1791; Honychurch, 1995). After 1763, the land was surveyed and a map produced, the Byres Map (Byres, 1776), which included a definition of the 'King's Three Chains', a coastal strip of Crown Land reserved for government buildings and defenses (Honychurch, 1995; Niddrie, 1966). Investors were sold parcels of land to develop plantations and cash crops, facilitated by the use of slave labor, (enslaved West Africans had first been brought to Dominica in the late 17th century) (Atwood, 1791). Importantly, the revenue was retained by the British Crown, since it was expected that profit and capital growth from land use would drive investment in the island's infrastructure and economic development.

Table 1. Historical population growth and recorded occurrence of hazardous events in Dominica.

Time Period	Population Estimate	Roseau population	Slave population	Cumulative recorded 'intensive' hazard events ⁽⁴⁾	Cumulative number recorded total events (Int and Ext)	Key Hazards with large impacts ⁽⁵⁾		Diseases (Crop and Human)
Up to 1511	13,300 - 17,600 ⁽¹⁾			1	1	Hurricane 1503		
1647	4,000 - 5,000 ⁽²⁾			1	1			Smallpox, measles and typhus
1745	3032 ⁽¹⁾		2000	2	2	Hurricane 1740		
1763	8090 ⁽³⁾		5872	3	3	Hurricane 1758		
1773	22853		18753	6	6	Hurricane 1778	Earthquakes 1765	
1787	16648		14967	14	14	Hurricanes: 1779;1780	Fire 1781	
1805	26499		22083	16	16		Fire 1805	
1811	26041		21728	18	19	Hurricane 1806	Flood/landslide 1806	
1826	19240		15392	19	25	Hurricane 1813(2), 1825	(Earthquake 1816)	
1833	18720		14186	19	28			Coffee blight
1844	22469	3883	-	21	34	Hurricane 1834	Earthquake 1843	
1861	25065	4697	-	21	35		(Earthquake 1849)	
1871	27178	4456	-	21	36			
1881	28211	5186	-	21	44		(Eruption 1880)	
1891	26841	5764	-	21	50			
1901	28894	6577	-	21	58			
1911	33863	6803	-	21	66			
1921	37059		-	22	70	Hurricane 1916		Root tip (limes)
1946	47624	9752	-	24	80	Hurricanes 1930, 1938	(Earthquakes 1937)	Red rust (limes)
1960	59916		-	24	85			
1970	69549		-	24	89			
1981	73795		-	26	92	Hurricane 1979	Landslide 1977	
1991	71183		-	26	97			
2001	71242		-	26			(Eruption 1997)	
2011	70739	16,500	-	26	177			
2018	73162 ⁶			28		Storm 2015 Hurricane 2017		

Notes

- (1) Burke and Lovell, 2000
- (2) Father Raymond Breton (1647), quoted in Burke and Lovell (2000)
- (3) This, and all subsequent demographic data until 1946, is taken from the summary in the 1946 census.

- (4) Post 1815, intensive events are those where more than 6 human deaths are recorded, or impacts occur that resonate island-wide. Prior to 1815, it is assumed that if an event is recorded, then it had intensive impacts. This alteration is reflective of changes in infrastructure robustness (and hence ability to withstand events) pre- and post-1815, which mean that it is appropriate to define 'intensity' differently.
- (5) Where events are reported in brackets they are recorded for their comparatively unusual occurrence (e.g. earthquakes), rather than the intensity of their impacts. Full details and sources in Appendix 1.
- (6) Current population estimate (for 2015) from UN World Population Prospects 2017 (accessed 20 June 2018 <https://esa.un.org/unpd/wpp/>).

Under British rule, the economic history of Dominica has been characterized by an '*economically dominant export crop of one kind or another*' (Yankey, 1969 quoted in Nelson, 2010). Even after the emancipation of slaves in 1834, labor and land use practices continued to promote employment on larger plantation estates and deter subsistence and income-generation from smaller landholdings. But disease, natural hazards and other economic stresses reduced employment opportunities, promoting a drift toward marginal settlement on Crown Land and at the edges of larger towns. It was not until 1945 that regulations allowed islanders to purchase less than 40 acres of land at a time.

In this paper we argue that the impacts of hazards, diseases, and other shocks on dominant crops, alongside the land use and labor practices created by this economic model, have all contributed to Dominica's under-development and high levels of disaster risk. We take an integrated approach to analyzing the historical, physical, and social and political drivers of risk accumulation, and the consequent barriers to the reduction of risk. In the following sections, we develop an understanding of the historical factors that have shaped Dominica's development trajectory, focusing on the underlying economic vulnerabilities and physical exposure to hazards created by agricultural, economic, and social practices, and successive government responses that have constrained post-disaster recovery.

This paper follows a now well-established understanding of disaster risk as both a social and physical condition, in which the chances of being exposed to, and adversely affected by, hazards are generated at least in part by the decisions, actions, behavior and policies adopted by individuals and institutions (see e.g. Hewitt, 1983; Bankoff et al., 2004; Wisner et al., 2004). However, we make the additional argument that historical processes are fundamental to understanding not only how conditions of risk emerge, but also how societal inertia causes them to persist over time. This historical approach is rare in disaster research: one notable exception being Anthony Oliver-Smith's study of Peru's five-hundred-year earthquake (Oliver-Smith, 1999). Using the example of Dominica, we demonstrate how processes much earlier than independence in 1978 have shaped where people and assets are located, the degree to which they might be harmed, the societal repercussions of that harm and the prospects for recovery. We argue that uncovering these historical drivers and persistent issues also elucidate how they might be avoided to improve the likelihood for progress to a more resilient development.

