7. REVIEW OF HISTORICAL & PROJECTED IMPACTS OF CLIMATE CHANGE IN THE CARIBBEAN

The impacts of shifts in climatic variables are far reaching and are particularly threatening to small island developing states because of the magnitude of the climatic events and increasingly recurrent nature of these threats. The Caribbean region which is home to 40 million people is extremely susceptible to climate impacts. This susceptibility is driven by several factors including-but not limited to- the following: the proximity of dense populations to flood prone coastal zones, the location of many islands within the path traversed by hurricanes and other tropical cyclones, and their small physical size with little reserve land capacity. Further, the region is also heavily dependent on climate sensitive sectors such as, Tourism, Agriculture and Fisheries and Freshwater Resources.

Although not exhaustive, this chapter explores the sensitivities of multiple sectors, vulnerable groups and resources to climate variability and extreme events in the Caribbean. The information is presented in tabular format based on review of the recent historical (from 2003) and projected impacts of climate change. It also provides social dimensions of these climate impacts on island people as it relates to climate sensitive sectors including-but not limited to- Agriculture, Tourism, Water, Health, and Education. Additionally, details are provided on Development, Poverty, and Security among other cross cutting themes.

Sections 7.1 and 7.2 present summaries of the major points presented within the impacts tables in Sections 7.3 (Sectors) and 7.4 (Crosscutting themes).

7.1. TABLE SUMMARIES: SECTORS

AGRICULTURE: CROP PRODUCTION, LIVESTOCK AND FISHERIES

The Caribbean has experienced marked increases in temperature in the few decades (1986-2010), with heavier daily rainfall and an increase in frequency and intensity of hurricanes (Stephenson et al. 2014; CSGM 2017). Droughts have also been very costly to the agriculture sector, especially given the over reliance on rain fed agriculture (Beckford and Barker 2007; Gamble et al. 2010; Farrell et al. 2010). Sea level rise also poses a threat to the availability of fresh water, which is a vital resource for the sector. The effects of these changes on this climate sensitive sector are examined in the tables below. For ease of reference, separate tables are used.

TOURISM

Tourism is one of the major economic sectors within the Caribbean region and due to its proximity to the coast, its most vulnerable (UNDP 2010). Tourism depends on the climatic features and attractiveness of a destination to attract or deter visitors (ECLAC 2011). In the Caribbean, climate change is already threatening touristic offerings and reducing tourist arrivals. Among impacts already experienced are increased beach erosion; increased incidence of vector borne diseases and recurrent damage to properties from hurricanes and other tropical cyclones. In 2016, tourism contributed US$56.4 billion to the Caribbean region and employed 2,319,500 of its people (WTTC 2017). The hurricane season in 2016 was particularly severe on the sector as several properties across the region were significantly damaged and there were marked disruptions to operations and loss of livelihoods. Projections for more intense hurricane in the future (CSGM 2017) therefore suggest that climate change will have adverse impacts on: (i) natural assets on which tourism depends (ii) man-made structures that support the activities of the sector, and (iii) the livelihoods on which so many of the region's people depend. Refer to the corresponding table for further information on the impacts of climate change on this important sector.

FRESHWATER RESOURCES

For the past 100 years (1900-2000), rainfall records have shown that there has been a slight reduction in Caribbean rainfall (See Section 3.2.2). Projections are that drier conditions (annual mean of 17%) are expected, as end of century is approached (See Section 5.3). However, increases are also projected in heavy rainfall events (see Section 5.3.3) which could cause flooding. Taken collectively, the following impacts could result from projected changes: increased temperatures could enhance surface water evaporation, floods could increase sediment load and increase turbidity in water systems, and sea level rise would likely contaminate freshwater sources. This table therefore highlights the degree to which increasing temperatures, droughts, floods sea level rise and flooding will affect the quality and availability of freshwater throughout the region. Refer to the corresponding tables for further information.

ENERGY

The Caribbean as a region derives up to 90% of its energy from imported crude oil (Bueno et al. 2008). Climate change presents increasing challenges for energy production and transmission, especially given the region's reliance on imported fuel and the concentration of critical energy infrastructure in the (flood-prone and exposed) coastal zone (Bueno et al. 2008; CMEP 2017). Further, as temperatures increase so too will the need for cooling thereby leading to an increase in energy demand and fuel importation. Severe weather systems (hurricanes and other tropical cyclones) could affect fuel transportation at times when energy demands have peaked. The sector table provides insight into how climate change could affect energy production and distribution, specifically focusing on increasing temperatures, hurricanes, inadequate rainfall and sea level rise.

BIODIVERSITY

The Caribbean region supports a wealth of marine and terrestrial biodiversity with a high proportion of species that are unique to the area (CEPF, 2011). These species live in special habitats and thrive best in a narrow range of environmental conditions (Miloslavich et al. 2010; Webber 2012). Climate change will alter these ideal conditions and will threaten both marine and terrestrial biodiversity (CANARI 2008; Webber 2012). For marine biodiversity, the table illustrates the degree to which climatic extremes like temperatures, sea level rise and hurricanes impact on coral reefs, Caribbean grazers like the parrotfish, sea turtle reproductive patterns and migratory patterns of some bird species. Refer to the corresponding tables for further information. Terrestrial biodiversity impacts examined include both direct (e.g. damage to forest trees) and indirect (loss of habitat and feeding ground) (CANARI 2008).

EDUCATION

The Caribbean's education sector is among the most critical sectors for consideration for present and projected impacts of climate change given, its impact on future generations. Extreme events (including hurricanes, droughts and floods) across the region, which have increased in the recent past, have been reported to adversely affect the formal education sectors at all levels. Among notable impacts have been damage to school infrastructure, lower teacher and student attendance, reduced productivity, as well as reduced student academic achievement for some subject areas. The following table summarizes key impacts of extreme events on the education system in the recent past; with reference to how the future could also be impacted.

HEALTH

Severe weather events have the potential to adversely impact the health of the people of the Caribbean (Bailey et al. 2009). This is particularly so in cases where health infrastructure is damaged or where conditions favour the life cycle of vectors or vector-borne diseases. The corresponding table includes the impacts of extreme temperatures on heat related illnesses and the emergence of vector borne diseases. Other impacts highlighted include drought and floods conditions and malnutrition and public health consequences associated with hurricanes/tropical storm passage. While the table is not exhaustive is provides useful reference information and should spur interest in further research.

FINANCE AND INSURANCE

Climate hazards have direct impacts on the financial and insurance sectors. Recurrent losses suffered in the region from hurricanes (2004, 2017) have emphasized the need for expansion of risk insurance and the type of hazards covered (CCRIF 2015; OECS 2004). It is more likely than not that the frequency of intense storms will increase in the Caribbean Region (see Section 5.4). This implies that insurance may have to be reconfigured to cover events with higher return periods. Furthermore, more frequent droughts and flood events have negatively impacted the economies of many islands (Farrell et al. 2010; CCRIF 2015). The table below demonstrates how impending changes in temperature, rainfall, droughts, and hurricanes could further impact this key sector.

