Application of national census data for vulnerability assessment and spatial planning in Grenada

MUJEEB ALAM

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SUPERVISORS:

Dr. Cees Van Westen
Ir. Mark Brussel

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MUJEEB ALAM
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SUPERVISORS:
Dr. Cees Van Westen
Ir. Mark Brussel

THESIS ASSESSMENT BOARD:
Prof. Dr. V.G.Jetten (Chair)
Dr. Johannes Flacke, ITC, University of Twente (External)

ABSTRACT

Spatial planning is considered to be an important instrument in disaster risk management, by which human exposure and vulnerability could be reduced and thereby disaster losses. And in order to make informed planning decisions, adequate and reliable hazard and risk information is indispensable. Therefore, in the first part of this study, the use of hazard and risk information in the physical planning process of 5 Caribbean countries (Grenada, Saint Vincent, St. Lucia, Dominica, and Belize) was examined through literature review and direct interviews with senior staff of each physical planning unit. Furthermore, fragility and resilience indices were produced for Grenada to analyze its vulnerability to natural hazards. These indices were constructed by adopting an indicator based approach making use of publicly available census data from 2011 that was aggregated at the enumeration district level. The main selected indicators are age, gender, insurance, education, housing, livelihood, health etc. The Spatial Multi Criteria Evaluation module of ILWIS was used to combine different factor maps and produce indices. Since, purely census data was used for measuring vulnerability these indices provide in a way household level fragility and resilience in the country. To check the sensitivity of the model and indices, both percent and absolute values of indicators were tested. A concept of a flood hazard matrix is introduced for Grenada that is based on probability of flood occurrence and its intensity (height). Flood hazard maps produced by ITC using OpenLISEM are classified taking this hazard matrix and the resultant maps could now be utilized for physical planning decisions. Unfortunately the census data is not geo-located, which makes it difficult to use in an exposure analysis. Therefore, a test was made to geo-locate census data in selected sites. Additionally, a country-wide population distribution map at building level was produced for the main Island following a dasymetric mapping concept by utilizing census data and available building footprints, which were visually classified according to their occupancy types. Using GIS spatial overlay techniques exposure analysis was carried to identify number of buildings and estimated population that is exposed to flooding and landslides.

Key words: Spatial planning, Indicator, Fragility index, Resilience index, Dasymetric mapping, Hazard matrix, SMCE

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1. INTRODUCTION

1.1. Background & Rationale

Natural hazards are possible dangerous phenomena that might cause damage to infrastructure and loss of lives. Although much can be done to mitigate them, the extreme triggering events, such as hurricanes or earthquakes are inevitable and they may occur at specific locations with specific frequencies. Moreover, in many parts of the world, human exposure to natural hazards has been increasing in recent decades, due to poor development activities (UNDP, 2004). Consequently, there has been a debilitating impact of disasters on human population and environment, causing widespread losses to life, property and environmental degradation. According to a recent UNDP report (2014), over the past two decades, "disasters have killed more than 1.3 million people, affected more than 4.4 billion and cost the global economy at least US$2 trillion. It is estimated that each year, earthquakes, hurricanes and cyclones cost more than US$180 billion". Furthermore, it is foreseen that the impact of disasters will increase in the future due to climate change (IPCC, 2014)

The Caribbean region is one of the most disaster prone regions in the world (Barbara, 2011). It is prone to multiple natural hazards, including hurricanes, tropical storms, floods, earthquake, volcanic eruptions, and landslides (Barbara, 2011;Haghebaert, 2012). Moreover, the Caribbean island states are particularly vulnerable to climate change (Edwards, 2014). As, according to IPCC's fourth assessment report, as quoted by the World Meteorological Organization (2012), "small islands, including those in the Caribbean, face some of the highest levels of threats and risks from climate change". In the recent years, disasters in the Caribbean have been causing colossal damages to property. For example, in 2004 alone, hurricane Ivan struck seven Caribbean countries and caused around US$2 billion in property damages (Kirton, 2013).

Disasters are largely linked to the process of human development (UNDP, 2004) as, unwise development creates human vulnerability to natural hazards (Benson & Twigg, 2007). As a consequence, we observe losses to humankind and environment. It is, therefore essential to mainstream disaster risk management in the development work (Benson & Twigg, 2007; Holcombe, Smith, Wright, & Anderson, 2011) in order to reduce losses, emanating from natural hazards. In this context, 168 Member States of the United Nations adopted the Hyogo Framework for Action 2005-2015 (HFA) (UN ISDR, 2007), following the devastating earthquake in Kobe, Japan. In this framework, the focus was given essentially on pre-disaster risk management.

Hazard and risk information are an integral part of disaster risk management and they are prerequisites for a safe and sustainable development of a society (Greiving et al., 2014). Results of risk information are being used for formulating disaster risk management policies and devising mitigation measures (Sagara & Saito, 2013). In this regard, the second priority of the HFA (UN ISDR, 2007) stresses upon generating and using hazard and risk information in spatial development decisions.

Spatial planning emerged as an important instrument for achieving sustainable development and enhancing quality of life (United Nations Economic Comission for Europe (UNECE), 2008). Additionally, it is considered to be a key instrument in disaster risk management (Sutanta, Rajabifard, & Bishop, n.d.; ITC & CENN,) aiming to limit the effects of natural disasters (UNECE, 2008). Conversely, if hazard information is not included in the development decisions, it may increase human exposure and vulnerability. Therefore, Fleischhauer (2006), state that "the vulnerability of populated areas to natural disasters is partly a consequence of decades of spatial planning policies that failed to take proper account of hazards and risks in regional and land-use planning as well as development decisions".

One of the main functions of the spatial planning is to prepare and make decisions about land-use (Greiving & Angignard, 2014; Sutanta et al., 2008). Thus, it is important to integrate hazard and risk information at this stage, while making choices about future land for any development work. In doing so, the planners are able to restrict hazardous areas from further development, particularly for housing and other critical infrastructure; thus, explicitly mitigating risk and reducing human vulnerability. Moreover, where area is already developed, hazard and risk information could be used for imposition of requirements for retrofitting, redeveloping or relocating existing development (Burby, Deyle, Godschalk, & Olshansky, 2000), stopping further development in those areas, and defining mitigation measures to reduce disaster risk. Fleischhauer et al.(2006) have identified four possible roles of spatial planning in risk management namely; keeping areas free of development in the highly hazardous areas, differentiated decisions on land use, regulating land use, and finally, hazard modification by influncing intensity and frequency.

Many authors like Burby et al.(2000) and Greiving et al.(2006) highlighted the need for incorporation of risk assessment within the spatial planning process. In this regard, many frameworks and models (Greiving & Angignard, 2014; Greiving & Fleischhauer, 2006; ITC & CENN, 2012; Sutanta et al., 2008; University Lancaster, 2007) have been proposed that are of relevance for the spatial planning and disaster risk management.

However, in many countries, including many of the countries in the Caribbean region, hazard information is often not used in the planning process, let alone risk information. This may be due to obstacles in the legal framework for land use planning or due to lack of adequate hazard and risk data. If available, hazard maps are often general and qualitative, and high hazard zones may cover unrealistically large areas, which makes it difficult to use them in land use planning.

Therefore, it is important to investigate how and what hazard and risk information could be integrated in the spatial planning in Caribbean island states. Such states are generally characterized by their small sizes, in terms of their area, population, and also their government capabilities and resources. It is envisaged that such studies will help relevant spatial planners in improving their understanding on defining data requirements related to hazard and risk information and applying such information in resolving their specific development problems.

1.2. Problem statement

Spatial planning has to decide on future use of space. However, planners are facing challenges in deciding on space as land is limited and there is a pressing demand for various uses, for example, agriculture to ensure food security, industry & tourism for economic growth, housing to provide basic shelter needs of the population, while ensuring safety of people from natural hazards and conserving natural resources such as forest, wetlands as illustrated in figure 1.1 below.

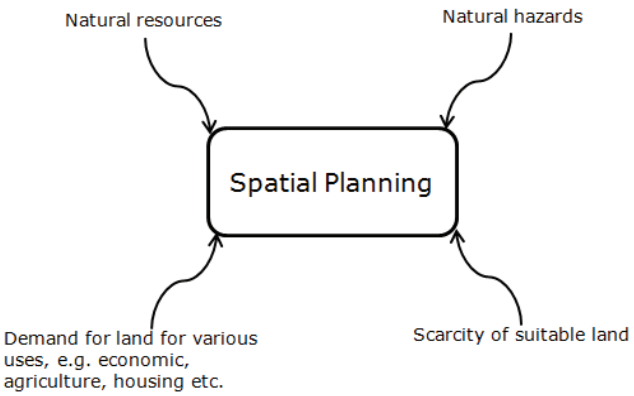

Figure 1.1: External pressures on special planning (modified from (Sutanta et al., n.d.)

The integration of hazard and risk information into spatial planning requires many aspects (Sutanta et al., n.d.). For example, policy, availability and access to required data, platform for sharing data, institutional mechanisms for mutual collaboration among partners, and importantly, awareness and technical know-how on what is needed (what critical information is required for a particular spatial development problem), how to generate such information and how to combine different sets of hazard and risk data and use them for making planning decisions as illustrated in figure 1.2.

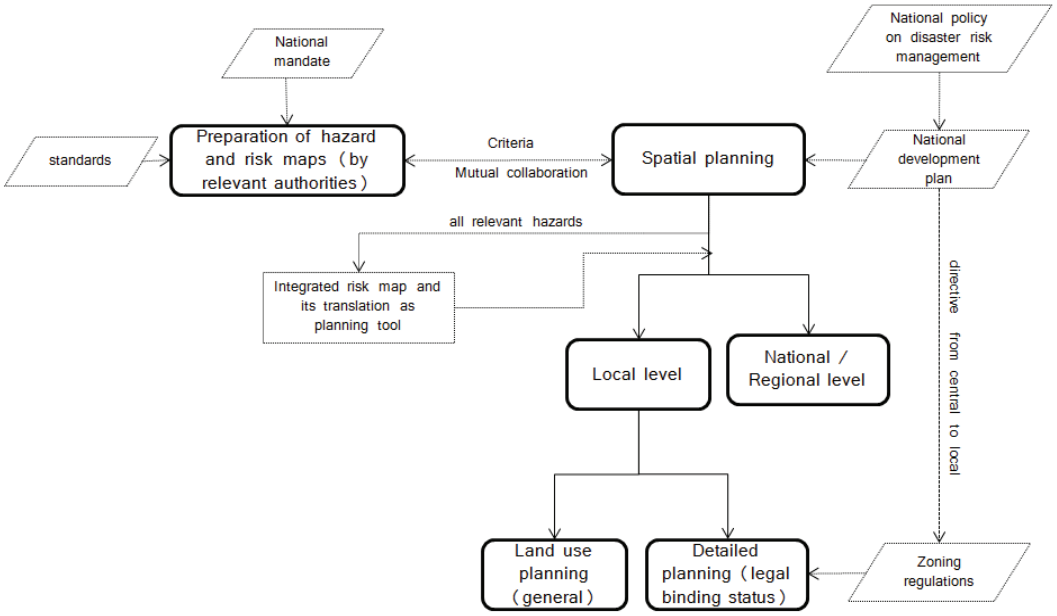

Figure 1.2: Conceptual framework on use of natural hazards information in spatial planning (source own)

Spatial planning takes place broadly at two levels i.e. regional and local land-use planning (it is further sub-divided into 2 stages; preparatory and detailed land-use plan) (Fleischhauer, 2008). It implies that, natural hazards information should be considered at each level. The intended scale and currency of the hazard information is crucial for planning as small scale hazard map will not provide sufficient details to be used for detailed planning at the local level. Similarly, the available hazard information should possibly reflect latest situation on the ground. Further, each element-at-risk is sensitive differently to each hazard type and intensity. For example, 0.5 meter flood may not damage a building but it may seriously damage standing crops and an earthquake of certain high intensity, has no serious effects on crops, but it may destroy weak buildings and other infrastructure. Other important aspect is the recurrence interval and temporal perspective (Burby et al., 2000). It means that the development planning should be based on specific return period of a particular hazard (e.g. 50, 100 years floods) to withstand hazard effects. And it is also important to consider for which land-use period (current situation and/or future scenario) risk should be considered and evaluated. What are possible alternative land-use scenarios?

The research problem of this thesis was that human exposure and vulnerability to natural hazards in 5 target countries (Dominica, Grenada, Saint Lucia, Saint Vincent, and Belize) is partly a consequence of not addressing adequately the consideration of prevalent natural hazards and their consequences in the spatial planning.

This research aims at evaluating the existing state of the use of hazard and risk information in these 5 countries, which were also the target countries in the World Bank CHARIM (Caribbean Handbook on Risk Information Management) project, to make a comparative analysis on integration of hazard and risk information in their physical development planning process, besides; generating a vulnerability index map

for Greneda, mainly using available census data and hazard maps. Grenada, like many other island states, disaster risk is high due to its exposure to a number of hazards (detailed description is provided in chapter 3). There is absence of a national land-use policy (Niles, 2013) to guide development work effectively. Furthermore, inadequate enforcement of existing physical development rules and regulations and absence of natural hazards information in physical planning (Niles, 2013) has increased the susceptibility to disaster losses in the country.

1.3. Research objectives

The overall objective of this research is to analyze the current state of application of hazard and risk information in the spatial planning of 5 target countries, and undertake vulnerability analysis of Grenada using publicly available census data and integrate this with national scale hazard mps that could be used for spatial planning

1) Determine current state of use of hazard and risk information in the physical planning of Dominica, Grenada, Saint Lucia, Saint Vincent, and Belize
2) Undertake vulnerability analysis of Grenada using census and flood hazard maps
3) Undertake exposure at the national level in Grenada

1.3.1. Research questions

Regarding sub objective 1, the research questions are as flows:

1. Is disaster risk management included in the physical planning policies & frameworks of the respective countries?
2. How does the planning process work? And what is the integration process of hazard and risk information in the development planning in the respective countries?
3. What are relevant hazards and what are the requirements for hazard and risk information that are considered to be relevant by planners for development planning?

Research questions regarding sub objective 2:

1. What census data can be used to assess the vulnerability at the national level?
2. What vulnerability indicators can be defined to express components of vulnerability applying census data
3. How hazard and vulnerability information could be used in the physical planning in Grenada?

Research questions regarding sub objective 3:

1. How many buildings are exposed to flooding and landslide?
2. How many people are exposed to flooding and landslide?

1.4. Thesis outline

This thesis has been organized in the form of chapters concerned to a specific topic. Chapter 1 explains background and relational of the research. In Chapter 2, related literature is presented and Chapter 3 discusses about the physical planning process and use of hazard information in the planning processes of target countries. Chapter 4 is dedicated to vulnerability assessment of Grenada at the national level and Chapter 5 discusses exposure analysis. In Chapter 6 conclusions and recommendations are presented

2. LITERATURE REVIEW

2.1. Spatial planning and hazard data requirements

The compendium of European spatial planning refers to spatial planning as methods used by the national and local governments to influence the future allocation of activities in space (Nadin, Hawkes, Cooper, Shaw, & Westlake, 1997). It is a public sector activity and it has both regulatory and development functions (United Nations Economic Comission for Europe (UNECE), 2008). As regulatory, it has to authorize for given development work; and as development mechanism, provide guidance on development tools for the provision of services and infrastructure development and preserving natural resources etc. However, the scope of spatial planning varies from country to country.