Table 2: *Historical developments and policies concerning land use, infrastructural development, governance, and social attitudes*

Time	Events and policies
1627 ⁽¹⁾	Dominica is a Kalinago stronghold , and base from which to launch attacks on European colonists.
1686-1763 ^(2,3)	Following continued battles for control between the British, French, and Kalinagos, Dominica is declared neutral territory. French develop coffee and cocoa plantations, with some English habitation. Leads to 'French-supporting' Kalinagos on windward coast and 'English-supporting' Kalinagos on the leeward side. Kalinagos free movement restricted, denying some access to fishing and gathering grounds.
1763 ⁽³⁾	Dominica ceded to Britain by the Treaty of Paris after the 7-year war (1756-63).
1763-1778 ⁽¹⁻⁵⁾	UK investment focuses on military infrastructure and raising of revenue via surveying (Byre's Map) and selling of land, generating revenue of £312,092 11s 1d. Payments were by instalment and deposit, instantly creating indebtedness and payment default. Existing (French) farmers were tolerated via land-rent and a coastal-strip was created as the 'King's Three Chains' – reserved for Government Building and defence. New landowners escalate importation and use of slaves and plantations. An ideal trading harbour, Portsmouth designed and laid out as the capital of Dominica, but thwarted by insect-borne disease bred in swamps.
1778-1783	French colonial rule.
1783-1812 ^(2,7,8)	Return to British rule by the Treaty of Versailles. Continued skirmishes associated with Anglo-French wars, encouraging further focus on defensive infrastructure. Period of increasing 'maroonage' as slaves use mountainous interior to hide and subsist, having escaped.
1812-1832 ^(1,2,9)	Maroon Wars (1812-15): Very severe repression by British of slave revolts. Hurricanes in 1813 exacerbate situation destroying infrastructure and slaves' 'provision' grounds inducing starvation.
1833-1838 ^(1,2,10)	Abolition of Slavery Act (1833) leads to full emancipation following period of 'apprenticeship'. Variable labour practices established, new land not made available. Poverty amplified by hurricane and coffee blight (Table 1). Successful petition for disaster relief as loans but these remain largely unpaid (Fig 4).
1850-1892 ^(1,11,12,13)	Local push to improve economic diversification on the island, but free labour largely forced to squat on estate margins or occupy the King's Three Chains which were sold to contiguous plantations in 1853, creating unrest following attempts at eviction. Lime cultivation encouraged by Imray from 1863, facilitated by development of Botanic Station (1884). Development hampered by lack of investment in road infrastructure (Figure 3). Dominica grouped in the Leeward Islands (1871); administrative union under one Governor.
1893-8 ^(13,14,15)	Three reports commissioned: Royal Commission ('Hamilton' Report, 1894) 'into the condition and affairs of the island of Dominica'; West India Royal Commission analyses regional depression of sugar industry - report includes recommendations for Dominica on growth of bananas and limes, and infrastructure development; C.O. Naftel commissioned by the local legislature appraises the island to attract 'capitalists and intending colonists'.
1900-1938	First World War – leads to drop in trade and increased price of food. Shortage of trade and export market for limes.
1938-1950 ⁽¹⁶⁾	West India Royal Commission (1938) to analyse continued poor social and economic conditions in the region ('Moyne Commission'). Action hampered by WW2, which also reduced fishing due to hostile ships. Introduction of measures allowing purchase of smaller plots of land. Dominica moved to the Windward Islands Administrative Union.
1950	Establishment of bananas as major crop (accounting for c.80% of all exports by the 1960s).

1955-1967	Various developments in the island's governance system leading up to independence. These include the introduction of the Ministerial system (1955) and first representative party (The Labour Party of Dominica); the first Chief Minister and formation of second representative party (The Dominica United Peoples Party) in 1957; the granting of Associated Statehood in 1967.
1978	Full independence attained under a republican constitution. Prime Minister Patrick John and Cabinet based on the Westminster model.

Source: (1) Honychurch 1995; (2) Honychurch 2017; (3) Murdoch, 1984; (4) Niddrie 1996; (5) Byres 1776; (6) Hauser 2015; (7) Welch 1968; (8) Parliamentary Paper 1814 insurrection; (9) Trouillot 1988; (10) Appendix A to the Report of the West India Royal Commission, 1898, into the Depression of the sugar industry; (11) Nicholls, 1894 (12) Hamilton Report, 1894; (13) Report of the West India Royal Commission, 1897, Parliamentary Paper by Command 8655; (14) Naftel, C.O., 1898, Report on the agricultural capabilities of Dominica. Colonial Reports; (15) West India Royal Commission Dominica Report, 1945 and Parliamentary Paper by Command 6607, 6608 and 6174 (Recommendations, dated 1940).