INFRASTRUCTURE AND HUMAN SETTLEMENTS

Sea level rise poses one of the most widely recognized climate change threats to low-lying coastal areas, particularly in small islands where the majority of human communities and infrastructure is located in coastal zones (CDKN 2014) In the Caribbean, more than 50% of the population live less than 1.5 km from the shoreline (UNECLA, 2011). Hurricanes and other tropical cyclones have also significantly damaged residential settlements and public infrastructure, especially roads and bridges. Climate change considerations need to be factored into designs to prevent recurrent damage. The impacts experienced to date are captured in the corresponding table for further information.

7.2. TABLE SUMMARIES: CROSS-CUTTING THEMES

POVERTY

Poverty is a critical factor in determining vulnerability to climate change and extreme events (CDKN 2014). Across the Caribbean, the rural and urban poor will be disproportionately affected by climate change because of their socioeconomic circumstances, living conditions and lack of capacity to adapt to climate extremities. Of particular note, this cohort of society comprises persons living in very vulnerable areas (flood prone, highly exposed), with limited alternative options for employment and limited financial resources and with little or no assets that would be easily insured. This table highlights the extent to which the poor will be affected by climate variables and extremes like temperatures, droughts, flooding and hurricanes. Refer to the corresponding table for further information.

SOCIETY

The vulnerability of the Caribbean society is well documented (Simpson et al. 2010; ECLAC 2011; CDKN 2014; CSGM 2017). Among adverse impacts that could be experienced are reduced access to freshwater (a key resource for socioeconomic development as identified in the UN Sustainable Development Goals), increased incidence of diseases and other adverse health impacts. This table details the vulnerabilities of climate sensitive livelihoods and groups including the elderly, women, children and indigenous people to the impacts of climate change. Social impacts from extremes like droughts, hurricanes and extreme temperatures are highlighted. Refer to the corresponding table for further information.

GENDER

Gender can be defined as the socially learned differences between men and women and the different societal roles they play. Across the Caribbean, women remain mostly in low skilled service-oriented positions while male counterparts enjoy higher skilled, better paying jobs. This, coupled with their roles as caregivers and mothers for the family, affect their ability to respond and recover from disasters. Further, children and the elderly are groups often unable to tend to themselves in adverse environmental conditions and especially in the aftermath of a severe weather event. This table illustrates how extreme events affect men and women differently and emphasizes how women, children and the elderly are disproportionately impacted.

DEVELOPMENT

Climate change will directly and indirectly impact socioeconomic development. Small island developing states are extremely vulnerable to climate change because much of their socioeconomic development is based on climate sensitive sectors like tourism and agriculture. In the Caribbean the vulnerability is further exacerbated by the limited reserve capacity (due to the prevalence of mountainous areas or flood plains) so that much investment has been made in areas inherently vulnerable to the adverse impacts of extreme events. This in turn affects the resilience of Caribbean development and the nature of adaptation options that can be explored. Recurrent damage from severe weather events are particularly costly and divert funds from development initiatives to recovery and rehabilitation projects. This table examines these challenges and also includes the smaller scale impacts such as the effects of increasing temperatures on worker productivity and the potential displacement of vulnerable groups (mountainous and flood prone communities) after a severe weather event. Refer to the tables for further information.

SECURITY

Climate change presents major security challenges for the region. This is attributed to the heavy dependence of life, livelihood and economy on the coast, which is magnified by a relatively weak emergency response to the severe and frequent disasters impacting the region. Additionally, the disruption that could result from climate hazards and attendant loss of livelihoods could result in in an upsurge in robberies, theft of goods and services and illicit activities. This table illustrates the impacts of sea level rise, hurricanes, increasing temperatures and heavy rainfall on counterdrug trafficking efforts, military readiness for search and rescue efforts and threats to livelihood and food security across the region. Refer to the corresponding table for further information.

7.3. IMPACT TABLES: CLIMATE CHANGE AND KEY SECTORS

Table 7.1: Impacts of Climate Change on Agriculture (Livestock, Crop Production and Fisheries)

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
LIVESTOCK	
INCREASING TEMPERATURE	**Higher temperatures will negatively impact livestock and animal protein production. Higher temperatures will result in increased incidence of heat stress.** Heat stress affects these animals' ability to control their own body temperatures (DeShazer et al. 2009) and that will cause decreases in voluntary intake of food, weight, fertility and milk production and could result in death in extreme cases (Amundson et al. 2006; Ben Salem and Bouraoui 2009; Hernández et al. 2011; Gantner et al. 2012). Other heat stress related impacts include decreases in poultry egg production and quality (Mashaly et al. 2004; Ajakaiye et al. 2011). Lallo et al (2018) reported that Caribbean livestock (chickens, goats and pigs) are under considerable heat stress even in normal conditions and especially during the summer period. Future temperature increases of 1.5^{o}C above pre-industrial levels (since 1860), will result in heat stress every month at dangerous or severe levels (Lallo et al. 2018). Increased temperature may speed up the life cycle of some pathogens and parasites living outside their hosts (Kimaro and Chibinga 2013; Karl et al. 2009; Harvell et al. 2002).
INADEQUATE RAINFALL AND DROUGHTS	**Inadequate rainfall and longer drought conditions will affect the production of forage and quality of hay.** This will adversely affect the nutritional value of feed for animals, which will compromise the nutritional quality of the meat produced from these animals (Chapman et al. 2012). **Water requirements will increase and could lead to dehydration and death in extreme cases. Variations in rainfall will also increase pathogen and parasite population and the emergence of new pests** (Henry et al. 2012; Thornton et al. 2009; Rojas-Downing et al. 2017).
CROP PRODUCTION	
INCREASING TEMPERATURE	**Higher temperatures increase water loss and reduce production, affecting crop yields.** Heat stress due to high temperatures causes a reduction in the absorption of nutrients which will retard crop growth and reduce yield. Warmer conditions may also lead to premature low quality crops (Mohammed & Tarpley 2009a; Seddigh & Jollif 1984). **High temperatures could also be more favourable to certain diseases and pests** which will compete with the plants for light and nutrients and could further reduce crop yields (Agrios 2005; Das 2016).
DROUGHTS	**Droughts will reduce crop yield and threaten food security.** The high reliance on open-field rainfed crop production in the Caribbean, makes the sector particularly vulnerable to droughts (Beckford and Barker 2007; Gamble et al. 2010). A number of studies have projected climate change induced decreases in yields of crops grown in developing countries like the Caribbean, especially in rural areas ((Parry et al. 2004; IPCC 2007, 2014; ECLAC 2011; Müller et al. 2010). The 2009/2010 drought in the Caribbean cost the government of Guyana US$1.3 Million to provide relief to farmers. Furthermore, production was 43% lower in Dominica in 2010 compared to the previous year, while production was 20% lower (on average) in St. Vincent and the Grenadines (Farrell et al. 2010).