Spatial planning is considered to be an important part of integrated disaster risk management (Swiss Federal Office for Spatial Development (FOSD), 2006). Its contribution in the long term disaster mitigation is quite evident. As disaster mitigation is aiming at minimizing damages to people and assets before a disaster strikes. The spatial planning measures are preferable and given higher priority over technical (structural) measures when it comes to long term mitigation and prevention of risks (FOSD, 2006). Spatial planning makes decisions on allocation and use of land for society; therefore, in a way it influences the vulnerability in cases of spatially relevant natural hazards (Greiving & Angignard, 2014). Fleischhauer et al.(2006) have identified four possible roles of spatial planning in risk management namely;

- Keeping areas free of future development that are; a) hazard pone, particularly with history of occurrence of disaster events, b) needed to lower the effects of hazardous event (e.g. flood retention basins), and c) needed to enhance effectiveness of disaster response (e.g. evacuation routes etc)
- Differentiated decisions on land use – allocating land for different uses based on hazard intensity, frequency or other hazard criteria. For instance flood prone areas may be used for agriculture purposes and may be forbidden for residential or siting of critical buildings, avoiding construction on steep slopes but encouraging forestation on those areas etc.
- Regulating land use by legally binding status – for instance regulating building density in earthquake prone areas, recommended roof types for buildings in the hurricane belt, or prohibition of basements in flood prone areas.
- Hazard modification - spatial planning can contribute in reduction of hazard potential of some of the natural hazards such as floods. This can be achieved by influencing intensity and frequency of a hazard.

As a pre-requisite for making informed planning decisions and carrying out its functions as identified above, spatial planning require adequate and reliable hazard related information. In the absence of such information physical planners may not be able to decide on, for instance, which areas should be prohibited for future development due to potential impact of any hazard event or allocate land for various potential uses on the basis of hazard intensity or recurrence interval. Different types of hazard maps, risk assessment information and related guidelines serve vital sources to inform planning decisions.

Noteworthy, spatial planning has no as such direct role in hazard and risk assessments, rather, it should be considered as an end-user of assessment results (Greiving et al, 2006). Spatial planning and risk management come together if spatial planning instruments are being applied in the risk management strategies or if risk considerations are being incorporated in the spatial planning process (ITC & CENN, 2012). Usually, in countries there are dedicated government agencies or sectoral departments responsible for production, standardization, and supply of such information to sister agencies, for instance, USGS, FEMA, US Engineering Corps etc; in the USA. Following table (2.1) provides an overview of hazard

Planning level and planning activity (scale)	Risk mitigation planning instruments	Required river flood hazard information	Required earthquake hazard information	Required landslide and avalanche hazard information	Required forest fire hazard information	Required volcanic hazard information	Contents of hazard map
Regional (1:50,000 – 1:500,000)							
Keeping areas clear of development	-priority zones for spatially relevant functions or uses	-extent of flood -frequency of flood	-extent of earthquake area -intensity of earthquake (possible damages) -frequency of earthquakes	-extent of landslides and avalanches -intensity of landslides and avalanches -frequency of landslides and avalanches	-extent of forest fires	-extent of volcanic effects -type of volcanic effects (pyroclastic flows, ash-cloud surges, lahars, lateral blasts)	-Scale: 1:25,000 to 1:50,000 -hazard zones -hazard intensities
Differentiated decision on land	-securing sites and routes for infrastructure	-extent of flood -frequency of flood	-extent of earthquake area -intensity of earthquake (possible damages)	-extent of landslides and avalanches -intensity of landslides and avalanches	- extent of forest fires	-extent of volcanic effects -type of volcanic effects (pyroclastic flows, ash-cloud surges, lahars, lateral blasts)	
Local / preparatory (1:5,000 – 1:50,000)							
Keeping areas clear of development	-areas with land-use restrictions	-extent of flood -frequency of flood	-extent of earthquake area -intensity of earthquake (possible damages) -frequency of earthquakes	-extent of landslides and avalanches -intensity of landslides and avalanches -frequency of landslides and avalanches	-extent of forest fires	-extent of volcanic effects -type of volcanic effects (pyroclastic flows, ash-cloud surges, lahars, lateral blasts)	-Scale: 1:1,000 to 1:5,000 -hazard zones -hazard intensities
Differentiated decision on land	-sites and routes for infrastructure -type of land-use	-extent of flood -frequency of flood -height of flood -speed of water	-extent of earthquake area -intensity of earthquake (possible damages) -type of earthquake effects (ground motion ,liquefiable soils)	-extent of landslides and avalanches -intensity of landslides and avalanches -frequency of landslides and avalanches -type of landslides and avalanches	-extent of forest fires -intensity of forest fires	-extent of volcanic effects -type of volcanic effects (pyroclastic flows, ash-cloud surges, lahars, lateral blasts)	

Table 2.1: Overview of requirements of spatial planning for hazard related information (Fleischhauer et al., 2006)

information that is considered to be relevant for spatial planning. This table was compiled under ARMONIA project (Fleischhauer et al., 2006) implemented under EU 6th Framework Programme. Since, spatial planning usually takes place at regional and local levels; therefore, required information has also been grouped under each planning level for various hazards that are relevant to participating countries. Also, in the first column the spatial planning actions are mentioned, whereas in the second column, names of possible tools that can be used in regional or local plans are described. The required information for each hazard may be then transferred into appropriate indicators to express hazard and damage potential.
It is evident from the above table that various hazard datasets are required for each level of planning. Also, the question of type of data i.e. qualitative or quantitative is also important aspect to take into account when deciding on data. Mainly, for local level planning quantitative data, e.g. flood height, velocity, intensity, frequency etc is essential to make differentiated decisions on building construction, for instance, which construction type or occupancy type could be allowed or not allowed in a particular area subject to hazard potential. Since, spatial planning has to decide on space, therefore, essentially all relevant hazards in that particular area to be considered. It is essentially the responsibility of spatial planning to combine all relevant hazards related information and make appropriate planning decision for that particular area.
In some countries the national law obligates the local authorities to create hazards maps and use them in the spatial planning. For instance, the Swiss law (rivers engineering and forestry law) makes special provision and obligates concerned authorities to produce natural hazards maps and consider them in land use planning and other activities affecting space (FOSD, 2006). Therefore, countries like Switzerland have spatial planning regulations based on specific hazard criteria. The Swiss risk concept from PLANAT (National Platform Naturgefahren) defines three intensity classes; based on flood depth and velocity (table 2.2) for flood vulnerability analysis and these are being used as basis for spatial planning regulations (Papathoma-Köhle, Kappes, Keiler, & Glade, 2010)

Intensity class	Criteria	Description
High	h > 2 m or v x h > 2 m²/s	Persons inside and outside of buildings are at risk and the destruction of buildings is possible or events with lower intensity occur but with higher frequency and persons outside of buildings are at risk
Middle	2 m > h > 0.5 m or 2 m²/s > v x h > 0.5 m²/s	Persons outside of buildings are at risk and damage to buildings can occur while persons in buildings are quite safe and sudden destruction of buildings is improbable
Low	h < 0.5 m or v x h < 0.5 m²/s	Persons are barely at risk and only low damages at buildings or disruption have to be expected

Table.2.2: Table 2.2: Intensity classes based on flood depth and velocity from PLANAT (Papathoma-Köhle et al., 2010)

2.2. Hazard, Vulnerability and Risk

Disaster losses occur not only because of a hazard event, but also inability of people and society to self-protect their lives, property, and livelihood (Chen, Cutter, Emrich, & Shi, 2014). Disaster risk is a function of hazard, vulnerability and elements at risk (Ebert et al., 2008; Dewan, 2013; Birkmann, 2007; Van Westen, Alkema, Damen, Kerle, & Kingma, 2011), which is illustrated in the figure 2.1, so called the risk triangle. Therefore, any changes in these

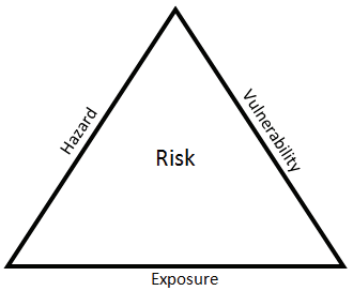

Figure 2.1: The risk triangle (Crichton, 2002)

three elements may increase or decrease risk (will increase or decrease risk area of the triangle), subject to nature of the changes. So, if disaster risk is intended to be reduced and thereby disaster losses in a particular jurisdiction, any one (and/or combination of) element of the triangle has to be altered. For instance, shifting buildings from a hazard prone area to a safer place, retrofitting of a weak building so that it withstands earthquake of a certain intensity, or building response capacity of a vulnerable community, stabilizing a unstable slope through appropriate mitigation measures etc.

2.2.1. Natural hazards

Natural hazard is a phenomenon that has potential to cause damage to human, property, and environment. The UN-ISDR (2009), defines natural hazard as "natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage". Hazard events are characterized by their magnitude or intensity, speed of onset, duration, and extent. Hazard assessments are undertaken to make an estimate of the spatial and temporal occurrence and magnitude of natural processes (Greiving et al., 2014). There are a variety of approaches for carrying out hazard assessments and mapping these processes, including inventory of historic hazard events, on-site studies, modelling, and remote sensing techniques. Conceptually and technically, there are well established methodologies for single hazard assessments. The choice of methodology is highly dependent on objective of the study, type of hazard, scale, time frame, availability of data, and human and material resources. Hazard assessment results are crucial inputs for risk analysis and devising risk reduction measures and spatial planning.

2.2.2. Vulnerability

In everyday use, the term vulnerability refers to the inability to withstand the effects of a challenging circumstance, however; it is a multifaceted concept (Ebert et al., 2008) and it is being used across many fields and disciplines, including disaster risk management, geography, anthropology, sociology, environmental studies, climate change etc. (Cutter, 1996; Chen, Cutter, Emrich, & Shi, 2014). Scientist with different backgrounds have a different understanding of this term (Papathoma-Köhle, Keiler, Totschnig, & Glade, 2012) and perhaps due to its diverse application and understanding, there is no unified agreement or universal definition of vulnerability (Bergstrand, Mayer, Brumback, & Zhang, 2014; Papathoma-Köhle, Kappes, Keiler, & Glade, 2010; Simpson & Human, 2008). For instance, Cutter (1996), compiled 18 different definitions of vulnerability introduced by the different authors and organizations in the context of risk, hazard and disaster. Therefore, Birkmann (2006), mentioned that "we are still dealing with a paradox: we aim to measure vulnerability, yet we cannot define it precisely".

Apparently, there are two main school of thoughts on the understanding of the term vulnerability: the first group is natural science and engineering and the second one is, the social science group (Sterlacchini et al., 2014; Ciurean, Schröter, & Glade, 2013; Papathoma-Köhle et al., 2012). The first group perceives vulnerability as degree of loss to an element at risk (UNDRO, 1980), whereas, the second group, focuses mainly on social characteristics of the society rather than physical aspects (Papathoma-Köhle et al., 2012). The UN-ISDR (2009), defines vulnerability as "the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard". This definition seems more geared towards socio-economic aspect of the vulnerability or in other words, the second school of thought of vulnerability. The UNDRO (1980) definition of vulnerability i.e., "the degree of loss to a given element at risk or set of such elements resulting from the occurrence of a natural phenomenon of a given magnitude and expressed on a scale from 0 (no damage) to 1 (total loss)", however, seems to be more practical when it comes to undertaking a quantitative/semi-quantitative risk assessment.

There are different aspects of vulnerability, arising from various social, physical, environmental, and economical factors UN-ISDR (2009). Physical vulnerability refers to the characteristics of physical structures (such as type of building wall, no of floors etc.) that determine their potential damage in case of occurrence of a specific hazard (Ebert et al., 2008). In the risk assessment framework, there are relatively

established conceptual frameworks and approaches for assessing physical vulnerability, however; they require good quality and detailed database for assessments (Ebert et al., 2008). Three main approaches are commonly applied for the analysis of physical vulnerability: they are vulnerability curves, damage matrices, and vulnerability indicators (Kappes, Papathoma-Köhle, & Keiler, 2012). It can be measure either qualitatively or quantitatively (Greiving et al., 2014). The physical analysis approach and measurement varies from hazard to hazard and subject to availability of data for analysis.

As compared to physical vulnerability, social vulnerability is relatively difficult to measure and explain. It is a complex concept (Ciurean et al., 2013) and wide range of interpretations are found in the literature. At the movement, a commonly accepted definition is still lacking (Ebert et al., 2008). Social vulnerability related to susceptibility of human being: individually or collectively as community to certain natural hazards and their existing capacity to respond and cope with any hazardous event. It includes matters related to social and health status, gender, age, religion, race etc (Sterlacchini et al., 2014). Generally, there are no, good or bad methods for social vulnerability assessments. Most of the methods look into the socio-economic fabric of the society and its coping strategies. Indicator based methods are commonly used for this purpose (Ciurean et al., 2013). Brinkman(2006), presented a comprehensive list of methods that are developed by various organizations and experts. Most of these methods are develop at global or country level assessments. Similarly, there is variety of vulnerability and capacity assessment (VCA) tools available, introduced by various international humanitarian & development organizations such as IFRC, ADPC, GTZ etc. to undertake assessments at the local level within the framework of community-based disaster risk management.

The economic vulnerability is related to potential impact on economic activities and assets as result of disasters. The economic losses may result due to disruption in business and production, loss of livelihood and investment opportunities and resultant poverty etc. These losses may be direct or indirect. It is rather challenging to assess any indirect economic losses associated with disasters. The environmental vulnerability is related to potential impacts of hazard events on environment. For instance, damage to forest due to forest fires, impact on marine life due to oil spill etc.

The notion of vulnerability is now considered to be a cornerstone in natural hazards studies (Dewan, 2013) and it is accepted as requirement for the development of emergency management capability (Tapsell, Mccarthy, Faulkner, & Alexander, 2010). Vulnerability forms an integral component of risk assessment in the disaster risk management cycle. A variety of conceptual models and related vulnerability assessment methods within the framework of risk management are available to measure vulnerability. It can be measure either on a metric scale (e.g. given currency) or non-numerical scale, based on social perceptions and evaluations (Ciurean et al., 2013).

Recently, European Commission, developed a comprehensive vulnerability assessment framework (figure 2.2) known as MOVE (Methods for the Improvement of Vulnerability Assessment in Europe) (MOVE, 2011). It is a holistic approach encompassing various aspects of disaster risk management. The core of this framework is vulnerability which comprises exposure, susceptibility and resilience. As mentioned earlier, fragility arises from different aspects like social dimensions and resilience is linked with the coping strategies of a community. Assessment of all these aspects is important in order to reduce risk.