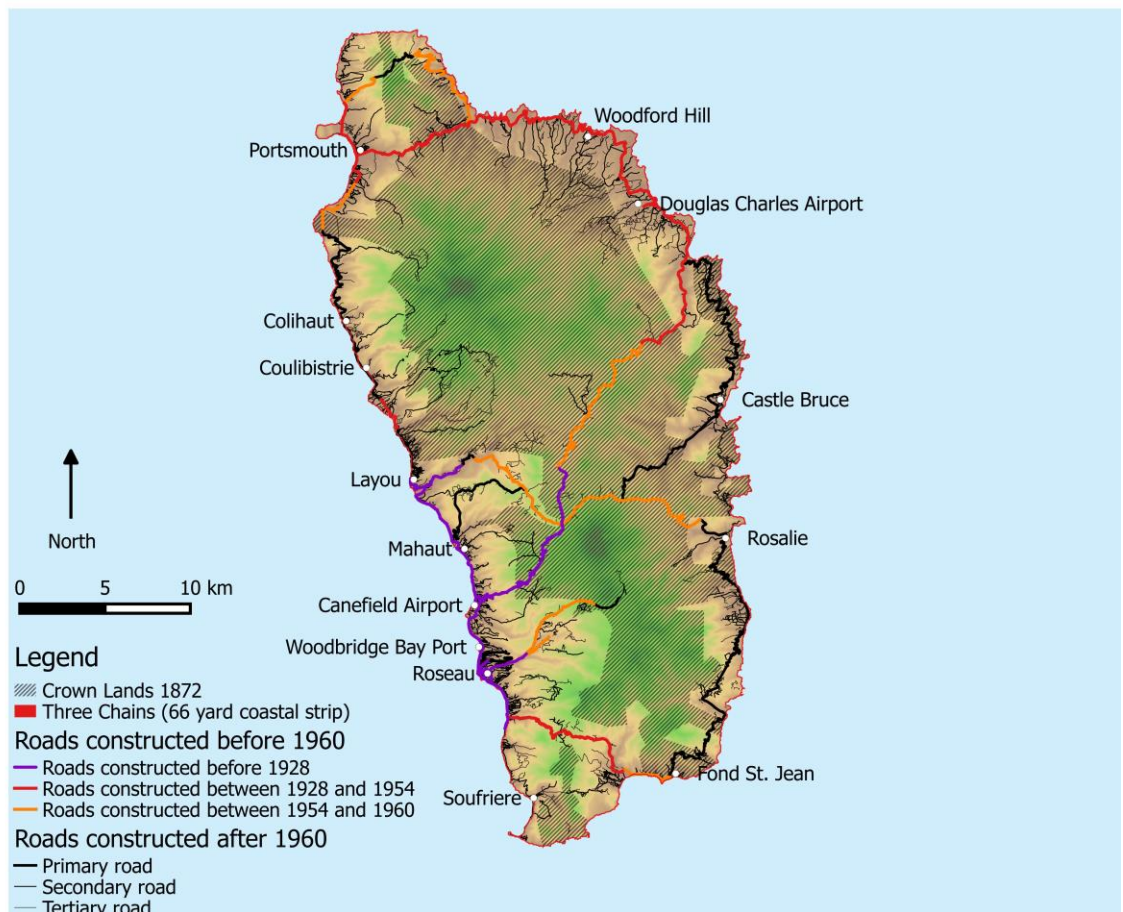


Figure 1. Topographic map of Dominica showing selected settlements, port and airports, main roads and rivers. Source: Archived historical maps and CHARIM geonode for Dominica <http://charim-geonode.net/>

Underlying economic vulnerability

The history of Dominica since the late 17th Century is characterized by successive (failed) attempts by British colonial powers to establish dominant large-scale agricultural production that would provide income for the colony and home nation and enable the island to flourish. During the colonial period, despite various thwarted attempts to rectify the situation, the island's economy remained structurally weak with low levels of productivity, and high susceptibility to external economic shocks and hazards. Decisions taken regarding land ownership, agricultural, and road infrastructure investments deepened this underlying economic vulnerability.

A succession of coffee, sugar, cocoa, limes, and bananas dominated as the main export crop at any one time (Figure 2a). Yet, the underlying assumption that investment and development in the island would follow from the profits from agriculture after land sale and re-distribution in the late 18th Century proved untrue in Dominica (Murdoch, 1984; Trouillot, 1988; Honychurch 2017). In 1894, an enquiry for the British government by Commissioner, Sir Robert Hamilton noted that *'Dominica, though one of the most fertile of the British West Indian Islands, is [...] less developed [...] and its inhabitants appear less prosperous and contented'* (Hamilton, 1894). Figure 2a illustrates the variations in economic output and typical regrowth times of key crops for the period 1810-1950.

Coffee was the principal export crop of Dominica grown in the 18th Century by French smallholders and until the 1830s, when a combination of factors, including the emigration of French landowners, deforestation, insect blight, a hurricane in 1834 and increasing sugar prices, signaled its decline. Sugar cane production increased, but external political factors affected its viability: by 1854, the Caribbean sugar crop was no longer protected by import duties in Britain, and by 1874 sugar was being traded on the free market (Figure 2b). Cocoa temporarily filled the gap in exports, but many trees were destroyed during the hurricanes of 1915 and 1916 (Nelson, 2010). Limes were first introduced as a possible alternative income source in 1860. The value of lime products and diversity of markets for juice, oil and extract encouraged growth, which peaked in the 1920s when it accounted for over 80% of the island's total export value (Nelson, 2010). However, withertip disease (Table 1), three hurricanes (1926, 1928 and 1930) and a drop in market value during US prohibition and global recession saw the demise of lime production in Dominica (Figure 2a). Bananas were next. A report by the West India Royal Commission (Morris, 1897) recommended Dominica establish fruit trade (bananas) with North America, emulating trade between Jamaica and New York. By 1953, this amounted to 45% of all export values, surpassing citrus (Trouillot, 1998 p52). Bananas, referred to as 'green gold' (Thompson, 1987), were the mainstay of Dominica's economy until the 1990s (Figure 2a), when, coupled with sporadic impacts from hurricanes, preferential trade tariffs from the EU that had existed since independence came to an end (Figure 2a, Payne, 2006; Payne 2008).