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
HEAVY RAINFALL/FLOODING	**More heavy rainfall and flooding will increase crop losses.** Heavy rainfall events and flooding often causes soil erosion and in other cases waterlogged fields. Stephenson et al. (2014) showed that there has been an increase in daily rainfall intensity as reflected in records from 1986-2010, which meant that when rainfall occurred in the Caribbean, it tended to be heavier.
STORMS/ HURRICANES/ TROPICAL CYCLONES	**More frequent and severe hurricanes/storms will cause significant crop loss.** The region has experienced an increase in the frequency of hurricanes since 1985 and especially of intense magnitude (category 4 and 5 hurricanes). Recent studies suggest the region could be impacted by more intense hurricanes, by the end of the century (CSGM 2017). The impacts of recent storms [Ivan (2004); Irma and Maria (2017)] have demonstrated that most crops in the Caribbean cannot withstand the associated strong winds and rainfall. Some crops could be totally destroyed, while others will have longer recovery periods (OECS 2004; CTA 2017)
SEA LEVEL RISE	**Sea level rise will affect crop production and availability of arable lands.** Saline intrusion from sea level rise will reduce freshwater availability and most crops are not tolerant to saline conditions. Crop water loss is accelerated in saline conditions leading to crop dehydration and ultimately crop failure (FAO 2005).
FISHERIES	
INCREASING TEMPERATURE	**Extreme temperatures will increase coral bleaching and affect fish habitats and populations.**Higher temperatures will increase incidents of coral bleaching, which will lead to ultimate destruction of spawning and feeding areas for many fish species. As a result, both fish populations and marine biodiversity will be adversely impacted (CDKN 2014; Simpson 2010). **Warmer seas will affect coral reefs and marine ecosystems.** Warmer temperatures will make the seas more acidic, and this acidification which is due to carbon dioxide, will impact the functioning, behaviour and dynamics of organisms. Reef building corals are highly susceptible to this acidification and when coupled with larger scale changes including lower oxygen levels, impacts are amplified. (IPCC 2014).
STORMS/ HURRICANES/ TROPICAL CYCLONES	**More frequent and severe storms will increase damage to fish habitats and natural barriers.** Higher intensity storms which are projected for the Caribbean could result in greater damage to coral reefs, mangroves and seagrass beds. This could reduce habitats and in turn increase exposure of fisheries to harmful winds (CMEP 2017).

Table 7.2: Impacts of Climate Change on Tourism

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
SEA LEVEL RISE	**Sea level rise likely to damage many resort properties across the region.** In the Caribbean, sea level rise has been combined with elevation maps to estimate that 49-60% of tourist resort properties would be damaged (CDKN 2014). **Beaches retreat inland at 100 times the rate of sea level rise (CSGM 2012).** Another estimate suggests that a 1 metre rise in sea level will lead to the loss of at least 16 multimillion dollar tourism resorts across the Caribbean, with a replacement cost of over US$1.6 billion and the livelihoods of thousands of employees and communities affected (Simpson 2010).
DROUGHTS	**Declining water quality and availability affecting tourism operations.** More frequent drought events limiting availability and quality of freshwater will have adverse impacts on tourism operations (CDKN 2014).
INCREASING TEMPERATURE	**Extreme temperatures can lead to heat stress and other heat related illnesses.** Heat stress remains a concern with higher temperatures affecting tourists and outdoor workers. Heat storage of built structures will lead to the heat island effect. This will lead to additional costs for cooling aids (CSGM 2012). **Coral bleaching will compromise tourism product offerings.** A 1 degree increase in sea surface temperature will lead to coral reef bleaching (CSGM 2012) This will compromise the quality of tourism based activities like diving and snorkelling of which reefs form the bases (CDKN 2014). **Climate induced vector borne diseases led to a decline in tourist arrivals.** Extreme temperatures are associated with vector borne diseases such as the chikungunya virus. In 2014, the tourism industry in the region incurred significant economic losses with cancellation or reduction in tourism arrivals because of the Chikungunya Virus (Ramrattan 2015). **Destination attractiveness compromised by Sargasso blooms.** Warmer seas have led to the massive influx of Atlantic Sargasso in the Caribbean Sea, affecting countries like Barbados and Jamaica, covering white sandy beaches, emitting a pungent odour; and discolouring nearshore waters (Oxenford et. al. 2015; Doyle and Franks 2015).
HEAVY RAINFALL	**Heavy rainfall may lead to the displacement of visitors or cancellations of outdoor events which would incur revenue loss for the industry** (CARIBSAVE 2009).
HURRICANES/TROPICAL STORMS	**More frequent and severe hurricanes may continue to destroy hotels and affect arrivals across the region.**

Table 7.3: Impacts of Climate Change on Freshwater Resources

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
INCREASING TEMPERATURE	**Higher temperatures increase evaporation.** This will decrease water availability from rivers and streams. **Increasing temperatures also leads to increase in pathogens, nutrients and algal bloom in water storage facilities which could lead to reduction or lack of potable water** (CSGM 2012, 2017).
INADEQUATE RAINFALL / DROUGHTS	**Inadequate rainfall and longer drought conditions will affect water availability:** Increased variability in rainfall patterns will increase water demand across the region and adversely affect stability of water supplies (CDKN 2014).
HEAVY RAINFALL/STORMS	**Heavy rainfall and storm events could cause damage to water infrastructure by increasing the volume of water and decreasing water quality, as a result of excessive runoff.** Higher than normal sediment load and turbidity could also affect water treatment costs and water supply lines**.**
SEA LEVEL RISE	**Rising sea level increase the salinity of both surface water and ground water through salt water intrusion, especially in coastal basins.** This will affect the availability of freshwater which is already in short supply in islands of the Caribbean, especially in the Eastern Caribbean (Bueno 2008; Simpson 2010; CDKN 2014). Saline intrusion reduces the amount of available groundwater and may require costly treatment options.

Table 7.4: Impacts of Climate Change on Energy Resources

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
INCREASING TEMPERATURE	**Higher temperatures will reduce efficiency of electricity production and further increase demand for cooling systems.** Extreme temperatures will likely increase energy demand for air conditioning (in both cars and buildings), as well as change our ability to supply adequate fuel, produce electricity, and deliver it reliably (WEC 2014). As temperatures increase the efficiency of power production for many existing fossil fuel and nuclear power plants will decrease, because these plants use water for cooling. The colder the water the more efficient the generator; so warmer (air and water temperatures) will reduce the efficiency with which these plants convert fuel into electricity (WEC 2014; EPA 2017). **Higher temperatures are less favourable for harnessing of solar energy; photovoltaic solar voltage and power decrease with increased temperature** (Arjyadhara et al. 2013). **Increased sea surface temperatures will increase the efficiency of Ocean Thermal Energy Conversion (OTEC) systems** (CSGM 2012).
INADEQUATE RAINFALL	**Inadequate rainfall and drought conditions will affect reliability of energy supplies.** This includes decreases in river flow, and ultimately, power output for hydropower plants (CSGM 2012). Increased evaporation, and drought may increase the need for employing energy-intensive methods (e.g. desalinization) to meet critical needs (e.g., drinking and irrigation water) (CSGM 2012). Irrigation water may also have to be pumped over longer distances, further increasing energy demand.
HURRICANES/ TROPICAL STORMS	**More intense hurricanes and storm events may damage energy infrastructure.** This includes both onshore and offshore (distribution) equipment, wind turbines and power lines. These events may also delay repair and maintenance work (WEC 2014).
SEA LEVEL RISE	**Sea level rise may impact coastal power plants.** Many power plants in the Caribbean are located within the coastal zone (Bueno et al. 2008, CMEP 2017). Sea level rise in the Caribbean is projected to be between 1-2m by end of century (Chen 2011). Critical infrastructure including oil and gas pipelines could be adversely affected by damage from increased storm surge, which will be exacerbated by more intense storm events (United States Senate Committee on Energy and Natural Resources 2015; CSGM 2012).