Vulnerability is usually derived using indicators and indices. Indicators are variables intend to represent the characteristic of a system of interest and they are used to inform decision making and understanding processes (Tate, 2012). The indicators serve as inputs to a vulnerability model, and choice of model and indicators is subject to scale, location, availability of data, and objective of the vulnerability study (Eidsvig et al., 2014). The literature on vulnerability assessment identifies several variables that can be used to assess the vulnerability. Some of these variables or elements such as population density, disability etc., can provide direct information and can also be collected directly from various sources

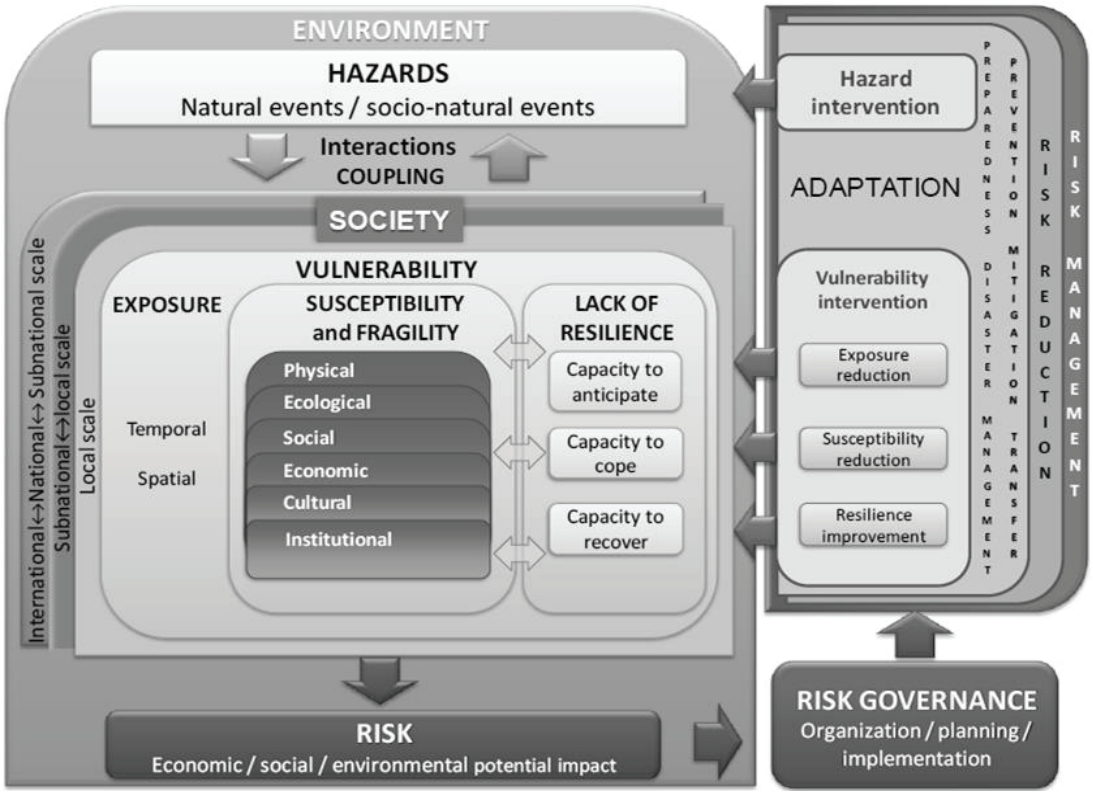

Figure 2.2: The MOVE framework developed under EU FP7 project (MOVE, 2011)

However, often times, direct measurements are not possible or actual variables are not available such as household income etc., in such cases, proxy variables are used to assess the vulnerability. Proxies are variables that can provide sufficient knowledge about a phenomenon that cannot be observed or collected directly, but which are conceptually linked (Ebert et al., 2008) and thus could be used to infer required information and assess vulnerability. There are a variety of sources and approaches ranges from community based methods to more sophisticated remote sensing techniques by which variables can be collected for carrying out vulnerability assessment. One of the important sources for social vulnerability assessment is census data. For instance, Cutter et al., (2003), derived Social Vulnerability Index (SoVI) at the county level for the entire United States using census data. They initially collected 250 variables, however; they were reduced to only 11 independent factors after checking for their collinearity and necessary computation of data. Similarly, there are several other examples such as presented by Arma & Gavri(2013), Chen et al., (2014), Dewan, (2013), Dwyer, Zoppou, Nielsen, Day, & Roberts (2004); Ainuddin & Routray(2012); Clark et al., (1998), Eidsvig et al., (2014), Guillard-Gonçalves, Cutter, Emrich, & Zêzere, (2014), etc., used census data to derive and quantify social vulnerability. In most of these studies, the predominantly applied variables were demographic (elderly, children, gender), disability, literacy, socio-economic (income, employment, poverty etc.), ethnicity, housing (type, ownership etc), access to basic services. Cutter et al., (2003), has complied a detailed list of variables that are frequently found in the literature influencing social vulnerability.

There are many logical steps involved in the construction of indices for measuring vulnerability. Tate (2012) suggested 11 steps (table 2.3) for social vulnerability index construction.

Stage	Description	Example options
Conceptual framework	Vulnerability dimension to include	Access to resources, demographic structure, evacuation, institutional
Structural design	Organization of indicators within the index	Deductive, hierarchical, inductive
Analysis scale	Geographic aggregation level of indicators	US county, census enumeration unit, neighborhood, raster cell size
Indicator selection	Proxy variables for dimensions	Income, education, age, ethnicity, gender, occupation, disability
Measurement error	Accuracy and precision of the demographic data	Census undercounts, reported margin of error
Transformation	Indicator representation	Counts, proportions, density
Normalization	Standardization to common measurement units	Ordinal, linear scaling (min–max, maximum value), z-scores
Data reduction	Reduction of large correlated indicator set to a smaller set	Factor analysis
Factor retention	How many principal components to retain?	Scree plot, Kaiser criterion, parallel analysis
Weighting	Relative degree of indicator importance	Equal, expert, data envelopment analysis, budget allocation, analytic hierarchy process
Aggregation	Combination of normalized indicators to the final index	Additive, geometric, multi-criteria analysis

Table 2.3: Social vulnerability index construction stages and options (Tate, 2012)

2.2.3. Risk

In the most simplified terms risk is the likelihood of loss. The UN-ISDR defines risk as "the combination of the probability of an event and its negative consequences". For instance probability of occurrence of a certain natural hazard such as debris flow and potential damages in a certain period of time as result of interaction with exposed assets like buildings, bridges. There are many conceptual and mathematical expressions to analyze risk. However, the classical expression for calculating risk was proposed by Varnes (Van Westen et al., 2014) and it is presented as: Risk = H x E x V

Where H is hazard probability, E is element-at-risk, and V is the vulnerability of the exposed elements-at risk. They are people, infrastructure, economic activities etc.

For risk analysis and calculation of risk quantitatively elements-at-risk is replaced with the amount. The amount is characterized as no. of elements-at-risk (for instance no. of buildings), area, or economic value of the elements-at-risk. The temporal probability is related to the return period of the hazard, which means the average frequency which the events is expected to occur. The intensity is the severity of a hazard and indicates the spatially distributed effect of a hazard event (Van Westen et al., 2011). This can be for example, water depth and velocity for flooding, and impact pressure for debris flow. As explained in the previous section (2.2.2), vulnerability is related to suffer harm, due to lack of capacity to withstand hazard impact. The potential impact is linked with hazard intensity and type of element-at–risk. It is evaluated by so called vulnerability curves and measured at a scale of 1 (total damage) to 0 (no damage).

3. PLANNING PROCESS AND USE OF HAZARD AND RISK INFORMATION IN THE TARGET COUNTRIES

This chapter provides an overview of physical development planning processes of five target countries and use of hazard and risk information in their development planning. First, it provides an introduction of each country, including the hazard context, available hazard information, and then discusses about the planning process, frameworks and policy matters regarding physical planning and hazard considerations in their planning process.

The five target countries i.e., Dominica, Grenada, Saint Lucia, Saint Vincent & the Grenadines, and Belize (figure 3.1) are the member states (except Belize) of the Organization of Eastern Caribbean States (OESC), which was established in 1981, to promote co-operation, unity, and solidity among the member states. All these countries are also members of the Caribbean Disaster Emergency Management Agency (CDEMA), a regional disaster management body for disaster preparedness and response. Moreover, they are also recognized as Small Island Developing States (SIDS) due to typical challenges they are facing. These target countries are exposed to a number of hydro-metrological hazards such as hurricanes, storm surge, flooding and geological hazards such as volcanic eruptions, earthquake, and landslides. In the past, these countries have been severally affected by different natural hazards.

Figure 3.1: Location map of 5 target countries in the Caribbean

3.1. Mtheodology

The process of getting relevant information on their planning process and use of hazard and risk information in these countries can be divided into three parts. In the pre-field visit part, through a literature review, I get an overview of hazard profile of these countries and basic understanding on their

development planning works. Although, there was limited information available over internet or other literature on actual planning processes of these countries, because they are not being widely shared with everyone. I prepared a questionnaire (annexure 1) as guide for taking interviews of respective Heads of the physical planning divisions in each target countries. The second part is related to field visit to Grenada and later on Saint Vincent to attend planning workshop. Under the CHARIM project, ITC organized a regional workshop in Saint Vincent, where among others; the Heads of planning divisions of each target country was also invited. From Grenada, I went to Saint Vincent for a couple of days to attend parallel session with the chief planners from the 5 countries, which was focused on the presentation of the spatial planning process in these countries. In the one day session, each country representative presented their spatial planning process including information whether they are including hazard and risk information in their planning. My third part of collecting information on planning was related to interviewing chief planners/representative of the respective countries. During the workshop, I got opportunity for taking brief interviews with the respective chief planners/representatives. Through questionnaires and interviews I collected additional information on the current level of application of hazard and risk information in the spatial planning, the obstacles to do so, and the requirements for hazard and risk information as posed by the chief planners. I used my questionnaire as guide for interviewing them in a discussion manner instead of just filing the blanks in the form. I took interview of Chief Planner of Grenada in Grenada, where I had more time available for detailed discussion. From Belize, the Principal Planner, from Dominica Development Control Officer and from other countries respective planning heads attended the workshop and from whom I got additional information. Therefore, all information provided hereunder in this chapter is based on information from the literature review, workshop and interview with representatives of each country. Information on hazard maps and hazard profile is mostly collected through literature review.

In the following sections each country is discussed separately and in the results chapter an comparative analysis is presented in the form of SWOT analysis.

3.2. Grenada

Grenada, which comprises three small islands; Grenada, Carriacou and Petit Martinique, is located approximately at 12º 07'N, 61º 40' W in the windward side of the chain of islands in the Caribbean. Grenada is the largest among these islands, with an area of around 344 km2 and an estimated population of 110,000. Its climate is tropical with an annual rainfall of 3,500 millimetres on the windward mountain sides and less than 1,500 millimetres in the lowlands. It has two seasons wet (June to November) and dry (December to May). There is highest rainfall in the wet season and this is the period of most likely occurrence of hurricanes. Grenada is volcanic in origin and its landscape is scenic with hilly landform and forested hillsides. About 77 % land area has slopes exceeding 20 degrees. Mount St. Catherine (840 meters) is the highest point on the Island. Most of the population is settled along the coastal belt and specifically in the south-west side of the main Island. Inland, there is extensive agriculture and forested area.

Like many other Caribbean countries, Grenada is also prone to multiple natural hazards, such as hurricanes, storm surge, volcanic, flooding, landslides, and earthquake. Additionally, there is risk of Tsunami; as Kick-em-Jenny, an active volcano (erupted about 12 times since 1939) is located about 8 kilometres to the north of the island under the sea at about 180 meters depth. According to (Global Facility for Disaster Reduction and Recovery (GFDRR), 2010b), approximately 50.1 % of Grenada's population is vulnerable to two or more hazards. Historically, Grenada is affected by a number of hurricanes which caused huge economic damages to the country. For instance, Hurricane Janet in September 1955 killed 200 people and hugely impacted agriculture sector. Hurricane Ivan, in 2004, caused around US $ 800 million economic damages (GFDRR, 2010). It damaged about 90 % of country's housing stock, besides killing 37 persons (World Bank, 2004). Furthermore, hurricane Emily impacted the

southern part of the country in 2005, when the country was still recovering from impacts of Ivan. At times, the country is also affected by topical storms, leading to (flash) floods and landslides. As per EM-DAT (n.d.) database, about US $ 4.7 million economic damages were recorded in November 1975 flooding in the area. Heavy rainfall and subsequent flood events in 2011 and 2013 have also affected the country.

3.2.1. Physical planning in Grenada

In Grenada, physical development is taking place in accordance with the Physical Planning and Development Control Act 2002 (the Act) (Act, 2002). The document was approved by the parliament in September 2002 for the orderly use of land for the public interest. The specific objectives of the Act are:

- Ensure appropriate and sustainable use of all publically and privately owned land for the public interest
- Maintain and improve the quality of the physical environment
- Orderly sub-division of land and the provision of infrastructure and other services
- Maintain and improve the standard of building construction in order to secure human health and safety
- Protect and conserve the natural and cultural heritage

The Planning and Development Authority (PDA/Authority) is the responsible entity in the country for all physical development related activities. It is a statutory body established in accordance with Part II, Section 6 of the Act 2002. It comprises 11 members from government ministries/departments and private sector as suggested in the Act. The role of PDA is to ensure above stated objectives set out in the Act. Therefore, the task is to guide the future development of land through physical development planning initiatives at national, regional and local level and to ensure orderly and progressive development of land by introducing development planning policies. The Physical Planning Unit (PPU) is the administrative arm of the PDA and as per the Act, the Head of the unit is the Chief Executive Officer of the authority. The Head is responsible for carrying out the general policy of the Authority. The planning unit has broadly two functions; development planning (setting out the vision of how a region should be developed) and development control (through regulations, standards and other regulatory instruments guide development undertakings in the country)

The Act, makes the provision of the preparation of physical plan for the whole country. Plans may also be prepared for specific regions or smaller parts of the country i.e. regional and local plans. The plan should set-out prescriptions for the use of land. The plan should allocate land for conservation, use, and development for agriculture, residential, industrial, commercial, tourism, or other specific purposes identified through a consultative process. The plan should also make provision for the development of infrastructure, public buildings, open spaces and other public sector investment works needed for the steady economic growth of the country. The plan must be prepared through an integrated planning process and ensuring its publicity in the public in the course of its preparation. The plan must be approved by the parliament for its enforcement. And then the plan remains in effect until rescinded by the concerned Minister. Nonetheless, it is important that the physical plan undergoes a review process after 5 years of its approval for any possible changes and improvements. Once the plan is approved, it is considered to be principal document to be consulted, while making any development decisions for the area the physical plan is concerned. National Physical Development Plan (NPDP) is prepared for the entire country for a period of 2003-2021. The purpose of this plan is to provide an integrated and coherent framework to promote and guide development activity in Grenada in a sustainable manner. Emerging out of the national physical development plan, few local area development plans have also been produced, importantly, Greater Grenville development plan.

As indicated, PDA is the only body responsible to determine applications submitted to the physical planning unit, seeking approval for any kind of physical development work in the country. The Authority reviews applications and makes decisions. The planning Act, clearly states that no person is allowed to

start any development work without prior approval of the Authority. Under Part IV, Section 19(1), it is stated that "Notwithstanding any other law to the contrary, but subject to Section 21, no person may commence or carry out the development of any land in Grenada without the prior written permission of the Authority". Therefore, it is mandatory for all persons to get written approval of the PDA for commencing any kind of physical development work in a particular area. The nature and type of development work for which written approval is required has been defined in the Act. However, there are minor development works for which no permission is needed and could be done without the consultation of Authority.