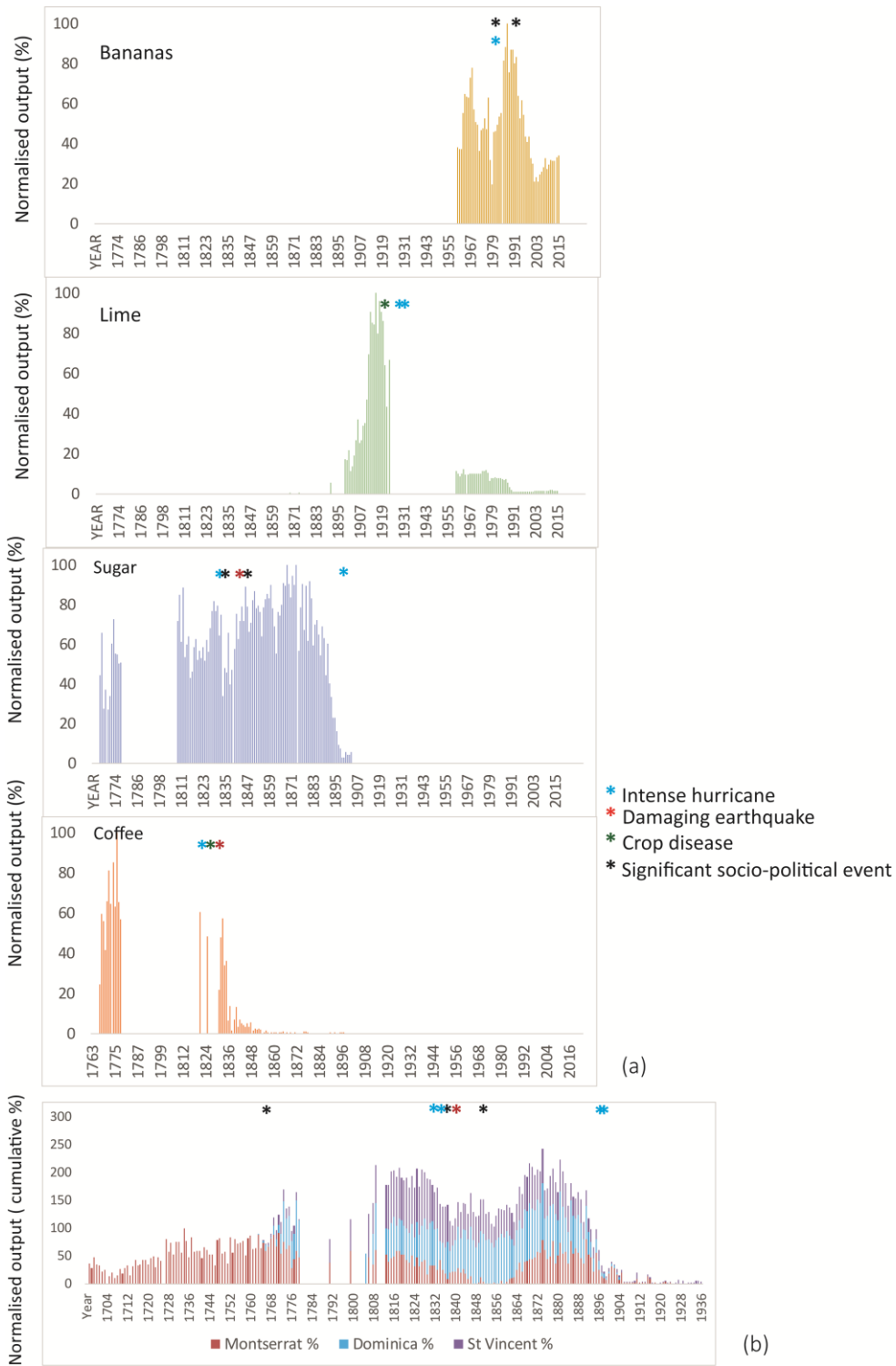


Figure 2a. The boom and bust of sugar, coffee, lime and banana production in Dominica, 1763-2016. Values are normalised against the year with peak productivity for each crop. Full details of data type and sources are in Appendix 2.

For each export crop, the rise and demise is therefore associated with a complex combination of factors, with output weakening due to a combination of disease, hazard and economic circumstance.

The factors often intersected cumulatively, threatening the long-term sustainability of each successive crop as a commercial enterprise.

By the end of the 19th Century, the British colonial powers began to express concern about the island's economic productivity, in line with the broader concerns of maintaining production in the West Indies (Hamilton, 1894; West India Royal Commission, 1897). The over-reliance on a few main crops for export and economic prosperity, alongside the subsistence economy was questioned in Dominica as it was in other parts of the Caribbean (Barker, 1993). The Hamilton Report (1894) and Naftel Report (1898) both recommended crop diversification and the encouragement of small landowners and labourers to produce more than 'provisions' (subsistence crops). This trajectory of insufficient investment in development and a weak economy was further highlighted in reports commissioned in 1927, 1939, 1947 and several more until Independence in 1978 (Browne, 1939; West India Royal Commission, 1945).