Table 7.5: Impacts of Climate Change on Marine and Terrestrial Biodiversity

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
SEA LEVEL RISE	**Mangroves migrate landward in response to sea level rise.** Mangrove vegetation may migrate landward in response to changing ecological conditions brought on by an inland movement of the sea and saltwater intrusion into coastal waterways (ECLAC 2011) In Caribbean island nations like Belize ,Guyana and Suriname with extensive mangrove vegetation, a 1 metre rise in sea level would lead to deterioration from accelerated coastal erosion (UNDP 2010). **Sea level rise threatens sea turtle nesting areas**. The impacts of coastal erosion due to a 1 metre rise in sea level would lead to degradation or loss of 146 known sea turtle nesting areas across the Caribbean region (UNDP 2010).
INCREASING TEMPERATURES	Seagrasses can only accept temperatures 2-3 degrees above summer temperatures (CARIBSAVE 2009). **Warmer seas may lead to further coral bleaching events across the region.** Severe mass coral bleaching may occur in the Caribbean by 2074. Already, coral species have declined by 80% on Caribbean reefs due to ocean acidification and warmer sea surface temperatures (CDKN 2014). In 2005, extremely high sea surface temperatures in the Eastern Caribbean and North Atlantic led to a widespread coral bleaching event resulting in 90% of coral being affected in British Virgin Islands (Taylor 2015). **Blooms of sargassum on shorelines, affecting marine life.** Increasing sea surface temperatures and low winds has led to the presence of the Atlantic Sargasso seaweed on Caribbean shorelines. This seaweed smothers sea grass beds and coral reefs and tangles many marine animals including fish and sea turtles (Oxenford et. al. 2015). **Increasing temperatures will affect sea turtle population.** Increasing sand temperatures can lead to changes in sex ratios (declining male turtle population) since sex is determined by temperature (Webber n.d.). **Warmer seas promoting northern migration of Caribbean grazers and coral reefs.** Rising sea surface temperatures are leading to the migration of Caribbean grazers like parrotfish to more temperate seas. These fish species can now be found in areas such as the Mediterranean Seas, Japan and Australia feeding on sea grasses and kelp forests. Caribbean coral reefs have also followed these fish populations and are replacing the sea grasses and kelp forests (Struck 2014).
FLOODS/STORMS	**Flooding degrades wetlands.** Extreme events such as flooding degrades wetlands and reduce their ability to function as natural filters and buffering systems for shorelines and coral reefs (CARIBSAVE 2009). **Intense Caribbean storms affecting migratory bird patterns.** More severe storms in the Caribbean appear to be reducing the number of some migratory bird species from reaching their breeding grounds (ECLAC 2011). **Hurricanes could damage forest stands making them more exposed and therefore less resistant to wind damage.** This could also lead to habitat loss for many animal and plant species (CANARI 2008) and ultimately loss of the species themselves.
RAINFALL	Adequate shading and soil moisture are necessary for positive seedling development of plants in tropical dry forests. This was found to be the case in the Hellshire Hills, Jamaica, where water prolongs the survival of all plants regardless of shading (McLaren and McDonald 2003a). Soil moisture availability is highly dependent on rainfall which is highly seasonal in tropical dry forest ecosystems. This seasonality affects patterns of seed production, germination, survival and seed development (McLaren and McDonald 2003a). Inadequate rainfall will therefore lead to high seedling mortality in these dry forests. Coppicing is generally the primary regeneration mechanism in cut dry forest sites where stem and roots remain in place. In the Hellshire Dry Forest (Jamaica), there is a high incidence of shoot regrowth or coppicing among and within the tree species after it was cut. This means that it has considerable resilience to disturbance in tropical dry forests where successful seed regeneration is highly susceptible to rainfall seasonality. If long term clearance continues it could affect species diversity (McLaren and McDonald 2003b).

Table 7.6: Impact of Climate Change on Health

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
INCREASING TEMPERATURE	**Warmer seas may contribute to seafood poisoning.** Warmer seas may contribute to toxic algal bloom and increased cases of shellfish and reef fish poisoning (GOJ 2011). Ocean warming would increase temperature sensitive toxins produced by phytoplankton which would cause contamination in seafood (Moreno 2006) Ciguatera Fish Poisoning which is the most common non-bacterial food-borne illness associated with fish consumption, is expected to rise in the Lesser Antilles where warmer waters are associated with high incidence (IPCC 2014). **Hotter temperatures may lead to more vector borne diseases**. High temperatures speed up the life cycle of the Aedes aegypti mosquito and the disease organisms they harbour and make adult mosquitoes bite more often (Bailey et. al. 2009). **Increasing temperatures may cause reproductive problems in both men and women**. High temperatures may lead to reproductive problems in men due to the relationship of repeatedly raising testicular temperature by 3-5 degrees and decreased sperm count (Silva 2016). Exposure of pregnant women to increasing temperatures may lead to hyperthermia which may result in a high incidence of embryo deaths and malformation of the head and the central nervous system (Silva 2016).
INCREASING TEMPERATURES AND PRECIPITATION (MOISTURE)	**Extreme temperatures may lead to more incidence of dengue fever**. Higher temperatures and moisture availability provide favourable conditions for high dengue transmission rates and mosquito breeding (Amarakoon et. al. 2008).
INCREASING TEMPERATURE, HUMIDITY, CIRCULATION OF WIND PATTERNS AND CONCENTRATION OF DUST FROM THE SAHARA	**Climate factors will increase respiratory problems across the region.** Higher temperatures, humidity and Saharan dust (air pollution) will increase the incidence of asthma, bronchitis and respiratory allergies across the region (Bailey et. al. 2009). Inhalation of air pollutants from fossil fuel and waste incineration will lead to more respiratory illnesses (Bailey et. al. 2009). There has been an established link between the concentration of dust and the outbreak of asthma affecting children, which could lead to an overall increase of asthmatic cases in the Caribbean.
INCREASING TEMPERATURE AND HUMIDITY	**High temperatures and humidity stress the body's ability to cool itself. Heat stress can lead to heat related illnesses such as heat strokes and cramps** (Bailey et. al. 2009). In extreme cases, it can become fatal. The heat island effect will exacerbate the impact of increasing temperatures (CSGM 2012).
STORMS/ FLOODS/ HURRICANES/TROPICAL CYCLONES	**More frequent and severe extreme events may lead to disastrous public health consequences across the region.** Extremes such as hurricanes, tropical storms and floods can cause adverse effects in food production (Moreno 2006); deaths by drowning; more mental cases; increases in infectious diseases (water, food and vector borne); and population displacement (Bailey et. al. 2009). In 2010, Hurricane Sandy caused many deaths across the Caribbean region, 60 in Haiti, 2 in Bahamas and 1 in Jamaica (Taylor 2015).
DROUGHTS	**Water storage during droughts may lead to more vector borne diseases.** Storage of water during droughts in drums provides suitable habitats for mosquitoes, augmenting the transmission of vector borne diseases like dengue fever and malaria which are likely to increase with higher temperatures (GOJ 2011). **Malnutrition from disturbances in food production may occur(CARIBSAVE,2009).** Drought conditions lead to food shortages. Food imports may lead to obesity due to the importation of calorie laden, high sodium foods (Silva 2016). **Drought affects sanitation due to the lack of water affecting the transmission of disease** (CARIBSAVE 2009).