An application for the permission to initiate development work must be submitted to the PDA through physical planning unit. The application is submitted through a prescribed form called "Application for Permission to Develop Land" together with other specified documentation such as set of drawings (e.g. site plan, floor & roof plans, foundation, elevation, structural drawings etc), location map etc. Moreover, depending on the nature of the land development, the authority may ask additional documentation and set of information such as topographic surveys, Environmental Impact Assessment (EIA) etc. Once an application is formally submitted to the planning unit, it undergoes a review process. The respective technical staff at the PPU and other concerned government departments examines different aspects of the development. For example, structural engineer checks details related to structure of the proposed development, for instance, foundation, beams, construction material, retaining walls, alteration topography, roof etc. The Development Control Officer (DCO) specifically visits the proposed site area for evaluating and completing prescribed observation form. The DCO then reviews different drawings such as surveyors' plan, location plan, site plan, elevation, architectural details, electrical and plumbing layouts etc. submitted by the applicant. Finally, the Public Health Officer (PHO) examines issues related to public health; including solid and liquid waste disposal, on-site drainage, ventilation of toilets and kitchen etc. The assessment findings are recorded in the prescribed form and attached with the application.

Once an application undergoes through technical review stage, it is then forwarded to the Authority for its review and determination of application. As per law (i.e. the Act), all land and development related applications have to be approved by this Authority. The members of the Authority meet every month or arrange special meetings to review applications. In the meeting the Authority decides whether an application is approved (fully approved), conditionally approved (approved with some conditions to be met), differed, or refusal. Once an application has been reviewed and decided upon, the Authority writes to the applicant and formally inform about the decision. As per law, the authority is bound to make decisions within 90 days after formally submission of an application for the land development. Once the land development plan has been approved with or without conditions based on the submitted documentations, the applicant has to strictly follow that plan. Part IV, Article 31(1) of the Act, states "whenever plans have been submitted to the Authority on an application for permission to develop land and such permission has been granted, the development must be carried out in accordance with the plans and any conditions imposed by the Authority." Failure to compliance may result in enforcement actions. Nonetheless, according to the law, the Head of the PPU may approve minor variations in the plan and at some point, if developer finds it difficult to implement the plan, then they may formally request for changes in the plan. However, the Authority may or may not approve such amendments. According to the law, any disputes between developer and Authority relating to the land development will be settled through Physical Planning Appeal Tribunal.

3.2.2. Disaster risk management in Grenada

Grenada's vulnerability is particularly high due to its size, fragile economy, growing poverty, and limited capacity in addressing and copping the impacts of any major hazard event. The government of Grenada has established National Disaster Management Agency (NaDMA) with a primary responsibility of coordinating all disaster related activities in the country. There is powerful National Emergency Advisory

Council (NEAC), headed by the Prime Minister, responsible for giving direction and control and the development of policies. At the local level, there are 17 District Disaster Management Committees (DDMC) with the primary responsibility of disaster preparedness and response (NaDMA, 2014). NaDMA oversees and coordinates the operations of DDMCs.

Disaster risk management (DRM) in Grenada is a reactive and committee driven program with no specific legislation. The national policy does not mandate DRM as a development objective (GFDRR, 2010). In 2003, the Caribbean Development Bank (CDB) and the Caribbean Disaster Emergency Management Agency (CDEMA) produced the National Hazard Mitigation Policy for Grenada. It was emphasized to mainstream disaster risk reduction into national development planning and decision making as a crucial strategy towards vulnerability reduction and stressed upon more proactive approaches to risk reduction (Linus, 2003). In 2006, a national hazard mitigation plan was developed through collaborative efforts of CDEMA and CDB under Caribbean Hazard Mitigation Capacity Building Programme (CHAMP) and Disaster Mitigation Facility for the Caribbean (DMFC) respectively (JECO Caribbean Inc., 2006). In 2011, NaDMA revised its National Disaster Management Plan (NDMP). However, none of above document has any legal status. They are just draft documents waiting for their formal approval by the Assembly.

3.2.3. Status of hazard and risk information in Grenada

In Grenada there is no specific organization that is responsible to undertake hazard assessments and produce hazard and risk information. However, there are many government agencies that has GIS setup such as physical planning unit, land use division etc that has been involved in many hazard mapping exercises and received basic knowledge and trainings through external consultants under various hazard mitigation and response projects. It is difficult for them to undertake any risk assessment exercise independently without external technical support. There are a number of hazard maps produced for different hazards by the external consultants under various sponsored projects. Most of these maps are produced using qualitative mapping methods. These maps either cover entire country or specific part susceptible to a specific hazard. Following (table 3.1) list gives an overview of available hazard maps in the country. This list provides information on hazard for which map was produced, scale, and respective consultant who produced these maps. It is rather uncertain whether all these maps are still exist and planning department has access to some of these maps, because there is no any centralized system in the country for storage and maintenance of geo-spatial data. It is also important to note that it is not necessary that these maps were produced in collaboration of the planning unit. They may have been produced under the funding that is concerned with other government department. However, these government departments usually share such with sister organizations.

3.2.4. Inclusion of disaster risk management in physical planning policies and development work

Although, there is no specific law which makes the provision of mandatory use of hazard and risk information in the physical planning in Grenada, but, there is provision in the planning process itself that require conducting such studies for making informed decisions. However, the issue arises who will produce and provide such information for planning purpose and other uses. As mentioned earlier, there is no specific organization in the country that has mandate to produce such information and planning unit has limited capacity to work independently on such studies. Therefore, the planning unit has to rely on maps produced by external consultants under specific projects and these products may not necessarily serve their purpose completely and this leads to often exclusion of hazard consideration in the development work. However, the physical planning unit has access to some of these maps listed above for to be utilized for the planning purposes. The planning unit is using rudimentary these maps particularly Island-wide landslide and flood maps to super-impose these maps with the parcels maps for identifying parcels that are at potential risk of flooding or landslides. Basically, they use simple GIS overlay techniques to analyze whether a person's property could be affected by flooding or landslides. In addition, hazard

maps have also been used for local area plan development of Greater Grenville area. Additional information on use of hazard information in this plan is provided in a separate section below.

Type	Purpose/ Description	Coverage	Scale	Date produced	Author/Consultant	Source of this information
Multiple hazards	To identify areas prone to natural hazards and recommend mitigation measures	Towns of St. George's, Gouyave, Victoria Sauteurs, Grenville, Tivoli, St. Paul, St. David Parish,	1:25, 000	June 1988	Vivian Bacarreza	(CDERA, 2003d)
Grenada erosion hazard map (draft)	100 year return period hurricane event. Island-wide coastal erosion hazard map	Island wide	1:25, 000	October 2006	JECO Caribbean Inc	(JECO Caribbean Inc., 2006)
Grand Anse erosion hazard map (draft)	100 year return period hurricane event.	Grand Anse	1:10, 000	October 2006	JECO Caribbean Inc	(JECO Caribbean Inc., 2006)
Landslide hazard map	Prepared as part of national hazard mitigation plan	Island-wide (not included adjacent Islands)	1:25, 000	October 2006	JECO Caribbean Inc	(JECO Caribbean Inc., 2006)
Landslide hazard map	Prepared as part of national hazard mitigation plan	Florida	1:10, 000	October 2006	JECO Caribbean Inc	(JECO Caribbean Inc., 2006)
Flood hazard map	Prepared as part of national hazard mitigation plan	Island-wide (not included adjacent Islands)	1:25, 000	October 2006	JECO Caribbean Inc	(JECO Caribbean Inc., 2006)
Flood hazard map	Prepared as part of national hazard mitigation plan	St Jhon's river		October 2006	JECO Caribbean Inc	(JECO Caribbean Inc., 2006)
Integrated Volcanic Hazard Zones– Based on Eruption of Mt. St. Catherine	Prepared as part of national hazard mitigation plan	Mt. St. Catherine area	1:25, 000	October 2006	JECO Caribbean Inc	(JECO Caribbean Inc., 2006)
Kick em Jenny volcanic hazard zones		Kick em Jenny area	1:10,000			
National level Flood map	Under the CHARIM project	Grenada (main Island)		February 2015	ITC	ITC
Local level flood maps	Under the CHARIM project and part of an MSc thesis	St Jhon's and Gouyava river catchments		February 2015	Aris	ITC

Table 3.1: List of different hazard maps produced for Grenada

Moreover, for the land development control, there are specific setback regulations concerning development in the coastal zone. These regulations are to ensure human safety and to protect development from storm surges, tsunami and other related coastal hazards, besides protecting sensitive coastal environment. It is stated in the Land Development Regulations section 17 that "the Authority shall not authorize any development closer than 165 feet (50 m) from the high water mark or on lands less than 10 feet (3 m) above mean sea level, whichever is applicable."

The National Physical Development Plan, which is an approved framework for physical development for the country, illustrates clear policy on risk management and emphasizes on preventive and mitigative measures to protect population and development work from natural hazards and the impacts of climate change (PPU, 2003). The policy states:

- Institute appropriate disaster mitigation and preparedness measures.
- Integrate vulnerability reduction and risk avoidance measures of climate change adaptation into the development planning process

The subsequent policy implementation activities are defined in NPDP, which are included here:

1. Assessment of the nature and threat of current hazards and formulate appropriate hazard maps to guide development.
2. Formulate and enforce land use requirements and building construction standards for disaster mitigation.
3. Institute disaster preparedness measures and provisions for emergency management.
4. Formulate vulnerability reduction and risk avoidance measures and the integration of such measures into the planning process.
5. Integrate vulnerability and risk avoidance measures into the planning process

The National Strategic Development Plan (NSDP), which was prepared by Agency for Reconstruction and Development (ARD) in 2007, is an approved document by the government, recognizes the significance of environmental and physical development considerations for the national development. The NSDP suggested for the full implementation of NPDP (and thereby points mentioned above) and mainstreaming disaster risk reduction and integration of environmental issues in the planning and development interventions.

3.2.5. Inclusion of hazard and risk information in the development planning: Case study of greater Grenville local area plan

The greater Grenville local area plan was prepared as consequent of proposals emerged herein the National Physical Development Plan. The town of Grenville, which is the second main town in Grenada, is located on the east coast within the Saint Andrew parish. This town needed regeneration measures to enhance its status as the regional hub of services for the east cost of the main Island. A development plan for the town was prepared keeping in view its regional significance. There were 7 goals and one of the main goals was enhance protection of the environment, this includes; storm water management and drainage, hazard mitigation (landslides and flooding), water and sewer services, coastal erosion, wildlife, environmentally sensitive areas and national heritage, and litter abatement and cleanliness. An integrated planning process was adopted following guidelines outlined in the Act. The greater Grenville local area planning process focused on short-term and long term development opportunities for implementation with an overall strategy of identifying urgent needs and concentrating on solutions that can be realistically implemented.

The Grenville area is vulnerable to flooding, landslides, and storm surge. The area has been effected number of times due to flooding. November 2011, flooding badly affected the town and surrounding areas. A study was conducted in 2007 to identify flooding problems in Grenville area. There were major issues related to existing storm water management system; including maintenance, disrepair, and capacity etc. The drainage analysis study identified key findings and observations related to flooding in the area and suggested several remedial measures including adoption of appropriate storm water management

technologies and planning strategies. The study also indicated that the town of Grenville is under threat from two sides: from the rising waters and storm surge and cumulative effects of run-off from agriculture and residential development upstream (PPU, 2007). Much of the downtown area of Grenville is less than 1.5 meters above sea level and according to a study on Grenada's coastal vulnerability (Moore & Charles, 2002), indicates that there will be significant damages on the north-east area including Grenville due to sea level rise and effects of storm surge. Based on different combined scenarios of storm surge and sea level rise (up to 2100), it is concluded that there will be a significant impact on homes, business, and infrastructure. The majority of the beaches will be disappeared.

The main issues related to hazard mitigation and suggested remedial approaches for the greater Grenville local area plan (PPU, 2007) are highlighted below:

- Protection of environmental significance and biodiversity
- Protection against erosion: Certain coastal regions in the Plan Area have experienced erosion. Some locations the erosion width is more than 70 meters. These are the sites of significant sand mining. Enforcement against illegal sand mining must be in place to avoid coastal erosion. Additional measure includes restoring mangroves for soil stability. In other erosion prone areas commercial development along the water should adhere to increased setbacks and have suitable foundation to raise structures to an acceptable level of protection from storm surge.
- Protection against landslides: Parts of Plan Area are susceptible to landslides in these areas no further development should be allowed in medium to high hazard areas. Restriction on any further development in these areas would limit any potential loss. However, updating of data and monitoring of the conditions is important. These measures should be complimented with public awareness and education on landslides issues.
- Protection against inland flooding: Parts of Plan Area are susceptible to flooding. Moreover, the projected storm surge data for 2020 levels indicates Grenville town and other areas in the Plan Area are subject to storm surge flooding. Development restrictions on areas identified as medium to high risk of flooding would limit any potential damage on these lands. Environmental initiatives, public awareness and education of local people and constant monitoring of these areas would ultimately reduce property damages.
- Appropriate measures for storm water management in the Plan Area:
    - Minimize storm water run-off from new and existing development by adopting storm water management approaches to accommodate increased run-off. This may include in combination of on-site storm water management (e.g. roof top, parking lot storage) remediation, conveyance controls, and detention/retention facilities.
    - Review development approval procedures – review of approval procedures for development at the subdivision and development permit stage; this may involve existing by-laws, regulations, and storm water management design guidelines.
    - Development of watershed management plan – eliminate increase in natural run-off for severe storm events e.g. 25 to 100 years due to new development, direct future development away from flood prone areas.
    - Minimizing soil erosion, sedimentation and mass wasting due to soil failure
    - Encouraging the natural recharge of water table without jeopardizing soil stability
    - Adopting a zero run-off concept – there should be no net increase in storm water discharge from a site due to development
    - Reviewing and adopting storm water management control systems
- Development limitation map: A development limitation map (figure 3.2) was produced by integrating all above mentioned hazards (flood, landslides and erosion) together with other land uses and included in the Grenville plan. This map is classified into 5 zones; namely Natural lands, Forest, Conservation area, Arable land, and Natural hazard risk. The natural lands, land use

include unused and marginal vegetated lands Development activities allowed close to the town area