There were some localized efforts to diversify and strengthen the economy. In 1838, stipendiary magistrate Phillips said 'laborers' should be encouraged to focus on exportable products in addition to home-serving ones; and the Governor of Dominica, JR Longden, exhorted the island's Assembly in 1865 to help secure land for the 'peasantry' for cultivating exports. Landowners, however, were wary of ceding land to laborers, so proposals to promote diversification, were often superseded by a desire to attract further 'capitalists and intending colonists' (Naftel, 1898). As a result, the promotion of the 'monoculture' model continued until the end of Dominica's colonial period, justified through reference to examples of its success in other (larger) Caribbean islands (Morris in West India Royal Commission, 1897), and partially driven by the tensions around land tenure and need for capital for infrastructural development. Nonetheless, the Botanic Station in Roseau started operating as a distribution center for plant species, increasingly used by agricultural laborers. A Kew-trained instructor provided information on new techniques and practices through the Dominica Agricultural School, which opened in 1900, and it quickly had an effect, enabling small ventures to flourish.

Dominica's mountainous terrain has posed systematic challenges to agricultural development, requiring significant infrastructural investment to unlock the agricultural potential of the interior. However, land purchase and ownership arrangements severely restricted this investment. All Caribbean islands ceded by the French to the British in 1763 (Grenada, St. Vincent and Dominica) had a carefully constructed scheme for the sale of 'Crown Lands' (Murdoch, 1984), which involved surveying, valuation and sale of parcels of land for cultivation and profit, usually via loans against the valuation of the land. This left little incentive to quit land permanently as debts grew. This economic system of plantation agriculture in the British West Indies in the 18th Century '*rested on a complex and permanent system of borrowed capital, to finance the establishment of plantations and short-term loans to finance the year-on-year running costs, the resultant debts being serviced out of the profits on each year's crop*' (Murdoch, 1984). Although land sale for any one plot was initially limited to lots of around 50 to 100 acres, this was easily circumvented by some purchasers when early 18th Century defaulters were forced to re-sell their land (Welch, 1968).

Roseau has been the main settlement since pre-colonial times when it was the seat of the Kalinago chief of leeward Dominica (Honychurch, 1995). Early British development focused on the creation of Portsmouth, with a natural harbor, as a capital but these plans were largely unrealised as low-lying shore grounds were also a natural breeding area for mosquitoes and associated diseases. Further coastal development elsewhere was encouraged by the creation of free lots for poor planters in the

late 18th Century (also providing a ready militia for future defense). In Dominica, the initial sale of land should have created £326,022 of revenue by 1773, but managerial incompetence and defaulted payments meant that less was realized (Murdoch, 1984). Some of this money was used to begin an interior road in 1768 and 1769, and some £100,000 was spent on fortifications as tensions remained high with the French in the late 18th and early 19th Centuries (Honychurch, 1995). But the lack of repayment and unpaid debt rapidly spiraled into rancor, further debt and uncertainty around obligations for infrastructural development and repayments; all of which was accentuated by asset and income losses due to hazards and disease. Many plots were completely inaccessible, with investors who purchased them required to construct roads to access their estates. The result was that most estates developed along the coastal strip, while plots in the interior remained inaccessible and undeveloped (Honychurch, 1995). By 1893, road networks suitable for motor vehicles consisted of no more than 40km around Roseau, of which 32 km were unmetalled track (Hamilton, 1894; Figure 1). The lack of roads separated smallholders from markets in Roseau and villages were obliged to operate largely self-sufficiently, further encouraging coastal development.

During the 19th Century, investment in roads and infrastructures remained low as the British Government attempted to ensure the colony was cost-neutral to it in economic terms. A series of unpopular taxes attempted to raise revenue for infrastructure in the mid-19th Century (Figure 3). Predicated on anticipated land values, these fell disproportionately on the poor, without delivering significant investment in road expansion. Roseau residents were exempt from the Road Tax, encouraging movement to the margins of the capital (Hamilton, 1894). Around the turn of the century two major attempts were made to tackle road infrastructure, the first started in 1888, financed by £40,000 in loans and increased taxes. Progress was prevented by the combined influences of incompetent engineering and severe flooding in 1891 (Hamilton, 1894). Later, the construction of the first 12-mile stage of the trans-insular road (known as the Imperial Road) was completed with a £12,000 in grant from the British government (Figure 1, Honychurch, 1995). The planned route for the road up the Layou valley was changed to allow access to a private estate purchased at the time by a wealthy investor. The revised route was controversial, requiring an additional 300m of ascent (Hulme, 2000), but the route remains a key road link through the island. The road opened up a swathe of interior land, resulting in an investment of £40,000 (according to the papers of Hesketh Bell, governor of the Leeward Islands) (Hulme, 2000). However, these estates largely fell into disrepair during the 1920s due to low productivity and problems paying for maintenance of the road (Hulme, 2000).

The 1950s and 1960s saw a concentrated program of road building to complete the major roads as well as the feeder road network (Figure 1). These feeder roads allowed the Crown Lands in the interior to be accessed and sold to smallholders for banana cultivation. The trans-insular road linking the east and west coasts was completed in 1956, and a road linking the main urban centers of Roseau and Portsmouth was opened in 1972 (Honychurch, 1995), financed initially by the Colonial Development and Welfare Office. Infrastructure upgrades have unlocked the agricultural potential of the island to small-scale farmers, but much of this expansion occurred during a period of minimal storm activity, so roads were not built to withstand hurricane impacts (see below). The cost of maintaining these roads in the face of more frequent tropical storms and hurricanes in recent years is a considerable challenge.

Consequences for exposure to hazards

Historical factors have exacerbated the exposure of people, livelihood assets and infrastructure to hazard impacts. Most notably, this section discusses how land tenure patterns have created spatial marginalization of the poorer sections of society to hazardous locations, and how badly situated critical infrastructure have resulted in high levels of exposure.