Table 7.7: Impact of Climate Change on Infrastructure and Human Settlements in the Caribbean

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
INCREASING TEMPERATURE	It is projected that there will be a 1-4 degree Celsius increase in temperature across the Caribbean (CDKN 2014). Warmer temperatures however are already affecting the region with greater impact in urban than rural areas. Bailey et al (2009) attributes this to a heat island effect which is a phenomena defined as heat absorption and storage in built structures allowing for radiant energy to thereby reduce night time cooling and relief.
EXCESS RAINFALL	Landslides are hazards that occur with extreme rainfall and flooding in some mountainous Caribbean islands such as Saint Lucia (GFDRR 2014). This subsidence of land has led to the degradation of foundation on which many houses were built across the Caribbean. The Christmas Eve Trough of 2013 is one such flood event in Saint Lucia which resulted in damages to 743 homes. Total damage and loss was estimated at EC$11.28 million and 3.81% in the housing sector (GFDRR 2014).
HURRICANES/ TROPICAL STORMS	**More intense hurricanes and storm events will cause damage to Caribbean infrastructure and settlements:** Hurricanes Irma and Maria's 2017 example confirms this fact with their landfall causing significant infrastructural damage in Caribbean islands such as Anguilla (EC$150.1 million), Bahamas (US$27 million) and British Virgin Islands (US$455 million) (ECLAC 2018). 6944 residential properties and several public buildings were damaged by Hurricanes Irma and Maria in 2017 in the British Virgin Islands which resulted in losses valued at US$680.2 million (ECLAC 2018). 81.5% of total losses in British Virgin Islands from Hurricanes Irma and Maria was attributed to the tourism sector with infrastructural damage so severe that many will not be operational until 2019. This is especially impactful because most of the population is employed by the tourism sector (ECLAC 2018).
SEA LEVEL RISE AND STORM SURGE	**Sea level rise will inundate coastal roads and lead to flooding of low-lying coastal plains where many human settlements are located:** In the Caribbean, more than 50% of the population lives less than 1.5 km from the shoreline (ECLAC 2011). Sea level rise therefore presents one of the most significant and widely recognised climate change threats to low-lying coastal areas especially in small islands where there are limited relocation opportunities for human communities and infrastructure, most of which are located in the coastal zones (CDKN 2014).

Table 7.8: Impacts of Climate Change on Caribbean Society

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
INCREASING TEMPERATURE	**Warmer seas threaten continuity of fishing communities.** Further warming of 1-2 degrees threatens natural ecosystems including risk of loss for marine and coastal systems and the goods and services they provide for coastal livelihoods especially fishing communities in the tropics (CDKN 2014 p.10). **Vector borne diseases put a strain on household resources.** Extreme temperatures may lead to the emergence of vector borne diseases like dengue fever. Households consisting of disabled or ill members are considered more vulnerable since this affects the number of people available for productive labour and puts a strain on household resources (Chen et.al. 2006).
DROUGHTS, STORMS, HURRICANES, FLOODS	**Storm surges, coastal flooding and sea level rise, as a result of extreme events will increase risk of death, injury, ill-health or disrupted livelihoods in small island developing states** (CDKN 2014). The circumstances, of many elderly persons who are already socially vulnerable due to limited income and health challenges, will likely be worsened by climate impacts such as extreme temperatures, droughts and hurricanes (CDEMA 2014). The geographical remoteness of many indigenous communities and their lack of access to education and health care, will likely increase their vulnerability to the impacts of climate change (CDEMA 2014), especially as it relates to evacuation after the passage of a tropical storm/hurricane. **Extreme events may increase the likelihood of Caribbean youth engaging in risky behaviour**. The Caribbean has a significant population of unattached youth (not employed or in school). Climate change is likely to worsen the circumstances of this group. Consequently, loss of homes and livelihoods as a result of an extreme event may increase the likelihoods of Caribbean youth to engage in transactional sex as a survival strategy (Dunn 2013).

Table 7.9: Impact of Climate Change on Education

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
INCREASING TEMPERATURE	**Increasing temperature can disrupt the learning process**. There is a correlation with body temperature, work performance and alertness, which has implications for students in classrooms without cooling aids. Higher temperatures can lead to lower productivity. This is due to the fact that heat exposure can affect physical and mental capacity and lead to exhaustion or heat strokes in extreme cases. There is the potential threat of increasing temperature on youth and their educational development. Reading speed, reading comprehension and multiplication performance of schoolchildren could be affected by temperatures of 27-30 degrees (CSGM 2012).
INCREASING TEMPERATURES AND PRECIPITATION (MOISTURE)	**Impact of vector-borne diseases on student and teacher attendance.** Extreme temperatures and moisture have led to the emergence of vector-borne diseases such as the Chikungunya and Zika viruses, which affected the productivity of the labour force including those in the education system. It was reported that in 2014, many students affected by the chikungunya virus were absent for many days from school in Jamaica (Ramrattan 2015).
INCREASING TEMPERATURE, HUMIDITY, CIRCULATION OF WIND PATTERNS AND CONCENTRATION OF DUST FROM THE SAHARA	**Saharan dust increases may induce and worsen respiratory problems across the region, with potential threat to students.** The increase of dust from Sub-Saharan Africa has been noted in several Caribbean territories, with special reports on its adverse impacts arising from 2011-2015 in some islands such as Grenada, Antigua, and Trinidad (Observer 2013a, Miami 2013, Observer 2013b, CSGM 2012). The dust, which peaks between May to September, coincides with the months marking the beginning and end of the school year (Observer 2013a, Lau 2007). This has been reported to have caused increases in paediatric asthma cases in territories such as Trinidad (Gyan 2005). It also has direct implications for students who are already prone to respiratory illnesses such as asthma, with particularly critical effects in the May-June months, which coincides with the sitting of regional examinations.
STORMS/ FLOODS/ HURRICANES/TROPICAL CYCLONES	**Hurricane activity during the school term affects Caribbean students' academic performance in Mathematics and Science subjects.** A detailed study of schools across the Caribbean region suggested that hurricane activity during the school term had a negative effect on student performance in Mathematics and the sciences (Biology, Chemistry and Physics) in the Caribbean Examinations. This is because the number of hurricanes occurring during the year increases the likelihood that school days and classroom time for required guided teaching, practicing problems and laboratory experiments are reduced. However, no significant impact was observed in academic performance in humanities (French, Geography, Spanish) subjects (Spencer 2016). **Hurricanes affect student school attendance.** Hurricanes and flooding events negatively affect student school attendance due to infrastructural damages affecting roads and school buildings and disruptions to electricity and water supply (Spencer 2016). **Hurricanes and storms affect the school term across the region**: For the past 20-25 years, hurricane events in the region have impacted the length of the school term, as many have been used as shelters for extended periods. For some events, resulting school disruption lasted for over a month on-end, e.g. 25-40 days disruption in schools in the Cayman Islands following the passage of Hurricane Ivan (2004) (Spencer 2016, ECLAC 2004b). Even in the event of extra days added to the normal duration of the school term, the disruption in lessons caused by the disasters have affected the productivity of teachers (Spencer 2016). **Hurricanes adversely impact school infrastructure**: During the period of 1993-2010, Caribbean countries were affected by at least 17 hurricanes with damages varying by territory and severity of the event. For example, following Hurricane Ivan in 2004, around 1000 public schools in Jamaica were reported to have severe infrastructural damage, affecting over 200,000 students (Spencer 2016, ECLAC 2004a).In 2016, it was reported that Hurricane Irma destroyed 130 schools in Anguilla, Antigua and Barbuda and the Turks and Caicos Islands affecting 20,000 children (Time 2017).