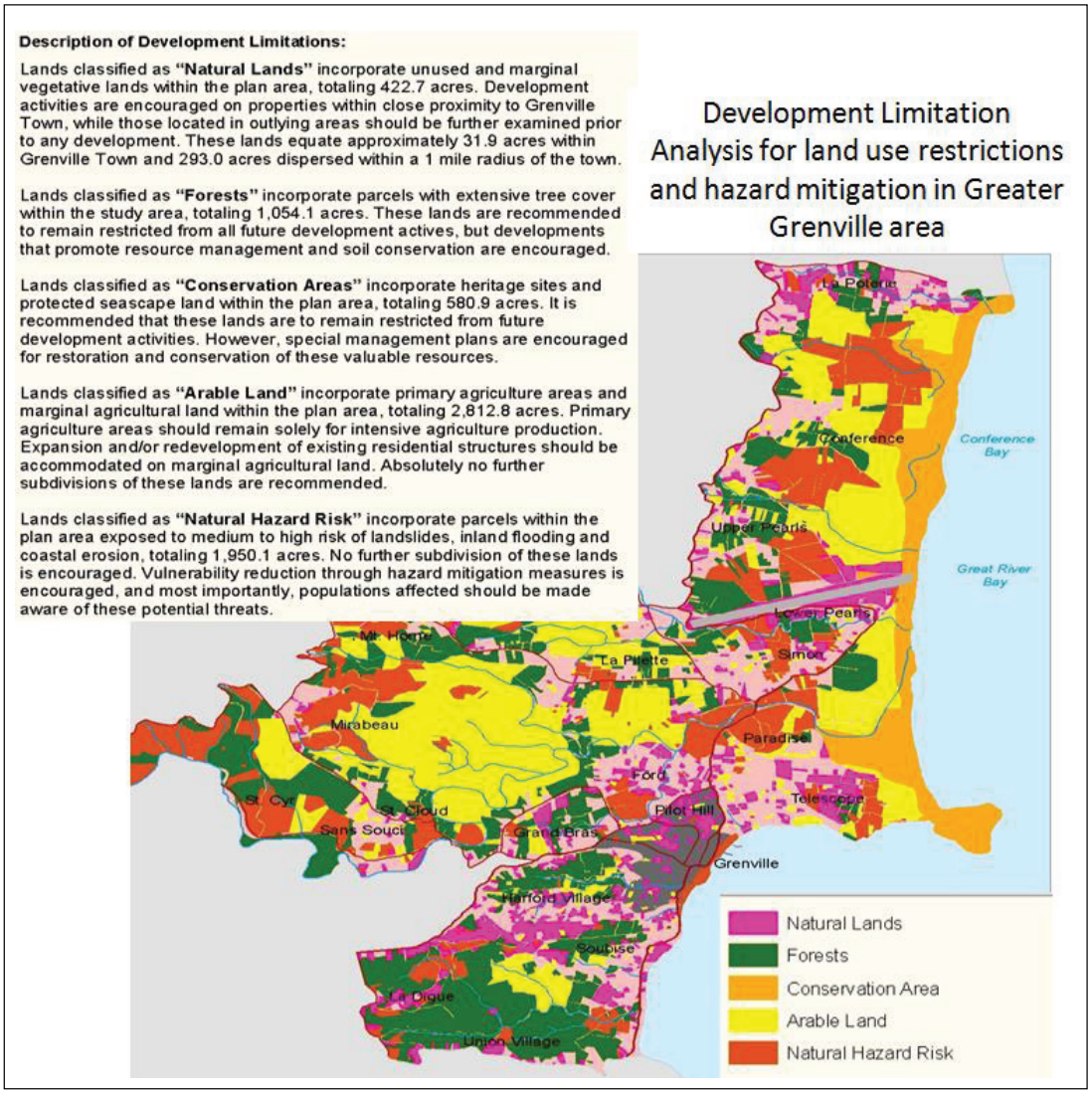

Figure 3.2: Development limitation map produced for greater Grenville area, East of Grenada (PPU Grenada, 2007)

The forested land use is not allowed for development except those activities which promote resource management and soil conservation. The conservation areas are heritage sites and protected seascape land. No development is recommended here except restoration and conservation of these resources. Arable land is the primary agriculture areas. The land is dedicated for agriculture purposes and no sub-division is permitted for any other development work. Finally, the natural hazard risk areas are identified as possessing medium to high susceptible to landslides, inland flooding, and coastal erosion. No development is encouraged other than hazard mitigation works. Public education and awareness is considered to be important for its implementation.

- Zoning: Establishment of system of zoning. A zoning permit will be required to ensure compliance with the land uses and standards contained within individual zones. However, this concept is recommended as long term goal due to challenges related to regulations and land tenure ownership.

3.3. Belize

Belize is the only English speaking country in the central America, located between 15° 52' and 18° 30' North Latitude and 87° 28' and 89° 13' West Longitude. It is bordered by Mexico in the north & west, Guatemala in the west & south, and the Caribbean sea in the east. Belize occupies a land area of about 22,963 km², including approximately 1,000 small islands known as Cayes (DoE Blize, 2014). Its population is approximately 340,000 and according to 2010 census report 54.9 % population living in the rural areas (Meerman, Mcgill, & Cayetano, 2011). Its climate is subtropical and June to November is considered to be wet season. Rainfall varies from 1500 to 3800 millimetre per year. According to GFDRR report (2010), Belize is the 61st highest exposed country to relative mortality risk from hazards and 8th ranked country for climate risk in the world. The country is hit by a number of hurricanes in the past, importantly, hurricane Keith (2000) and hurricane Iris (2001) and caused the damages reaching 45 % and 25 % of the GDP respectively. Hurricane Hattie (1916) caused the financial cost of US$ 413 million to the country (GFDRR, 2010). Tropical Storm Chantel (2001), caused BZD$ 31437617 in damages (CDB, 2006). Many settlements of Belize are at flood risk; both from inland (along streams and rivers) and coastal (caused by storm surge).

3.3.1. The physical planning process in Belize

In Belize, Housing and Town Planning Act (Act 1947) was enacted in 1947 to regulate use and development of land. Under this Act, Central Housing and Planning Authority (Central Authority) was established to administer the Act. It was main piece of legislation for the planning in the country, which included both development planning and building control. However, in 2003, Belize Building Act, 2003 (Act 2003), was passed, which repealed building functions within Act 1947 and established Central Building Authority to administer building Act 2003. Consequent, the Act 1947, left with only planning functions and the Central Authority, which was established to implement Act 1947, is not physically existed anymore. In fact, there is no development planning (forward planning) is currently taking place as a whole for Belize due to absence of the Central Authority. All planning initiatives are usually done under the externally funded projects coordinated by the Lands and Surveys department. Main towns in the country are being administered through respective municipal plans. However, for development at the lot level, Land Utilization Act has been enforced since 1981. And in accordance with this Act, an 8 member, Land Subdivision and Utilization Authority (the Authority) is setup to review sub-division applications. As per land utilization Act, no person is allowed to do any sub-division without the provisional approval of the concerned Minister for lands. The department of Lands and Surveys through its physical planning section receives and vets applications for land subdivision/consolidation. Once an application is vetted, it is then submitted to the Authority for its recommendations for the Minister. Provisional and final approval comes from the concerned Minister subject to the recommendations of the Authority. Sub-division guidelines are prepared as policy guide for developers, however; they are not yet approved in the form of regulations.

3.3.2. Status of hazard and risk information in Belize

In Belize, no government agency is producing hazard and risk information, however; according to the law (Governement of Belize, 2000) i.e. disaster preparedness and response Act, 2000, under section, Part II 4(2)(f), the Head of the National Emergency Management Organization (NEMO) is responsible for providing hazard maps, it states "prepare and review disaster risk assessment maps of Belize". However, they are not producing any such information for whatever reasons. Following table (3.2) provides an overview of different hazard maps produced for Belize. It is not certain that who owns all these maps and whether land use planning department has access to all these products.

Type	Purpose/ Description	Coverage Area	Scale	Date produced	Author/Consultant	Source of information
Coastal flooding	Storm hazard assessment for St Lucia and Belize. combined storm surge and wave hazards	Caye Caulker, and Ambergris Caye	1:25,000	Unknown	Kinetic Analysis Corporation	(Kinetic Analysis Corporation, n.d.)
Wind hazard	Storm hazard assessment for St Lucia and Belize	Caye Caulker, and Ambergris Caye	1:25,000	Unknown	Kinetic Analysis Corporation	
Coastal flooding	Storm hazard assessment for St Lucia and Belize. combined storm surge and wave hazards	San Pedro	1:10,000	Unknown	Kinetic Analysis Corporation	
Wind hazard	Storm hazard assessment for St Lucia and Belize	San Pedro	1:10,000	Unknown	Kinetic Analysis Corporation	
Belize flood risk map	Unknown	Entire country	Unknown	1992	Kings et al	Principal Planner, Beliz
Belize wildfire risk map		Entire country	Unknown	2007	Jan Meerman	http://biological-diversity.info/fire.htm
National scale flood hazard map	Under the World Bank CHARIM project	Entire country		February 2015	SSBN (Bristol University, UK)	ITC

Table 3.2: List of different hazard maps prepared for Belize

3.3.3. Inclusion of disaster risk management in physical planning policies and development work in Belize

In Belize, as such no forward development is taking place and main activity of physical planning section is land sub-division. In the process of sub-division hazard considerations are included in the form of setbacks and buffers. For example, development is not allowed within 66 feet from the high water mark, river, creek or other main water body. Furthermore, a buffer in addition to 66 feet reserve, for an area that is known to have high risk of flooding as way to protect loss of life and damage to property. For large sub-divisions, environmental impact assessment is mandatory and for certain projects applicants have to prepare flood evacuation plans and get clear from NEMO.

Recently, the Belize municipal government developed a Master plan for Belize city. In this plan, issue of flooding and drainage is specifically addressed, since Belize city is located at the mouth of Belize river and at the waterfront of the Caribbean Sea. Therefore, it is highly susceptible to both riverine flooding as well as storm surge. Following strategies were proposed for flood risk mitigation and control in the city (PADECO, 2011)

1. Prioritize spatial planning to avoid placing new development in flood risk areas
2. Minimize the probability and severity of flood (control)
3. Minimize the potential consequences of a flood on occupants and properties (mitigation)

Several mitigative and control measures were then defined under each strategy and integrated in the Master plan for flood risk management in the city.
The government of Belize recently produced national land-use policy for land resource development in the country. The policy encompasses many important land development issues including land use planning in relation to flood risk and suggested several strategies for flood risk management (Meerman et al., 2011). The strategies include among other; development restrictions in high flood risk areas, use of flood plains only for agricultural activities provided that they don't increase further flooding risk, preparation of flood hazard maps for both inland and coastal areas and making development planning decisions based on such information, protection of wetlands, and discouraging permanent infrastructure development in floodplains, reforestation on hillsides, potential landslide areas, and other areas which may cause high run-off etc. These strategies are good; however, there is no ownership of land-use policy (document) among government departments for its implementation and thereby flood risk management.
For Belize, national hazard mitigation policy document and national hazard mitigation plan are prepared. Both documents stresses upon the need for integration of hazard risk reduction in to national development process and sectoral planning. However, these documents are not formally approved by the parliament for their enforcement.

3.4. Saint Lucia

Saint Lucia is a windward and volcanic island, located in the eastern Caribbean Sea at 13° 53' 0" N, 60° 58' 0" W. It covers a land area of about 616 Km^2 and an estimated population of 169,000. Its climate is tropical, and is warm & humid throughout the year. Saint Lucia, like other eastern Caribbean countries, is vulnerable to a number of natural hazards, including landslides, flooding, hurricanes, storm surge, earthquake, drought, and volcanic activity. The effects of these phenomena are exacerbated by anthropogenic activities, e.g., deforestation, poor building practices, indiscriminate garbage disposal, and squatting (Heholt, 2013). Saint Lucia experienced a number of storm surges and hurricanes in recent past, which severally affected country's economic growth. For instance, losses due to tropical storm Debby in 1994 exceeded EC $230 million, tropical wave in 1996 led to damages of EC $12 million, estimates from tropical storm Lili in 2002 are EC $54 million, and Hurricane Dean in August 2007 caused damages and losses of about EC $50.7 million (2.5% of GDP) (Wright, Cynthia, & Maria, 2013). The hurricane Tomas in 2010 was most severe one that resulted floods and landslides across the country. The total cost of the damage and losses to the different sectors, from Tomas amounted to EC $907.7 million (US$336.2 million), which represents 43.4% of the county's GDP (ECLAC, 2008). Saint Lucia, due to its rugged topography and steep slopes, prone to landslides. There were widespread landslides following the passage of hurricane Tomes in October 2010. Christmas Eve flooding in December 2013, due to heavy rainfall and storm led heavy damage to infrastructure, causing an estimated loss of $242.6 million ($89.2 million) (Wright et al., 2013)

3.4.1. The physical planning process in Saint Lucia

The current legislation that is enforced in St Lucia is Physical Planning and Development Act of 2001 (Act, 2001), and amendments of 2005. The original Act or parent Act is called the Town and Country Planning Ordinance of 1961. That Act was repealed by the in-term Land Development and Control Act of 1971. Within the physical planning section, there is Development Control Authority (DCA). This Authority is responsible for granting permissions for land development in the country. DCA is managed by a board, called Development Control Board (DCB). There are 13 members of DCB from various government departments appointed by the Cabinet. The physical planning section has responsibility of preparing land use planning. The planning Act, under Part II (10), makes the provision of preparing physical plan for the whole country or any specified part (regional, local level) and guides how such a plan should be developed. The development plan may allocate land for conservation, industrial, commercial,

agriculture, residential, recreational, touristic, institutional, or any other purposes. Broadly, the development plan provides a strategic direction for physical development in the country or part of the country.

The Act, gives an indication of what should be the contents of a development plan. The plan should include maps, descriptive information, profiles, and other related details necessary to illustrate the proposal. Hazards and risks and various environmental protections have to be incorporated in the plan. In this regard, various researches may be carried out or collected available information from other agencies such as National Emergency Management Office (NEMO), Metrological Department etc to get the sufficient information to feed the plan. The Head of the planning section is authorized to submit draft plan to the concerned Minister for review. The Minister may approve the plan with or without modifications or may reject it. Once approved by the Minister, it is then submitted to the House of Assembly for their approval. When a Physical Plan is approved by the House, it becomes legal document and remains in effect until it is rescinded by the concerned Minister. The plan may be revised any time needed or at least after 5 years of its formal approval. An approved development plan is then given principal consideration in approving applications for development. For Saint Lucia, no such plan (Development plan) for the country is prepared as yet and local plans which are prepared for some parts of the Island not received statutory status for enforcement.

Like other target countries, development approval is needed from the DCA, prior to commencement of any land development work in the Island. The Act, Part III 16(1) says "Subject to this Act, a person shall not commence or carry out the development of any land in Saint Lucia without the prior written permission of the head of the Physical Planning and Development Division". An application for the permission to develop land has to be made on the prescribed application form accompanied by necessary maps, drawings, and related documentation for review. Depending on the nature of the proposed development work and likely negative impact on the environment, an EIA report has to be submitted in order to evaluate the application and make decision for the client. The EIA has to be undertaken on agreed terms of reference and by a qualified professional. Permission for land development may be granted unconditionally, with specific conditions or application may be rejected at all. The decision on application has to be made within 90 days of formal submission of complete application. In certain circumstances, application may also be forwarded to the Cabinet for their review. The client may appeal to the Appeal Tribunal against any decision of the DCA.