The restrictions on land use and availability of small holdings for successive generations described here have not only made the economy more susceptible to natural hazards, it has also caused much of the population to be concentrated in locations with heightened exposure. In complex ways this process is tied to the legacy of emancipation. In 1838, when freedom from slavery was granted, the colonial government pursued an intentional policy to keep 'former slaves' from owning land. In 1836, Lord Glenelg, Secretary of State for the Colonies had sought to maintain levels of labor on colonial estates in order to ensure economic stability for Britain. An effective way of ensuring this was to 'impede' the acquisition of land by free slaves, and therefore force them into estate labor for survival (Honychurch, 2017). In the late 18th Century the decision to sell land to the highest bidder above a set minimum price, kept most people as landless laborers (Trouillot, 1988). Although the colonial poor were somewhat accommodated, landless black laborers were caught in a vicious circle until as late as 1945, as purchase of less than 40 acres of land was not permitted, and wages were kept low. In the 1950s, Crown Lands were sold to smallholders, and were located inland from the colonial estates (Honychurch, 1995).

After emancipation, landless former slaves who wished to grow their own provisions had no choice but to settle illegally where they found unoccupied land. Illegal settlement was particularly concentrated in coastal areas within the 66 yards of the King's Three Chains defined by John Byres during the land survey of the 1760s. *The Almanac* [1870] describes how former slaves who were no longer willing to live on plantations:

"rush like a torrent upon the vale", [...] carrying posts and boards to the bays at night, [where] houses were seen weekly rearing their trashy heads, irrespective of the law meun and tuun as far as lands were concerned. Indeed, some of the people believed that the boon of freedom was incomplete, if not insecure, without a small piece of land being attached to it."

Some estate owners with land near to the King's Three Chains attempted to eject 'squatters', but these attempts often revealed a lack of clarity over estate boundaries and land tenure, and in some instance estates tacitly endorsed these processes. As a result, laborers remained on land where no eviction action was taken, which explains some of the crowded beachfront communities on the West coast of Dominica (including Dublanc, Colihaut, St Joseph, Layou, Mahaut, Massacre, Loubiere, Pointe Michel, Soufriere, and Scott's Head) (Honychurch, 2017). Many of these beachfront communities are today exposed to coastal hazards: Pointe Michel was one of the hardest hit in Hurricane Maria, with at least 30 fatalities occurring there (Dominica News Online, 2017).

Dominica's public infrastructure is highly exposed to natural hazards and became increasingly so during the 20th Century as infrastructure expanded to serve communities along the coast and in ravines as urban settlements expanded. The origin of this high exposure lies in the colonial partitioning of land and post emancipation settlement described here.

The road network expanded between 1950 and 2018 to 566km (main and secondary roads), 338km of feeder roads, and 200 bridges, as the interior road was completed and a subsequent creation of feeder roads took place to service the smallholders participating in banana cultivation. The roads (Figure 1) traverse unavoidably steep landslide-prone slopes and flood-prone river crossings in order to serve communities strung out along the original King's Three Chains settled by emancipated slaves. These feeder roads place a substantial burden on the government in terms of both general maintenance and repair following extreme weather events. For example, in 2009, a road condition assessment showed that about 24% of the main roads and 90% of the secondary, urban, and feeder roads were categorized as in poor or bad condition. In 2015, Tropical Storm Erika damaged or destroyed 40% of roads and 50% of bridges (Government of the Commonwealth of Dominica, 2015).

Critically, network expansion coincided with a relatively quiet period in terms of numbers of hurricanes (Table 1). Designing a resilient network may have not been considered as a high priority at that time (Benson et al., 2001). Limited grant funding, and a major infrastructure deficit may have incentivised a least-cost approach to road design and construction, which has left Dominica with a legacy of rapidly deteriorating roads. Roseau, as the capital, has become a significant port, despite exposure to wave action during storms. At least six jetties near Roseau have existed at various times, and, in turn, been destroyed by hurricanes (Honychurch, 1995). Dominica's first and only deep-water port at Woodbridge Bay, north of Roseau, opened in 1978. In 1979, this facility was extensively damaged by Hurricane David, with a rehabilitation cost estimated at 41% of the total original project cost. Strengthening of part of the jetty against swells in 1996 was vindicated following Hurricane Lenny in 1999, which damaged only the unreinforced part of the jetty deck. The port continued to operate following Lenny, providing the only lifeline berthing facility (Benson et al., 2001).

Historical decision-making processes have therefore exacerbated exposure to hazards in several important ways. Firstly, the development of settlements in hazard-prone locations can be traced back to the colonial era and particularly emancipation, when settlement in highly exposed coastal locations and marginal Crown lands occurred. Secondly, some of the poorest and most marginal settlements are relatively isolated and particularly vulnerable to disasters. Thirdly, the late development of roads, air and seaport during the 1950s to 1970s, during a period of infrequent hurricanes, may have disincentivized designs capable of withstanding the type of extreme events seen in the latter part of the 20th and early 21st Centuries.

Disaster response, relief and governance

We have demonstrated that successive disasters in the 18th and 19th centuries affected populations, crops, and infrastructure, in multiple and complex ways. Finally, we consider the extent to which historical practices of response and relief have acted to create deep-rooted structures and expectations that resonate today. After 1763, Island administrators and communities on Dominica responded by requesting assistance from the Crown Estate in Britain, which in turn, provided ad hoc grants and loans that drew on the already complex system of borrowed capital with which the colony was established by the British Government. Although intended to facilitate the economic and social recovery of both private landowners and public infrastructure, these actions were also rooted in the primary function of the British Empire at the time: maximising profit for the UK while minimising debt burden. Loans involved lengthy correspondence (through a hierarchy of governance layers), usually required repayment and frequently accrued substantial interest. These loans were not distributed equitably, and repayment was often renegotiated, sometimes formally and sometimes on an ad hoc basis. This led to an emphasis on backward looking repayment and recovery in response to past disaster rather than on the creation of incentives to invest, learn and prepare for future problems, despite over 100 years of reporting and analysis that suggested some alternative pathways (Hamilton, 1894; West India Royal Commission, 1898, 1945; Benson et al., 2001).