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
SEA LEVEL RISE	**Schools among infrastructure vulnerable to sea level rise**. Schools and other educational institutions are highlighted among the most vulnerable infrastructure that are likely to be adversely affected by sea-level rise and floods in the region, given the proximity of these institutions to the coast. Guyana, with an approximate 80% of their population by the coast, has about a quarter of their coastline infrastructure now protected by seawalls (Statistics 2007).
DROUGHTS	**Prolonged drought conditions from 2009-2015 disrupted the school term for many schools across the Caribbean**. Severe drought events in the recent past have caused school closure in the Caribbean due to a lack of water needed for proper hygiene and sanitation. For example, the 2009/10 drought event, resulted in countries in the Eastern Caribbean (Barbados, Grenada, and St Lucia (Jessop 2010) having to close some schools. During the 2014/15 event, several primary-level schools in Jamaica, were forced to close early for the Easter break during April 2014 due to critically low piped water supply. This period also coincided with the Grade Four Literacy Test examinations, which forced this cohort to have to still attend school. It was reported that the situation reached a 'crisis' proportion as trucked water was not available to alleviate the schools' situation (Cunningham 2014). **Drought may affect school feeding programs:** Several school feeding programs in the region are supplied primarily by local agriculture, e.g. Nippes region, Haiti through the World Food Program initiative (WFP n.d., 2016). Drought may impact school feeding programs that depend on local agriculture.

Table 7.10: Impacts of Climate Change on the Finance and Insurance Sectors across the region

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
DROUGHTS	**Droughts are very costly and will cause disruptions to key economic activities.** There were notable price increases for basic commodities during drought periods. This was experienced in the 2009/2010 drought when vegetable prices increased by 250% per lb (St. Vincent) and the price of fruit prices increased by between 40.7-60.8% (Farrell et al. 2010). There is a noted increase in bush fires during severe droughts and these too can be very costly. Forest fires destroyed large areas of citrus farms in Trinidad and Tobago resulting in a TT$12 million increase in citrus imports in 2010, when compared with 2008 (Farrell 2010).
HEAVY RAINFALL/FLOODING	**Heavy rainfall damage will occasion the need for additional insurance coverage.** Heavy rainfall events not associated with tropical cyclones and hurricanes will be costly to most Caribbean islands. The Caribbean Catastrophe Risk Insurance Facility Segregated Portfolio Company (CCRIF SPC) which provides parametric insurance for *inter alia* heavy rainfall events, reported a pay out of over US$ 4.7 million in just two years (2014 and 2015) for only three member states of the CDB: St. Kitts & Nevis, Barbados, and Dominica (CCRIF 2015). With projections suggesting that rainfall events could be more intense, islands will have to allocate financial resources to deal with associated damage.
INCREASING TEMPERATURES	**Increasing temperatures may lead to the emergence of more vector borne diseases which may increase premiums and expenditures across the region.** In Jamaica, there was an increase in health insurance premiums during the outbreak of the chikungunya virus (Ramrattan 2015). Jamaica also allocated US$ 3.62 million to control the chikungunya virus in 2014 (Ramrattan 2015).
STORMS/ HURRICANES/ TROPICAL CYCLONES	**More severe storms will result in costly damages to most islands.** Most projections of climate change suggest that hurricanes and tropical cyclones will be more intense in the future. The damage resulting from these more intense systems will be more costly for the Caribbean and this could significantly derail economic development, since funds would have to be diverted from other development priorities to finance recovery efforts. For example, following the passage of Hurricane Ivan in 2004, the fiscal position of Central government in Grenada deteriorated from a surplus of EC$17 million to a deficit of EC$54 million, or 4.5% of gross domestic product (OAS, 2004). In two hurricane seasons (2008 and 2010), pay-outs for damages to four Caribbean (Turks and Caicos Islands, Barbados, St. Lucia and St. Vincent & the Grenadines) amounted to US$19.2 million (CCRIF 2015). **Landslide hazards resulting from hurricanes are not covered by insurance.** This was a major problem faced by the government of St. Lucia in 2010, where despite suffering greater damage (rainfall and landslide events) from tropical cyclone Tomas, it received a much lower pay-out (US#3.24 million) than that received by Barbados (US$8.56 million) from the same cyclone (CCRIF 2015). For hurricanes Irma and Maria in 2017 (both category 5 hurricanes, the estimates of insured damage in the Caribbean is US$6-12.75 billion and emphasizes how destructive these severe events can be (Insurance Journal, 2017). Moreover, separate premiums have to be paid for hurricane/tropical cyclone versus heavy rainfall damage, resulting in costly insurance coverage (maximum coverage per year per hazard is US$100 million), which does not cover all damage that could result. **Insurance premium rates will likely increase across the region due to property damage from more severe extreme events,** In 2017, the Insurance Association of Jamaica reported that Jamaican property owners will be expected to pay 30-35% more for their premium as reinsurers have been adjusting to their rates to recover from the massive losses incurred during the active 2017 Atlantic Hurricane season. While Jamaica did not suffer from any hurricanes, it shares similar risks with other Caribbean islands (RJR News Online, 2017).

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
STORMS/ HURRICANES/ TROPICAL CYCLONES	**More severe extreme events will increase insurance premiums for Caribbean hoteliers.** Caribbean hoteliers should now anticipate paying increased premiums for their facilities ranging from 10-40% due to the very active hurricane season which affected several countries across the region (Caribbean Hotel and Tourism Association 2017).