3.4.2. Status of hazard and risk information in Saint Lucia

There is no any specific organization in the country to produce hazard and risk information. Usually, this has been done on project basis with the external support. Due to limited technical capacity in-house the planning department has to mostly rely on maps being produced under various externally funded projects. In many such cases, hazard information produced is too general, not specific and detailed enough to be included with certain level of certainty in the development planning. Following table (3.3) provides an overview of different hazard maps available for St. Lucia. There are a number of hazard maps produced mainly for landslides and flooding at various scales. Some large scale maps are also available for the capital city Castries, where flood issue is main problem

Type	Purpose/ Description	Coverage	Scale	Date produced	Author/Consultant	Source of this information
landslide risk	Mapping landslide	Entire country	1:50,000	Nov 1985	Jerome V.deGraff	(CDERA, 2003a)
landslide risk	Updating of 1985 landslide map	Entire country	1:75,000	1992	Cassandra Rogers	(CDERA, 2003a)
Debris risk	Mapping debris flows and	Entire	1:75,000	1992	Cassandra	(CDERA,

severity	slides	country			Rogers	2003a)
Volcanic	Mapping of areas to be affected by volcanic hazards	Entire country	1:25,000	June 2002	Seismic research Unit	(CDERA, 2003a)
Landslide susceptibility map	For the development of hazard mitigation plan for Saint Lucia	Entire country	1:50,000	2006	CIPA	
Landslide susceptibility map	For the development of hazard mitigation plan for Saint Lucia	Castries	1:10,000	October 2006	JECO Caribbean Inc	Saint Lucia and Grenada LandslideHazardMappingFinal_Report_2-28-06
Coastal flooding	Storm hazard assessment for St Lucia and Belize. combined storm surge and wave hazards	Entire Island	1:25,000	Unknown	Kinetic Analysis Corporation	(Kinetic Analysis Corporation, n.d.)
Wind hazard	Storm hazard assessment for St Lucia and Belize	Entire Island	1:25,000	Unknown	Kinetic Analysis Corporation	
Coastal flooding	Storm hazard assessment for St Lucia and Belize. combined storm surge and wave hazards	Castries	1:10,000	Unknown	Kinetic Analysis Corporation	
Wind hazard	Storm hazard assessment for St Lucia and Belize	Castries	1:10,000	Unknown	Kinetic Analysis Corporation	
Landslide inventory map	Christmas Eve storm in Saint Lucia	Entire Island		Unknown	Daniel B. Wright, Cynthia Linero Molina, Maria Carolina Rogelis	(Wright et al., 2013)
Flood hazard map	Development of flood hazard maps for Grenada and St. Lucia	Entire Island	1:25,000	February 2006	Vincent Cooper, Jacob Opadeyi	(Cooper & Opadeyi, 2006b)
Detailed flood hazard map	Development of flood hazard maps for Grenada and St. Lucia	Castries	1:25,000	February 2006	Vincent Cooper, Jacob Opadeyi	(Cooper & Opadeyi, 2006b)
Landslide susceptibility map	Landslide susceptibility and risk in Saint Lucia	Entire Island	unknown	2012	Quinn	(Quinn, 2012)
Flood and landslide maps	Various large scale landslide and flood maps	For different parts of Castries city	unknown	2012	ICF GHK, Kings college London, Grupo Laera	(ICF GHK, 2012)
Flood hazard map	Under the World Bank CHARIM project	Entire country	unknown	February 2015	ITC	ITC

Table 3.3: List of various hazard maps produced for Saint Lucia

3.4.3. Inclusion of disaster risk management in physical planning policies and development work in St. Lucia

In the planning Act, there is no specific mentioning of use of hazard information for planning purposes. However, in the course of preparation of development plan for the country or specific region, the planning unit can seek advice from concerned departments on natural hazards such as National Emergency Management Office (NEMO), Metrological Office, and Water Resource Management Agency. The planning Act makes the provision of undertaking EIA for specific projects, which may likely effect the environment. In the course of EIA study, it is possibility of inclusion of considerations of specific hazards. Ministry of physical development, environment, and housing, of government of St. Lucia produced land use policy in 2007. Although it is still in draft and currently under revision for its endorsement by the Assembly, speaks about minimizing potential damages and losses from the impacts of hazards and disasters and further recommended to implement related national policies and plans including; national climate change policy and adaption plan, coastal zone management policy, and national hazard mitigation plan. (Ministry of physical development, 2007)

The Development Control Authority (DCA) of St Lucia has specified setbacks (figure 3.3) requirements for coastal area development. For example, no contraction will be permitted within 25 to 100 feet from high water mark (HWM) depending on the slope of the area, nature of the sub-strata, and prevailing oceanographic conditions (Norville, 2003).

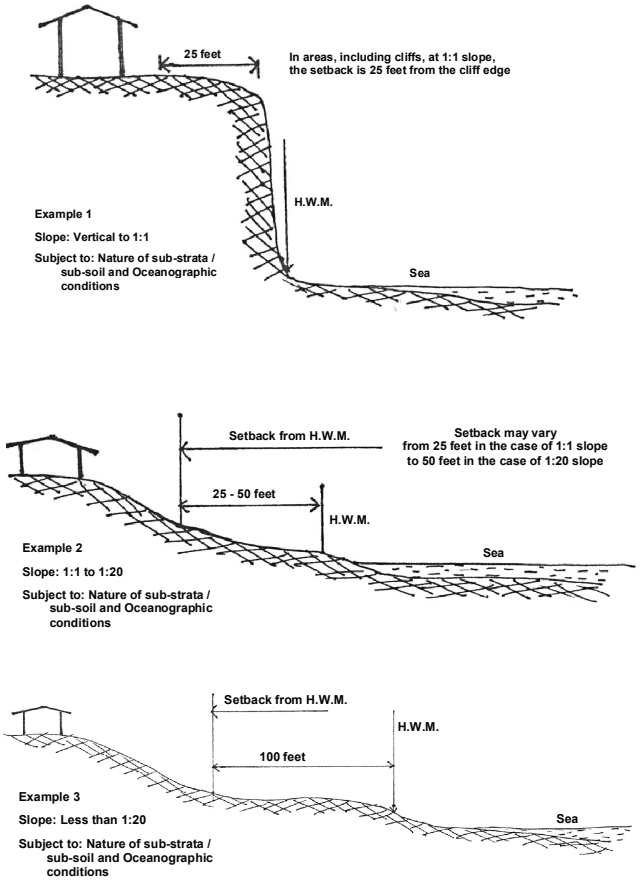

Figure 3.3: Setbacks requirements in coastal areas (Norville, 2003)

3.5. Saint Vincent and the Grenadines

Saint Vincent and the Grenadines (SVG) is comprised of 32 islands, islets, and cays, the largest being St. Vincent (GFDRR, 2010c). The country covers a total land area of about 384 km^2 and has total population of about 111,000 (SVG gov website). The Island's topography is mountainous with average temperature of 27° C, and an annual rainfall of 2100 mm (Government of SVG, n.d.). The islands are part of the Lesser Antilles Island arc, a region known for its active volcanism caused by subduction of the South American Plate and/or North American beneath the Caribbean Plate (Robertson, 2003). The population of SVG and structures are vulnerable to many hazards, particularly from hurricanes, tropical storms, and geological hazards such as landslides and volcanic activity. Most construction has taken place on steep slopes, often exceeding 45 degrees, thus prone to land sliding during prolong rainfall and impacts of heavy winds (GFDRR, 2010c). Since 1900, St. Vincent has been hit by 8 named storms; most notable are: Hurricane Allen (1980) and Hurricane Lenny (1999) (GFDRR, 2010c). Hurricane Tomas in 2010, caused an estimated EC$65 million damage to the country's agriculture sector (Lumbroso, Boyce, Bast, & Walmsley, 2011). The country is also at the risk of La Soufriere volcano located on the north of St. Vincent, which may also trigger shallow earthquakes. The volcano has already erupted 5 times in the recorded history (1712-1979) (GFDRR, 2010c). The country is also at the risk of Tsunami, which may triggered as a result of an eruption by an undersea active volcano, called Kick-em-Jenny, located close to Grenada in the north. According to a GFDRR report (2010c), a significant proportion (41.6%) of the population is exposed to risk of mortality from 2 or more hazards and there is a large economic risk (41.6% of GDP) from two or more hazards.

3.5.1. The physical planning process in SVG

Physical planning in SVG is taking place in accordance with the Town and Country Planning Act, 1992, (Act, 1992), and subsequent amendments in the Act. A Physical Planning and Development Board (PPDB) of 14 members has been established in accordance with the act. These members are selected from various government ministries/departments, and outside public offices. The Cabinet selects Chairman and Deputy Chairman from the board members. The main functions of PPDB, as outlined in the Act 1992 are;

- Institute study of town and country development;
- Ensure the orderly and progressive development of land and the proper planning of the country and town areas;
- Prepare a national, regional, and local development plans and keep under review;
- Control development according to the provisions of the Act.

The Physical Planning Unit (PPU) is responsible for the implementation of the Act and board directives. In this arrangement, the Head of the PPU is Secretary to the board and Chief Executive Officer (CEO). In this respect, the planning unit is responsible for development planning (figure 3.4) and development control as regulatory body.

In the course of preparation of development plans (figure 3.4), the Board to consider the population distribution and future growth, trends in economic and social development, prevailing physical and environmental conditions, foreseeable need and availability of land for agriculture, forestry, national parks, public spaces, coastal management matters etc. In fact, the national development plan should take the strategic framework by creating strategies for development, focus development along broad statements and out of those broad statements go down to the regional and local area plans. A development plan is to be approved by the Cabinet for its enforcement. It is important to review a plan after 5 years of its formal approval and conduct fresh surveys to feed the plan.

However, with the permission of the concerned Minister, Board may review it any point of time. A national physical development plan (for a period 2001 to 2020) is already prepared for SVG. However, it

is still in draft form and currently efforts are underway in preparing a new national plan. Few local area plans are already developed. No regional plan is produced.

Figure 3.4: The Hierarchy of plans envisaged by the Act 1992 (Kemp, 2013)

For land development in SVG approval of Board is mandatory as dictated in the Act. According to the planning law, Section 16(1) "Subject to subsection (3) and notwithstanding any provisions in any other law, no person shall carry out, or cause to be carried out, any development except under and in accordance with the conditions of a grant permission for development given in writing by the Board". The application is to be submitted on a prescribed form attaching required documents and drawings for the review of the Board. In dealing with an application for the grant of permission for land development, the Board has to take into account provisions of approved national, regional, or local development plans and environmental impact assessment studies of the area. After reviewing the application for its conformity with existing regulations, guidelines, existing policy, the Board may grant permission for land development with or without conditions or refuse the permission for the stated reasons. Any person who, starts development work without prior approval of the Board or implement development work without complying agreed terms and conditions, the person commits an offense and is liable for punishment as per the law.

3.5.2. Status of hazard risk information SVG

There are relatively limited hazard maps are available for SVG. Mainly landslide susceptibility maps exist. Below is the list (3.4) of hazard maps prepared by consultants/institutions under different project.

Type	Purpose/ Description	Coverage	Scale	Date produced	Author/Consultant	Source of this information
Landslide	To map landslides in the island	Entire Island	1:25,000	1988	Jerome deGraff	(CDERA, 2003b)
Landslide susceptibility map	To map landslides in the island	Saint Vincent	Unknown			Physical planning, SVG
Landslide	Compilation of	Entire Island				Physical

inventory	historical records of landslide events of last 20 years					planning, SVG
Volcanic hazard map	To study volcanic hazard of Saint Vincent	Saint Vincent	Unknown		Seismic research center, UWI	(Catherine, 2010)
Landslide susceptibility map	Under the CHARIM project	Saint Vincent	Unknown	February 2015	ITC	ITC
Landslide susceptibility map	Under the CHARIM project and part of an MSc thesis	Saint Vincent	Unknown	February 2015	Diana	ITC

Table 3.4: List of different hazard maps produced for Saint Vincent

3.5.3. Inclusion of disaster risk reduction in physical planning policies and development work in SVG

Town and country planning Act 1992, does not make any specific provision of use of hazard information and related instruments for the development planning. The physical planning unit controls physical development by making use of existing guidelines and other regulatory instruments such as national building codes and regulation, planning guidelines, environmental impact assessment regulations, and coastal zone management etc. The physical planning unit is using landslide susceptibility maps in making decisions related to sub-divisions. However, due to large scale differences between landslide map and sub-division working scale, the usefulness and applicability of hazard maps becomes limited. These maps can only provide an overview situation of the area hiding local details.

Nonetheless, there is reorganization within the physical planning unit of the mainstreaming DRR in their development work. For instance, the methodological framework for the development of national physical development plan, they have specifically recommended inclusion of climate change mitigation and hazard and risk management (e.g. restricting development in highest risk areas, mitigation measures, requiring hazard assessment when development is proposed, prevent development that may increase hazard risk etc.) (Kemp, 2013).

3.6. Domica

The commonwealth of Dominica is the largest Islands among the OESC countries that occupy a land area of around 751 Km^2. However, its population is relatively low, which is around 70,000. Dominica is among the Caribbean countries, where disaster risk is potentially high due to its mountainous topography and heavy rainfall. The average rainfall along the windward east coast exceeds 5,000 mm and inland mountainsides receive up to 9,000 mm. It is among the highest accumulations in the Caribbean as well as in the world (Global Climate Change Alliance, n.d.). The island is of volcanic origin and is the most mountainous among the eastern Caribbean countries, with deeply incised river valleys and steep ridges, and dense vegetation. The island has one of the largest river densities on the earth (Lindsay, Smith, Roobol, & Stasiuk, n.d.). Due to its mountainous topography, approximately 90 % of its population resides close to the coastal belt, which makes them particularly vulnerable to coastal hazards (Global Climate Change Alliance, n.d.). The Island has suffered several times in the past with damaging effects of hurricanes such as Hurricane David in 1979, a category 4 storm, which had damaged some of 80 % of the island's housing stock (GFDRR, 2010a). Moreover, Dominica is highly susceptible to volcanic hazards. It has nine volcanoes, one of the highest concentrations of potentially active volcanoes in the world (Lindsay et al., n.d.). According to a report (CDERA, 2003c) an estimated 90 % of the population lives within five kilometer buffer of an active volcano.

3.6.1. The physical planning process in Dominica:

The physical development in Dominica is dictated by the Physical Planning Act (the Act), 2002 (Act 2002), and Physical Planning and Development Authority (PPDA) is responsible for the implementation of this Act. Besides, Act 2002, there is Building codes and Minimum property standards, for guiding development work in the country. However, these documents are still at draft stage and needs formal approval. PPDA is a statutory Authority established in accordance of the Act. The role of the Authority is to keep under review a study of matters pertinent to planning the use and development of the land besides consideration of applications for development and regulating building construction in the country. The Chief Physical Planner (CFP) is Secretary to the Authority and responsible for the administration and system of planning outlined in the Act. CFP is the Head of Physical Planning Division (PPD). It has three sections; namely Administration, Land use, and Development Control sections. Development regulations are enforced through Development Control section and Land use sections is responsible for land use and development planning.

There is special provision in the Act for the preparation of development plan for Dominica called "National Physical Development Plan" or specific part of a country. The planning Authority has responsibility to initiate such preparation of such plans with the approval of concerned Minister. Part III, (9)(2) of the Act says the development plan should set out a statement of the principal aims and objectives with respect to the development and other use of land in the area by highlighting existing conditions of the area and policies for future development and land use. The development plan has to be prepared in consultation of wide-spectrum of stakeholders. Its publicity has to be ensured in the preparation process particularly those who may affected by the development plan. After the approval of the draft development plan by the concerned Minister, the plan should be submitted for the approval of the Cabinet and subsequently in the Parliament to pass as law. The development plan may be approved with or without modifications or may be rejected completely by the Minister, Cabinet or Parliament in the review process. In case of rejection, fresh plan may be prepared following part III, section (9) of the Act. An approved development plan will remains intact until it is revoked by the concerned Minister by notice. Approved development plans may be available for inspection or purchase by public. No National Physical Development Plan has been prepared for Dominica as yet, however; there is discussion in the planning division for preparing one. Nevertheless, land use and development plans for some parts of the Island including the main town and capital Roseau are prepared. However, some of these development plans are still in draft status.

Under Part II, Section 4(h) of the Act, the Physical Planning and Development Authority is responsible to receive and consider applications for the permission to undertake any development work. However, according to the Act, it is the duty of the CFP to sign and issue development permissions, refusals or other notices as authorized by the Authority. The physical planning Act, dictates that no development can be carried out without the permission of the Authority. Part IV, section 17(1), it is mentioned that "No person shall carry out any development of land except under and in accordance with the terms of a development permission granted in that behalf prior to the commencement of such development, on an application made in accordance with the regulations made under section 88, unless the development is permitted development authorized under subsection (2)".