This amplification of disaster impacts via complex administrative and financial responses is best illustrated through a detailed example: the records relating to the aftermath of the 1834 hurricane, for which an estimated £291,500 losses were incurred (Governors, 1854). Responses in the decades following this event were both bureaucratic and ineffective in terms of creating a self-sufficient recovery, failing to provide a spur to sustainable economic growth and no incentive to break with the monocultural model of production. The timeline for our analysis is illustrated in Figure 3. Initial response and requests after the 1834 hurricane focussed on alleviating civil expenditure and providing tax breaks (the initial 1835 Relief Bill allowed duty free imports of lumber, shingles, flour, beef, pork, and fish for a few months). The island was granted £80,000 (by session 5&6 Will.4, c51; see Figure 3) and of this, £10,000 was loaned for public services and a total of £66,950 was loaned to estate proprietors in the form of 64 individual loans. However, this came from a reallocation of the West Indies Loan Act (1832), where £1m had been allocated to Jamaica, Barbados, St Vincent, and St Lucia for hurricane relief and 'insurrection'. These loans, provided via the newly formed West Indies Relief Commission, were at lower interest rates (3% originally), secured by mortgages, with interest payments charged against future estate revenue, mirroring commercial practice in the private credit market (Smith, 2012). Little direct support was given to slaves or anyone of mixed race, but local government agents received grant-in-aid at a low cost to coordinate supplies of shelter, food, and clothing (Smith, 2012).

Public debts and interest, and private interest accruing were then variably repaid until a damaging earthquake in 1843 generated claims of £8,000-£10,000 damage to the whole island (1843 papers). The Subsequent Relief Act offered further loans up to a total value of £50,000 to Dominica for a three-year period at 4% interest. This set-back, exacerbated by the 1846 Sugar Duties Act, which equalised import duties on sugar from British colonies (West Indian colonies had been favoured by lower sugar import duties since 1814) meant that loans were no longer repaid and debts accumulated. By 1855

outstanding public loans were calculated at £7,002, while loans on estates now totalled £92,352. Further amendments to the Relief Act were created in 1848, 1860 and 1867, to accommodate differing repayment terms and incorporate the payback on further loans (Figure 3, Hamilton, 1894). Arguments for the particularity of Dominica centred on the impacts on the coffee industry, amplified by longer disease and regrowth time for coffee bushes (and cocoa trees) in comparison to sugar cane (1854 papers). Detailed correspondence reveals the compounding issues of increasing agricultural and freight costs, the financial impacts of troop withdrawal on local markets and the readjustment of sugar. By 1878, the West India Relief Commission was wound up and there was a remission of most unpaid loans. The decision was taken that some loans could not be repaid because payment depended on profit from plantations, which had been substantially reduced. Eventually, with the 1879 West India Loans Bill, all private (estate owners') outstanding loans were written off, and the last payment for the outstanding public services loan (£ of the £10,000 advanced) was in 1880. Attention then returned to the means by which Dominica could once again become profitable (Hamilton, 1894).

The balance of loans and grants over time (see Figure 3) show a consistent pattern of requests for financial assistance from the Lieutenant-Governor of the island followed by inability to make repayments, patterns that are repeated in analyses through the 20th Century (West India Royal Commission, 1945, Benson et al., 2001). Despite the geographical, cultural, and historical diversity of Caribbean islands, the approaches to requesting repayment of loans by the British Government was similar and uniform: islands that were not performing well in terms of exports and profits could be managed by following the pattern of colonial development established on others. On the other hand, island governors and British-commissioned reviews argued for recognition of the particularities of individual islands. The legacy of unpaid loans (despite remission of most by the early 1880s) continued to be felt, through difficulties in re-establishing profitable agricultural outputs and fit-for-purpose infrastructure at the end of the century and beyond, as discussed in previous sections. Deeply entrenched patterns of post-hoc requests for remission from debt and hardship set in, rather than forward looking arguments for radical change.

The recent passage of Hurricane Maria has already undone much of the rehabilitation effort following Tropical Storm Erika. Perhaps now it provides the opportunity to re-assess the resilience of agricultural practice, infrastructure and recovery assets, by placing the lessons of history in sharper focus.

Discussion

This paper presents an analysis of historical social, economic, and political processes that have had overwhelming implications for Dominica's development trajectory. Notwithstanding the severe challenges posed by the island's geographical location, topography, and exposure to multiple forms of hazard, lessons can be drawn from an historical analysis to inform recovery planning and help manage risks more effectively in the future.

This paper underscores the role that seemingly unrelated social, economic, and political processes can play in generating disaster risk for decades to come. In Dominica, this can be seen in decisions taken at the beginning of British colonial rule. These include: the division and sale of land; decisions about labor and land use at the time of emancipation; coastal zoning and the establishment of the King's Three Chains; and the pursuit of an export-led economic development model, based around large

plantations with the aim of generating economic surplus from the colonies (and with the largely unfulfilled expectation that these profits would lead to private investment in infrastructure). All these decisions, actions, and policies had serious implications for the local economy and the freed slave populations at the time, and set Dominica on a trajectory of accumulating hazard exposure and high economic vulnerability. Dominica, to this day, has an agrarian-based economy with a weak transport infrastructure network that is highly vulnerable to hurricanes and other hazards. Damage and losses to crops from Hurricane Maria was estimated at US\$ 129.9m, with estimated losses of 65% of coconut, 80% of cocoa, 80% of citrus trees, and 100% of banana trees and vegetable crops (Government of the Commonwealth of Dominica, 2017). Total losses in Dominica from Hurricane Maria were approximately US\$930.9m.