7.4. IMPACT TABLES: CLIMATE CHANGE AND CROSSCUTTING THEMES

Table 7.11: Impact of Climate Change on Gender

CLIMATE CHANGE VARIABLE/EXTREME EVENT	IMPACTS
HURRICANES/TROPICAL STORMS/FLOODING	**Hurricanes threaten the livelihood of many women across the region.** Majority (18.1 million) of the 19.6 million household workers across the Caribbean are women and they are particularly vulnerable to climate change because hurricane passage could result in the destruction of their workplace (the home). This job loss has a negative multiplier effect because in Jamaica, for example, many of these women are heads of single parent households and occupy the poorest section of the society (Dunn 2013**).** **Women are at an increased risk of sexual violence in shelters. Furthermore, these shelters lack facilities to accommodate pregnant women and lactating mothers (Dunn 2013; UNDP 2009)** **Human trafficking during extreme events disproportionately affects women and girls.** Trafficking increases in low income communities during hurricanes and floods, with 85% of its victims being women and girls being sex trafficked, while 15% of men and boys are trafficked for forced labour (Dunn 2013). **Educational value has gender biases.** After the passage of a tropical storm, in some cases, girls have the opportunity to continue with their education, while boys are removed from school and sent to assist with recovery efforts (CDEMA 2014; IGDS 2013). **HIV rates increase among women in times of disasters, especially among those who engage in transactional sex as a survival strategy** (Dunn 2015a). **Disasters overburden women (especially in poor communities) to fulfil duties considered "women's work".** These responsibilities include collecting water, caring for the infants and elderly, providing medical support and food, washing and cleaning in the house. They would be burdened with 'trying to get things back to normal' and get the children back to school (CDEMA 2014). **Post disaster, men prioritise rebuilding efforts outside the home.** After a disaster (especially in poorer communities) men focus on reparation efforts outside the home, including removing debris, rebuilding, putting roofs back on and where possible obtaining resources (CDEMA 2014). **Men and women's vulnerabilities increase after a disaster due to their gendered roles.** In some post disaster analyses, it has been shown that men suffer higher mortality rates than women because they take more risks trying to save themselves and their families (IGDS 2015) On the contrary, many women sacrifice themselves during disasters when their own caregiving roles hamper their own rescue efforts. This also reflects women's social exclusion because they are less able than men to run, and have behavioural restrictions that limit their mobility in the face of risk especially since their voices often do not carry as much weight as men's in their households (UNDP 2009; Dunn 2015). **Indigenous peoples tend to have limited rights and access to resources which make them particularly vulnerable to disasters** (CDEMA 2014). **Rural women are particularly vulnerable to climate change.** Across the Caribbean, women residing in rural areas are particularly vulnerable to climate change because they have less opportunities to earn a living than their urban counterparts and experience higher levels of poverty. Many rural women experience various forms of inequality, related to their gender roles in the household(primary caregivers of their families) and more limited support services Also their livelihoods (vending and small scale farming) are climate sensitive. All of these socioeconomic circumstances affects their abilities to respond and recover from disasters (Dunn 2013)**.** **Greater loss of income for women in rural areas due to breakdown in road infrastructure.** Women in rural areas also experience greater income losses than their male counterparts from the breakdown of road infrastructure after a disaster due to their role in market vending and their dependence on road transportation, which would affect their food and livelihood security (IGDS 2015). In Jamaica, for example, women comprise over half of the population but represent 70% of persons living below the poverty line. With higher levels of poverty, poor women are more vulnerable to the impacts of climate extremes such as droughts, floods and hurricanes. They are also likely to bear the heaviest burdens when these disasters occur (UNDP 2009).

CLIMATE CHANGE VARIABLE/EXTREME EVENT	IMPACTS
HURRICANES/TROPICAL STORMS/FLOODING	**The elderly, women and children (especially girls) are particularly vulnerable in post disaster situations.** This is because they lack land and other assets that could help them cope. Therefore, they are more likely to face food shortages, sexual harassment, unwanted pregnancies and vulnerability to diseases and could be forced to drop out of school or marry earlier (Dunn 2015). **Hurricanes exacerbate the pre-existing gender inequalities in islands in the Caribbean.** Hurricane Ivan (2004) served to emphasize this in Grenada. Grenadian women, prior to the event had restricted skills bases, higher rates of poverty and were burdened with caregiving, while Grenadian men had mobile skills, no special restrictions and were excluded from childcare responsibilities. Due to these disparities, the women disproportionately had limited access to the labour market and less wage-earning possibilities than their male counterparts and therefore took a longer time to recover from the ill-effects of hurricanes. For example, within the nutmeg industry female farmers, due to Hurricane Ivan took a longer time to come back to their income stream than the men because of these realities (Kambon et.al 2005).
DROUGHTS	**Women in drought affected areas have time-consuming water carrying responsibilities which limits ability to earn and diversify their income.** Women and children have the main responsibility for securing water supplies daily from springs or other sources. Significant commuting time/ work is spent performing these duties This has implications for how they use their time which can be considerable because of the distances they have to travel to get water (IGDS 2013).

Table 7.12: Impacts of Climate Change on Poverty

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
HEAVY RAINFALL	**Heavy rainfall likely to affect public health, especially in riverbank communities.** Heavy rains contaminate watersheds by transporting faecal products and other waste into groundwater. Heavy rainfall also affects the health and sanitation of some communities without proper toilet facilities. Flooded pit latrines release waste directly into the rivers. This solid waste then threatens the health of the people in the communities and especially the health of the children who use the river for bathing purposes. This has led to an increase in diseases associated with water sanitation and poor hygiene practices (CSGM 2012).
INCREASING TEMPERATURES	**Heat waves may lead to increased fatalities in poor communities.** Increased frequency or severity of heat waves in the Caribbean will possibly cause an increase in human mortality and illness, especially in poor communities without access to cooling aids like air conditioners or refrigerators (CARIBSAVE 2009). **Poor communities more susceptible to vector disease transmission.** In low income communities and squatter settlements, people are more susceptible to vector borne diseases because of the necessary water storage and lack of immunisation to the virus (dengue) (Chen et. al 2006).
HURRICANES/TROPICAL STORMS/FLOODING	**The passage of extreme events increase the risk of human trafficking in low income communities.** This is because hurricanes, floods and other climate extremes increase the possibility of human displacement especially in poor communities which lack security. Children are particularly vulnerable to trafficking (Dunn 2013). **Housing quality and location increases poor communities' vulnerabilities to tropical storms/hurricanes.** In these communities, houses are made of poorer quality material and are often located on marginal lands or high-risk areas. Because of this, these communities tend to suffer great losses from extreme climatic events and take longer to recover (CDEMA 2014). **Flooding and landslides may lead to population displacement because of the vulnerabilities of those settlements in floodplains** (CSGM 2012).
DROUGHTS	**Longer drought periods increase likelihood of disease transmission**. During water shortages in some communities diseases spread because of poor infrastructure, waste disposal issues and lack of access to clean water resources (Silva 2015). **Elderly poor increasingly vulnerable to climate impacts.** The elderly poor living in rural areas across the Caribbean, may face serious health threats from the lack of water or adequate sanitation associated with droughts and other climate impacts (ECLAC 2011).