An application for the grant of development permission has to be submitted to the Authority through CFP. The application has to be made following regulations accompanied by supporting documentation such as drawings, title of ownership, and other supplementary information, which may help in making decision on application. Subject to the nature of the proposed development every application should be accompanied by an EIA report for the consideration of application. EIA process has to be completed following regulations defined in the Act. When an application received for development, the Development Control section reviews the application, and subject to completion of the application it consults with Land use section, Fire department, Flight path, and Environmental health. Development Control Officers visit

specified development sites in order to ascertain suitability of land. Also considerations regarding NFDP or local development plan (if available) is taken into account in making decisions. The development application has to be in consistent with the development plan. Afterwards, applications are reviewed in Technical Staff Meeting (TSC) and Technical Committee Meeting (TC) and decisions are made for the clients. As per law, the Authority is bound to make decision on an application within 120 days or notify the client for extension. The Authority may grant permission with or without conditions or may refuse the application for development.

3.6.2. Status of hazard and risk information in Dominica

A list (table 3.5) of hazard maps is compiled that are prepared by different consultants for Dominica. Most of these maps are prepared covering the whole Island. Some of the maps that I have seen such as flood, landslide, earthquake, composite map are qualitative and they are lacking information on magnitude/intensity.

Type	Purpose/ Description	Coverage	Scale	Date produced	Author/Consultant	Source of this information
Landslide Risk	To map landslides occurrence	Entire country	1:50,000	November 1987	Jerome de Graff	(CDERA, 2003c)
Volcanic hazard assessment	To map and assess volcanic hazards	Entire country	1:50,000	June 2000	Seismic Research Unit	(CDERA, 2003c)
Flood	To undertake flood hazard mapping of the Roseau river basin	Roseau river basin	Unknown	December 2002	Caribbean Council of Science and technology	(CDERA, 2003c)
Landslide hazard map	To develop landslide hazard map and	Entire country	1:25,000	October 2006	CIPA	(CIPA, 2006)
Inland flood hazard map	To develop landslide hazard map and	Entire country	1:25,000	October 2006	CIPA	(CIPA, 2006)
Coastal hazard flood map	To develop landslide hazard map and	Entire country	1:25,000	October 2006	CIPA	(CIPA, 2006)
Volcano hazard map	To develop landslide hazard map and	Entire country	1:100,000	October 2006	CIPA	(CIPA, 2006)
Earthquake hazard map	To develop landslide hazard map and	Entire country	1:100,000	October 2006	CIPA	(CIPA, 2006)
High wind hazard map	To develop landslide hazard map and	Entire country	1:25,000	October 2006	CIPA	(CIPA, 2006)
Composite hazard map	To develop landslide hazard map and	Entire country	1:50,000	October 2006	CIPA	(CIPA, 2006)
Seismic maps	Seismic hazard maps of various return periods available online at the UWI website for download	Entire country	Unknown			(The University of the West Indies, 2011)
Landslide susceptibility map	Under CHARIM project	Entire country		February 2015	ITC	ITC
Landslide susceptibility map	Under CHARIM project and part of an MSc thesis	Entire country		February 2015	Diana	ITC

Table 3.5: List of various hazard maps prepared for Dominica

Some of these maps and documentation are also available at Dominode (http://dominode.net/). It is an open data portal for sharing geographical information on Dominica.

3.6.3. Inclusion of disaster risk reduction in physical planning policies and development work in Dominica

Recently, the Physical Planning Division (PPD), prepared land use policy document for Dominica. The document is in the draft form and currently in the Cabinet for its approval. It recognizes the importance of hazard mitigation and policy stresses upon increasing resilience to natural hazards in order to protect social and economic development gains (Dillon Consulting, 2014). It highlights following land use strategies for the sustainability of the development and minimizing the potential impacts of natural hazards on society:

1. Increasing resilience to natural hazards – planning to recognize the hazard vulnerability of the country and development will incorporate appropriate measures to be resilient
2. Build and retrofit to be resilient to natural hazards – the planning and location of development will consider resilience to natural hazards and climate change by following specific guidelines and designing infrastructure that are less susceptible to hazards such as hurricane, storm surge, earthquake.
3. Avoiding hazards through planning – The planning of new development will take into account areas that are hazard prone. And existing development located in highly hazard areas will be considered for relocation.
4. Preventing and managing manmade hazards – risk of landslides will be reduced in construction practices and agriculture etc

A development plan for the whole country (NPDP) or part of a country should guide and provide the strategic direction for the land use and development in Dominica. In the course of preparation of such a plan, the Authority may identify hazard prone areas and restrict development work in those areas. It is stated in the Act, under Part III, Section (9)(4a) "designate any area as an area which should not be developed due to its susceptibility to aircraft hazard or to flooding, erosion, subsidence, instability or other condition of the physical environment". Furthermore, any environmentally sensitive area could be declared as environmental protection area subject to specific survey for the purpose. It is further stated in Part VI, Section (56) (3)(C)(v), that "in determining whether it is desirable to declare any area an environmental protection area, the Authority shall have regard to any special natural hazards to which the area is or may be subject". Only certain development or class of development is permitted in such areas. In situations, development is completely prohibited and an EIA study is pre-requisite for development permission for the areas declared as environmentally protected. For the environmentally protected areas, a special management plan is to be prepared for preservation and management of the special features of the area including; prevention of erosion, landslips, and flooding, prohibition, restriction or regulation of access to any area and the prevention of squatting as mentioned in Part VI, Section (59) (2)(c)(h).

Although, the planning division has access to hazard maps, the planning division is not as such using these maps explicitly for development control. The decision on development permission is basically based on site observations, knowledge, and experience of Development Control Officers, who are responsible for reviewing applications and visiting sites, besides input from concerned departments and EIA report. The decisions are somewhat discretionary rather based on specific standards and tools.

3.7. Strengths–Weaknesses–Opportunities–Threats (SWOT)

An evaluation of integration of disaster risk management in the physical planning policies & frameworks and use of natural hazard and risk information in the development planning of the target countries is presented through a SWOT analysis (table 3.6).

Grenada	**Strengths:** a) National Physical Development Plan (NPDP) for the whole country is prepared and risk management is included in their development framework b) Development limitation map is introduced by incorporating flood, landslide, and erosion hazards and included in Grenville local area plan to restrict development in hazard prone areas c) There are setback regulations (e.g. distance from the high water mark) for coastal area management d) A GIS set-up exists within the physical planning unit (PPU) and most of the hazard maps are available in GIS format, where they do simple overlay analysis to identify land parcels that are potentially at risk d) There is will in the physical planning unit to use hazard information in the planning	**Weaknesses:** a) Inclusion of risk management is lacking in the Act 2002. Moreover, the Act does not advocate use of any hazard information for planning. b) Physical planning unit has no specific strategy regarding implementation of action plan (related to risk management) mentioned in the NPDP c) Limited capacity within PPU in producing and using hazard and risk information. d) Development limitation map is based on qualitative maps e) Most of the available maps to PPU are qualitative, relatively old and of medium to small scale, which are not very useful for local level planning and development control. f) No government agency or centralized body producing / systematically collecting hazard and vulnerability information and coordinating its further use.
	Opportunities: a) The PPU is in the process of reviewing planning legislation (i.e. Act 2002). Explicit hazard considerations in the physical planning may be incorporated in the legislation. b) Furthermore, there is planning for development of a national lands policy for Grenada. A clear policy and strategy for Mainstreaming DRR in to the physical planning may be included, which is already recognized in the National Strategic Development Plan (see section 3.2.4 for further details).	**Threats:** a) It will be challenging and difficult to implement any hazard related measure, unless there is uniformity and consistency in the planning legislation, NPDP, and Grenville local area development plan. Currently, there is lack of uniformity because no legal cover b) No specific organization in the country to produce and provide hazard and risk information. It will certainly limit use of such data for physical planning in Grenada. c) Over 80 % of the land tenure in private hands. This calls for close collaboration with private sector and active participation of public in abiding laws related to risk management.
Belize	**Strengths:** a) Approval of national land use policy and formulation of land use planning strategies for flood risk management. b) Legislation for land sub-division and utilization. Additionally, preparation of sub-division guidelines to streamline process. c) Representation of NEMO in Land Subdivision and Utilization Authority. This Authority is responsible for making recommendations for concerned Minister on	**Weaknesses:** a) No specific government body for development planning in the country b) No ownership of national land use policy to implement flood risk management measures defined in the policy c) No specific guidelines related to natural hazard consideration in the sub-division guidelines or legislation d) No updated flood maps available. Currently, an old map, which was produced 1992, has

	applications related to sub-division and land utilization. d) Preparation of Belize city Master plan and special considerations for flood risk management.	been used f) No local government agency producing hazard and risk information.
	Opportunities: a) Lands and Survey Department is in the process of revising national land us policy. The department may maintain and where necessary revise land use planning strategies for flood risk management mentioned in the current policy. b) Implementation of flood mitigation and control measures proposed for Belize city Master plan.	**Threats:** a) Limited supply of updated and large scale hazard maps and other related data such as topographic data may limit use of such data in the physical planning. This is particularly true as development is taking place mainly at plot level
SVG	**Strengths:** a) Physical planning legislation i.e. Town and Country Planning Act, 1992 is enforced in the country for orderly use of land. b) A GIS setup exists within planning unit to facilitate physical planning. This section is currently in the processing of developing national GIS system by collecting and integrating spatial data from various sources.	**Weaknesses:** a) There is no provision in the physical planning legislation regarding use of hazard information for development planning. b) Non availability of good quality landslide maps and seldom use of existing hazard maps for planning. No flood hazard map is available irrespective that country is quite vulnerable to inland flooding due to its hilly topography. c) No local government agency is producing hazard and risk information.
	Opportunities: a) The Ministry of Housing, Informal Human Settlements, Lands & Surveys and Physical Planning is currently in the process of developing national lands policy (draft is ready) and national physical development plan (currently revising methodological framework which was earlier prepared in 2013) for SVG. The Ministry may consider to include risk management in their national policy and NPDP.	**Threats:** a) There is no government organization that has mandate of undertaking hazard assessments and provide relevant data for physical planning. It ultimately hinders in use of hazard information for planning purpose
Saint Lucia	**Strengths:** a) Physical planning legislation (i.e. Physical Planning and Development Act, 2003) has been enforced since 2003. b) National land use policy is prepared and hazard and disaster risk management is specifically addressed (see section 3.4.3 for further details). c) Large number of hazard maps prepared under different donor projects (table 3.2) and available for physical planning section.	**Weaknesses:** a) Inclusion of risk management is lacking in the physical planning legislation. b) National land use policy (which also addresses the issue of hazard and disaster risk management) is not approved by the Cabinet and in draft form since 2007. c) Limited utilization of available hazard maps for development control and planning. d) National physical development plan is not produced and most of their local area

	d) Setback requirements and guidelines available for development control.	development plans are not received formal approval of the Cabinet and the National Assembly. e) No local government agency producing hazard and risk information.
	Opportunities: a) Although, risk management is not specifically included in the Act 2003, however, there is provision for addressing hazard issues through EIA. However, it will be effective only on specific projects that require mandatory study of an EIA for approval. b) The physical planning section is currently revising national lands policy and getting its approval besides, preparing a national physical development plan for the whole country. There is opportunity for including risk management in the national policy and plan.	**Threats:** a) Since there is no specific government agency in the country for carrying out hazard mapping and assessments, therefore, supply of updated data for physical planning will be lacking and ultimately, no utilization of such data in the physical planning.
Dominica	**Strengths** a) Physical planning Act, is in place to dictate physical planning and orderly use of land in Dominica. b) There are specific provisions (details are in section 3.6.3) in the planning law to consider natural hazards in allocation of space for development planning. c) Inclusion of risk management concepts (3.6.3) in newly drafted national land use policy for the country d) A number of hazard maps available (table 3.5) to be used by the physical planning division.	**Weaknesses** a) No utilization of existing hazard maps. Additionally, most of the existing maps are relatively old, qualitative and medium to large small scale, which are not much useful for planning c) Absence of risk management in local area development plans (it was not reflected in their reports) d) No local government agency producing hazard and risk information.
	Opportunities a) Getting formal approval of national land use policy and its implementation (with special reference to risk management) b) Physical planning division is in the process of preparation of national physical development plan for Dominica as a whole. Risk management may be addressed in the national plan. In other words, the national land use policy recommendations are ought to be incorporated NFDP. c) Getting formal approval of draft Building Code and draft Minimum Property Standards documents	**Threats** a) No organization in Dominica is responsible for carrying out risk assessments and producing hazard and risk information. Under these circumstances, it is challenging who would provide desired information for physical planning. It is setback for utilization of hazard data in the physical planning.

Table 3.6: SWOT analysis matrix

4. VULNERABILITY ANALYSIS

A vulnerability index map describes susceptibility of a community to natural hazards (Dewan, 2013). An index map is derived by mathematically combining different indicators that describe the relative state of the vulnerability (Catherine, 2010) and usually being measured at a scale 0 (no vulnerable) to 1 (complete vulnerable). The values in between describe different vulnerability levels. Similarly, a resilience index may also be constructed to measure resilience of a community or society.

Census data has widely been used by the experts in vulnerability assessment related to natural hazards (see section 2.2.2 for examples). It is a main source of demographic and socio-economic data in any country. However, type, scope, and level of details may vary from country to country. Census data is usually collected at the household level and due to its confidentiality; it is usually aggregated to a higher level (for instance census tracts in the USA) and being shared with other government organizations for its use.

The main premise of my work was to examine vulnerability of Grenada (main Island) by using national census data and available national level hazard maps. Broadly, the MOVE framework (2011) approach was followed to measure vulnerability. The framework characterizes vulnerability as a combined result of exposure, susceptibility, and resilience. Exposure is geographical positioning of elements-at-risk in relation to a particular hazard. Susceptibility (fragility) is weaknesses and lack of strength within a society or an individual to withstand hazard impacts, whereas resilience (capacity) acts as positive factors within a society or an individual which support in mitigating and recovering from hazard impacts. Resilience and fragility (vulnerability) is dealt in this chapter whereas, exposure analysis is presented in chapter 5.

Vulnerability of Grenada to natural hazards was measured in two aspects i.e. Resilience and Fragility of the country. Fragility and resilience indices were generated by adopting an indicator based approach by using national census data that was collected in 2011. The scale of the implementation was at national level using household census data that was aggregated at the Enumeration District (ED) level. Therefore, fragility and resilience indices describe cumulative effects of households in a ED. A final disaster resilience index (DRi) of the island was derived by calculating simple resilience to fragility ratio. The whole process of vulnerability analysis was implemented mainly using ILWIS and ArcGIS software. The

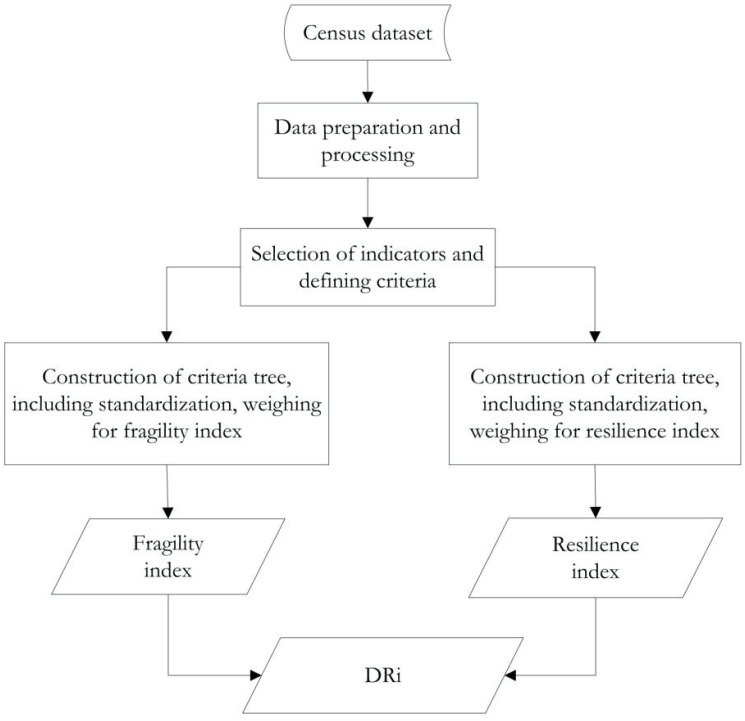

Figure 4.1: Conceptual framework for the construction of vulnerability indices

module of ILWIS called SMCE (Spatial Multi-Criteria Evaluation) was used to combine spatial factors and produce indices. The conceptual flow of work is presented in the figure 4.1 and individual process has been explained in detail in the subsequent sections.