Natural hazards have played a dominant role in the island's development. Severe hazard events have occurred with such frequency (and often coinciding) that economic recovery has been repeatedly set back, yet little attention has been paid to the potential impacts of natural hazards on economic policy. When disasters hit Dominica, landowners took on high levels of debt to replace lost assets, but when crops failed to recover, loans could not be repaid and indebtedness increased, deepening their vulnerability to further shocks, and rendering the economic model less viable. This pattern of disasters devastating crops and reducing exports, followed by a colonial response that further undermined development, has been repeated without prompting any changes in agricultural policies or post-disaster aid. Despite the fact that the colonial export-led model of development was inappropriate for Dominica, the model was not modified. It was assumed that the same things would work for all Caribbean islands. Yet lessons can be learned from disasters, and 'mistakes' avoided if the right questions are asked about who was affected and why recovery processes were slower than anticipated. Dominica can engage differently with donors and aid agencies than it has in the past. Post Hurricane Maria, support should be sought that promotes restructuring and diversification, reducing risk and dependency in the future.

The marginalization of former slaves after emancipation played an important role in risk accumulation, forcing many people into hazardous locations on the margins of the plantations and to live in conditions of 'informality' that discouraged investment and improvements in housing conditions. Today, Dominica's low-income families continue to live in informal settlements along what was Crown Land: along the thin coastal strip known as the King's Three Chains, in river valleys and on the margins of urban centers, highly exposed to floods and erosion, and easily cut off by damage to the one coastal road linking them together. These settlements were severely impacted by Tropical Storm Erika and Hurricane Maria, with many houses being completely destroyed by river flooding (Government of the Commonwealth of Dominica, 2017). An important finding from this study is that decisions about access to land, and ownership patterns that marginalize the poor and accentuate inequalities, also create disaster risk and constrain development. They are as critical as the decisions and investments taken intentionally to manage risk – such as the development of early warning systems and preparedness plans. Recognizing these historical drivers of risk is key if Dominica is to avoid taking decisions in the future that will undermine and compromise efforts to build the island's resilience.

Conclusions

In this paper, the authors argue that policy decisions and practices taken during the colonial period have led to an accumulation of risk in Dominica. Combined with multiple hazard events, island-wide

impacts for some hurricanes, and coupled with attritional damage from smaller floods, landslides, and earthquakes), this has precluded the necessary re-structuring that could ensure long-term resilience to the inevitable hazardous events the island faces. Identifying these processes and barriers creates an opportunity to tackle them directly during the extensive recovery required in the wake of Hurricane Maria. Yet this situation is not unique to Dominica, and a similar analysis of the precise historical factors that have shaped development would be beneficial for other Caribbean islands and SIDS with colonial histories. A larger and broader study would enable comparisons to be analyzed, and enable patterns – if they are present - to emerge.

Disaster research rarely considers past events or decisions taken further back than the very recent past. This can result in superficial sets of recommendations that fail to recognize the deep structural problems, and their ongoing consequences, that need to be understood and addressed to reduce disaster risk effectively and build future resilience. Tropical Storm Erika - like other disasters in the late 19th and early 20th centuries - prompted a reflection on the (in)adequacies of previous policies in Dominica, but lessons were based primarily on that event and therefore policy recommendations were insufficient or incapable of implementation. To address the institutional issues and broader development decisions that have generated risk over time, policymakers and practitioners need to understand and learn from history.

Materials and methods

This research draws on historical data obtained through archival research in the UK (predominantly from The British Library collections and The National Archives) and Dominica (from The National Archives Unit) between November 2016 and July 2017, in addition to an extensive web-based search of peer reviewed and grey literature. The data was collected and analyzed by a multidisciplinary team of social and physical scientists, with expertise in disaster and climate risk governance; geological hazards and interdisciplinary approaches to risk reduction; vulnerability and adaptation to environmental hazards and climate change; and colonial and maritime history and cultural encounter. The data focuses on decisions taken around agriculture, land tenure, capital investments, impacts of hazards, post-disaster aid, and Caribbean development priorities for colonial governments. Where possible, the research consulted original sources such as parliamentary papers and records, contextualized with relevant critical sources from the historiography of Dominica. Further details and clarifications were collected during a visit to Dominica in March 2017, through a series of discussions with local historians, academics and disaster risk stakeholders.

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Author Contributions

EW and JB conceived the study with RF. JB, CW, CS, JF, IL, CJ undertook the detailed analysis with GW and HS. All contributed to the analysis, synthesis and writing of all or sections of the paper, while EW framed the writing process. CJ and LH provided historical guidance and input.

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Figure Legends

Figure 2a. The boom and bust of sugar, coffee, lime and banana production in Dominica, 1763-2016. Values are normalised against the year with peak productivity for each crop. Full details of data type and sources are in Appendix 2.

Figure 2b. Disaster impacts on sugar export crops in three Eastern Caribbean volcanic islands, 1700-1937. Values are normalised against year of peak productivity (as value in pounds sterling) for each island. All data from Deer, 1950.

Figure 3. Post-disaster loans and accumulation of debt in Dominica, 1830-1880