Table 7.13: Impacts of Climate Change on Development

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
INCREASING TEMPERATURES	**Chikungunya virus and economic loss in Jamaica and Trinidad and Tobago** Extreme temperatures have led to the emergence of vector borne diseases like the chikungunya virus (Chik-V) in Trinidad and Tobago and Jamaica in 2014 which devastated the economies of both countries. Chik-V led to US$60 million in financial losses in Jamaica in 2014 with 81% of the companies reported having workers affected by the virus. There were also severe losses of production as a result of absent workers affected by Chik-V and loss of productive time by the sick workers unable to work at full capacity because of the infection .10% of the population (130,000) in Trinidad contracted the chikungunya virus, resulting in the country incurring US$13.2 million dollars in losses (Ramrattan 2015). **Declines in productivity as a result of increasing temperatures**. Across the region, increasing temperatures have the potential to threaten social and economic development. This is due to the correlation with body temperature, work performance and alertness, which has implications for outdoor workers such as sportspeople, farmers, manual labourers and indoor workers and students in classrooms without cooling aids. Higher temperatures can lead to low productivity, given that heat exposure can affect physical and mental capacity and lead to heat exhaustion or heat stroke in extreme cases. (CSGM 2017).
STORMS, FLOODS, HURRICANES	**More frequent extreme events increase the risk of disease infection**. With a rise in the occurrence of extreme events, availability of freshwater may also be constrained and contaminated. This could lead to communities experiencing food-borne, water- borne and respiratory diseases (cholera, salmonellosis and asthma). This happens especially in rural or remote communities that have minimum public health care infrastructure. (CARIBSAVE 2009) Haiti has been dealing with a cholera outbreak since 2010 which is now categorised as the largest in the Western Hemisphere (United Nations Haiti Country Team, 2015). **Improper land use/ development in watershed/flood prone areas increases vulnerabilities to landslides and floods (CSGM 2012)** Flooding from heavy rainfall and other climate extremes increases the incidence of land slippage in unstable mountainous areas**.** In some Caribbean islands including Dominica, Jamaica, Haiti and St Lucia, many mountainous communities are prone to land slippage. In extreme cases deaths do occur (Edwards 2012; UNDP 2010).
DROUGHTS	**Drought induced water shortages will negatively impact socioeconomic development.** This will create disturbances in agriculture and tourism among other climate sensitive sectors. These shortages will create a need for increased food importation (UNECLAC 2011) Malnutrition resulting from these disturbances in food distribution and production may occur (CARIBSAVE 2009).
SEA LEVEL RISE	**Continued coastal development and removal of natural barriers increases exposure of coastal communities and infrastructure (roads and bridges) to flooding and erosion** (CSGM 2017). This may exacerbate the impacts of tropical storms and hurricanes on coastlines which will intensify as the sea level rises (Simpson 2010). With 4 degrees warming, sea level rise could lead to the displacement of between 1.2 and 2.2 million people from the Caribbean and other regions (CDKN 2014). More than 550 km of roads are projected to be inundated by a 1 metre rise in sea level in CARICOM nations (UNDP 2010).

Table 7.14: Impacts of Climate Change on Security

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
SEA LEVEL RISE	**Sea level rise threatens livelihood security in many small island developing states.** Land loss, due to sea level rise threatens livelihood security in small island developing states, which has implications for food supply and rural livelihoods. It is estimated that a one metre rise in sea level will lead to a loss of agricultural land by (4% in Suriname, 3% in Bahamas and 2% in Jamaica) (CDKN 2014; Simpson 2010). **Further sea level rise and storms may affect coastal military facilities and hamper regional counter drug trafficking efforts.** Sea level rise and more intense storms may lead to destructive inundation and erosion of coastal military facilities. This will impact not only these facilities' clean water supply but will also increase maintenance costs. As a result, this will degrade military readiness, which will adversely affect the American-led counter-trafficking fight in the region since Caribbean military's coastal facilities often serve as launching pads for maritime patrol and interdiction operations (Barrett 2015). **National security policies are likely to become influenced by the impacts of climate change on critical infrastructure and territorial integrity of many small island states.** Land inundation as a result of sea level rise poses a risk to those countries with extensive coastlines (CDKN 2014)
INCREASING TEMPERATURES	**Increasing temperatures may lead to increased incidence of aggression.** Increasing temperatures affect aggression because of a positive correlation with increased testosterone and adrenaline production (fight or flight) responses (Silva 2016).
HURRICANES/STORMS/ FLOODING	**Rivalries are also likely to occur among some island states due to the impacts of climate change on shared water resources and pelagic fish stocks (**CDKN 2014). **Crop loss and flooding will devastate farming communities across the region**. Crop loss and flooding are some of the effects of extreme weather conditions that also affect farming communities which are largely vulnerable to climatic variability (ECLAC 2011). Flooding from hurricanes Irma and Maria destroyed homes and farms in the coastal areas of Haiti, affecting 18,000 poor families who lost food crops. Haiti's population consists mainly of subsistence farmers (VOA 2017). **More frequent extreme events may continue to displace island people and damage critical infrastructure**. The 2017 hurricane season in the Caribbean affected 20,000 children, displaced 32,000 people with 17,000 of those people in need of shelter and over 1.2 million people were affected by damages to water infrastructure. Electrical lines, houses and public buildings such as schools and hospitals, as well as private sector structures which are significantly important to Caribbean economies and people's livelihoods were also affected (The Gleaner 2017). **The declines in the availability of food, water and other critical resources after an extreme event may lead to an increase in looting across the Caribbean**. It was reported that after Hurricane Maria there was widespread looting in the island of Dominica where the local police detained over 100 persons (Caribbean National Weekly 2017) Looting in Antigua and Barbuda and British Overseas Territories (Anguilla, British Virgin Islands and Turks and Caicos Islands) after Hurricane Irma was also reported (Time 2017). **More frequent and severe extremes may increase migration within the region and sometimes even within the same country**. IIt is likely that there will be increased migration from fragile countries like Haiti into neighbouring countries like Dominican Republic as a result of hurricanes (Barrett 2014). Hurricane Irma's landfall forced the migration of 1700 persons from Barbuda into Antigua rendering the island of Barbuda uninhabitable for the first time in 300 years (CNN 2017)

CLIMATE CHANGE VARIABLE/ EXTREME EVENT	IMPACT
HURRICANES/STORMS/ FLOODING	**More hurricanes and tropical storms will overburden the military's search and rescue efforts and recovery operations across the Caribbean**. Caribbean military forces especially those supporting national civil authorities and CDEMA can expect increased search and rescue efforts and recovery operations in the wake of more storms and hurricanes of increasing frequency and severity (Barrett 2014). Hurricane Irma's devastation in Dominica necessitated the deployment of 120 personnel from the Jamaica Defence Force who assisted with security, distribution of relief supplies, medical care and recovery planning (Jamaica Observer 2017). **More frequent storms will also necessitate further capacity building and intraregional cooperation.** Militaries will have to build capacities in equipment procurement and training exercises to assist distressed communities and will also be required to work with regional defense organisations such as the Inter American Defense Board to pool resources and share best practices (Barrett 2014). **More frequent extreme events can damage economically important infrastructure**. More severe hurricanes can destroy coastal infrastructure like ports and roadways which many Caribbean countries depend on to facilitate key economic activities like agriculture and tourism. Such destruction of infrastructure can have a devastating impact on the region's economies (Barrett 2014).
DROUGHTS	**Longer drought periods threaten food and water availability and may possibly cause civil unrest.** Due to shortfalls in these critical resources, governments across the region will be stressed to provide alternative supply and improve water infrastructure management. In these times the military will be expected to provide emergency food packages to the most affect citizens and assume non-traditional roles as crisis responder and peacekeeper (in extreme cases of civil unrest) (Barrett 2014).