4.1. Available census data

The latest census data for the study was provided by the Central Statistical Office (CSO), Ministry of Finance, government of Grenada. The statistics office collects a whole range of data including, demographic, housing, health, education, income, crime etc. (the census form is attached as annexure 2) and stores it in a relational database for analysis and reporting. In general, a comprehensive database is available with CSO. They collect data at the household level which is relationally linked with Enumeration District and Parishes (It is also called district and it is an administrative boundary - there are 8 Parishes in Grenada). An Enumeration District (ED) is a polygon consisting of a certain number of houses that is specially established to facilitate census survey. Grenada is sub-divided into 287 EDs (figure 4.2) including two small islands. However, this ED is not any administrative unit. Further, there is no as such fixed number of households in each ED. The minimum number of households in a ED based on available data are 3 and maximum is 467 (average 126 households).

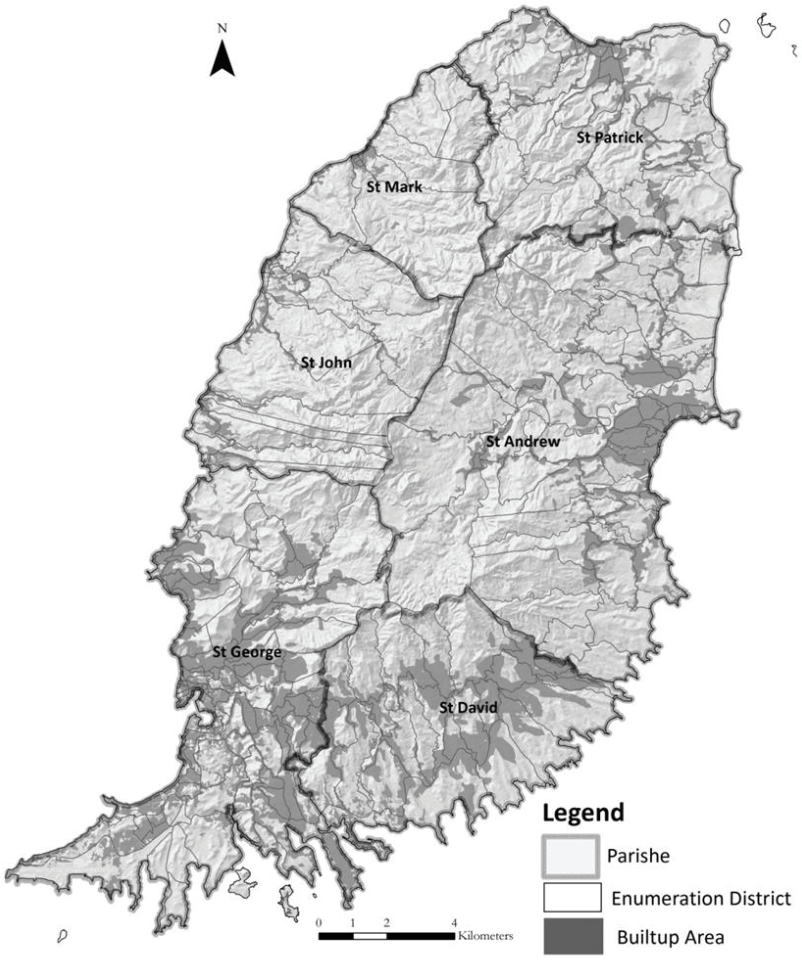

Figure 4.2: Map showing census enumeration districts of Grenada (Main Island)

In table 4.1 an overview of data is presented that was shared by CSO for the whole country. The data was aggregated at ED level. The main drawback in this data was that it was not spatial. No building coordinates were collected during the census survey. For, instance, it is not clear, how population is spatially distributed over the island. Geo-locating these buildings and linking all census data physically on the ground was one of the main challenges of this study. Looking into the size of the country and distribution and sizes of each ED, it was good scale to examine vulnerability at the national level using household datasets.

No.	Dataset	No.	Dataset
1	Households (number of HH)	16	No. of bed rooms
2	Dwelling types (10 types)	17	Access to internet (4 options)
3	Material of wall (9 types)	18	Vehicles (for private use)
4	Roofing type (7 types)	19	Garbage disposal method (7 types)
5	Construction period (9 periods)	20	Contents (16 household items)
6	Dwelling insurance (yes/no)	21	Disability (7 types)
7	Contents insurance (yes/no)	22	Health problems (14 types of illness)
8	Ownership of dwelling (7 categories)	23	Health insurance (7 types)
9	House mortgage (monthly payment)	24	Education (17 categories)
10	Rent period (quarterly, monthly, fortnightly, weakly)	25	Sources of livelihood (12 categories)
11	House rent (amount)	26	Water supply (7 types)
12	Toilet facility (5 types)	27	Drinking water source (8 types)
13	Source of lighting (5 types)	28	Use of fuel for cooking (7 types)
14	No. of rooms	29	Enumeration District (shape file)
15	Demographics(children, elderly, population)		

Table 4.1: List of census data provided by the Central Statistics Office, Grenada

4.2. Data preparation and processing

The provided was in SPSS format. This data was converted into MS Excel format to be able to easily analyze it and use with ArcGIS and ILWIS. Even, the exported data in Excel was not in a suitable shape (due to specified reporting format they set in SPSS) that could be analyzed easily and linked with GIS. Therefore, all exported tables were re-arranged and adjusted in Excel for their formal use in assessment. Data is then checked for its quality and suitability for its use in the study. A new unique enumeration ID is assigned to each Enumeration District polygons and subsequently, all related census data was linked with respective EDs accordingly.

4.3. Selecting indicators and defining criteria

Vulnerability is usually characterized and measured using indicator based methods (Ciurean et al., 2013) and in the literature wealth of examples are available, where indicators were employed to produce indices. For example, UNDP's Disaster Risk Index (DRI), a global index to measure and compare disaster risk between countries (Birkmann, 2007) and county-level Social Vulnerability Index (SoVI) developed for the United States using census data (Cutter et al., 2003). Each index was produced using a different approach. It reflects that there is no common approach available that other researchers could follow. Moreover, there

is no consensus on what to include and how to combine different variables to produce a vulnerability index (Catherine, 2010).

Brinkman (2006), defined a vulnerability indicator for natural hazards as "a variable which is an operational representation of a characteristics or quality of a system able to provide information regarding the susceptibility, coping capacity, and resilience of a system to an impact of an albeit ill-defined event linked with a hazard of natural." Freudenberg (2003), described three levels of indicator grouping; 1) Set of individual indicators, which represents a menu of individual indicators or statistics, 2) Thematic indicators, which are grouped together around a specific theme, and 3) Composite indicators, which are formed when thematic indicators are compiled into a synthetic index and presented as a single composite measure.

With reference to this research the crucial step was identification of suitable indicators out of the available datasets. Since, the quality of composite results hinges on the quality of the individual variables that were included therefore, the chosen indicator must be relevant, robust, and representative (Cutter, Burton, & Emrich, 2010). The indicators were selected and grouped into two main vulnerability components; Fragility and Resilience (figure 4.3) that potentially exhibits related characteristics. The broad selected indicators are age, gender, socio-economic status, and health, which are also often found in the vulnerability assessment literature.

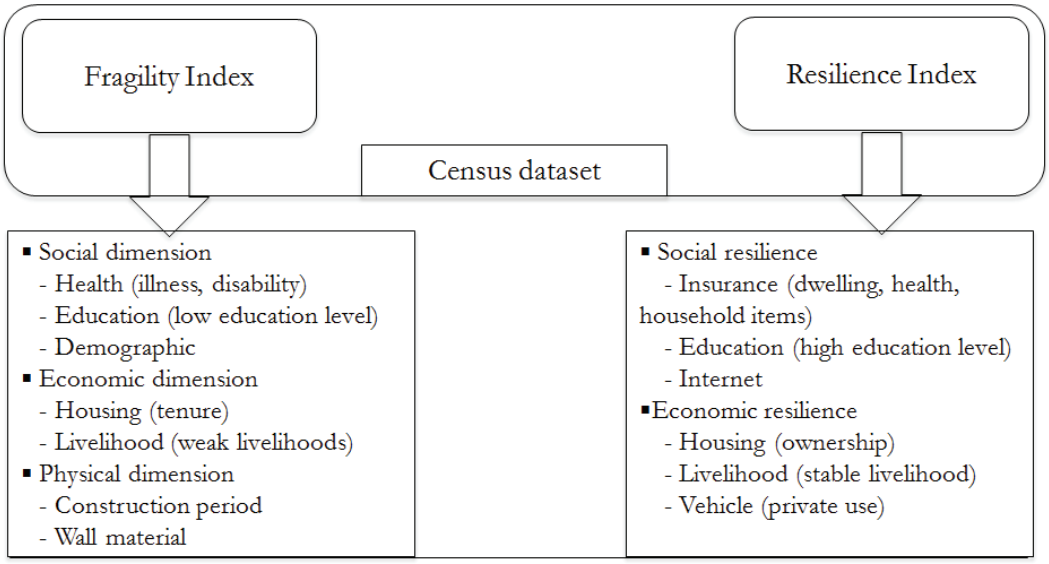

Figure 4.3: Indicators and their grouping into vulnerability components. Complete list of indicators and criteria are presented in the following sections

The main considerations for the selection of variables were; 1) their relevance to the specific theme based on the literature 2) their relevance with respect to the study area, 3) quality of available dataset, and 4) potential co-linearity among variables. For instance, source of drinking water is not included because all EDs have more or less similar water source i.e. public pipe into or outside their houses. Similarly, fuel for cooking, source of lighting were not considered important. No. of bedrooms was chosen instead of no. of rooms, which indicates better socio-economic status. Ownership status provides similar information with house rent and house mortgage payments etc. These variables were further grouped into specific themes that are logically similar and exhibit specific aspects of fragility and resilience as presented in the figure 4.3. For instance, insurance, higher educational attainment and access to internet are grouped under social resilience. A list of selected indicators is presented in the table 4.2 with relevant references for justification and each indicator has been further explained in the following sub-sections.

Input dataset / category	Indicator	Reference
Age	Children (under 5 years)	(Armas & Gavris, 2013 ; Müller et al., 2011 ; Fekete, 2010; Clark et al., 1998 ; Dwyer et al., 2004 ; Tapsell et al., 2010 ; Guillard-Gonçalves et al., 2014; Bergstrand et al., 2014 ; Ainuddin & Routray, 2012; Tate, 2012; Eidsvig et al., 2014; Cutter et al., 2003; Dewan, 2013)
Age	Elderly (over 64 years)	(Armas & Gavris, 2013 ; Müller et al., 2011 ; Fekete, 2010 ; Clark et al., 1998 ; Dwyer et al., 2004 ; Tapsell et al., 2010 ; Guillard-Gonçalves et al., 2014 ; Bergstrand et al., 2014 ; Ainuddin & Routray, 2012; Tate, 2012; Eidsvig et al., 2014 ;Cutter et al., 2003; Dewan, 2013)
Gender	Female	(Armas & Gavris, 2013 ; Müller et al., 2011 ; Fekete, 2010 ; Dwyer et al., 2004 ; Tapsell et al., 2010 ; Guillard-Gonçalves et al., 2014 ; Chen et al., 2014; Cutter et al., 2003; Dewan, 2013)
Material of outer walls	Wall type (material)	(Müller et al., 2011)
Construction period	House age	(Cutter, Burton, & Emrich, 2010 ; Ainuddin & Routray, 2012)
Dwelling insurance	Insurance	(Dwyer et al., 2004)
Contents insurance	Insurance	
Health Insurance	Insurance	(Cutter et al., 2010 ; Ainuddin & Routray, 2012 ; Bergstrand et al., 2014 ; Dwyer et al., 2004)
Disability	Disability	(Cutter et al., 2010 , Clark et al., 1998 ; Tate, 2012 ; Bergstrand et al., 2014 ; Eidsvig et al., 2014 ; Tapsell et al., 2010 , Guillard-Gonçalves et al., 2014 ; Dwyer et al., 2004 ; Fekete, 2010)
Health	Illness	(Cutter et al., 2010; Eidsvig et al., 2014, Tapsell et al., 2010)
Education	Education level	(Cutter et al., 2010 ; Müller et al., 2011 ; Chen et al., 2014 ; Tate, 2012 ; Ainuddin & Routray, 2012 ; Bergstrand et al., 2014 ; Eidsvig et al., 2014 ; Tapsell et al., 2010 ; Armas & Gavris, 2013 ; Fekete, 2010 ; Cutter et al., 2003 ; Dewan, 2013)
Internet	DRR awareness /communication	(Cutter et al., 2010)
Nature of dwelling ownership	Ownership type / Tenure	(Cutter et al., 2010 ; Chen et al., 2014 ; Tate, 2012 , Ainuddin & Routray, 2012 , Bergstrand et al., 2014 , Guillard-Gonçalves et al., 2014 ; Dwyer et al., 2004 ; Armas & Gavris, 2013 ; Cutter et al., 2003)
No. of bedrooms	Socio-economic status/poverty	(Eidsvig et al., 2014; Tapsell et al., 2010; Armas & Gavris, 2013)
livelihood	Socio-economic status/ poverty	(Cutter et al., 2010 ; Clark et al., 1998 ; Müller et al., 2011; Eidsvig et al., 2014 ; Armas & Gavris, 2013 ; Fekete, 2010)
Private use vehicle	Socio-economic status/ poverty, mobility	(Clark et al., 1998 ; Tate, 2012 ; Bergstrand et al., 2014 ; Dwyer et al., 2004)

Table 4.2: Selected indicators for vulnerability analysis with relevant references

4.3.1. Age

Age, particularly related to infants & children and elderly is considered to be an important factor in vulnerability. They are vulnerable to natural hazards because of their restricted mobility, difficulty in the evacuation in any emergencies, and physical fragility. Children need care and support and they are dependent on their parents. They are less aware of hazards and preparedness measures. Elderly people have also special needs and they need special attention from other people. They may not be able to act on their own in emergency. Also, they suffer with more stress following disasters. For instance, 30 residents of an elderly house died in Grenada within six months due to increased stress living in unsanitary conditions following Hurricane Ivan in 2004 (Tony, n.d.). Moreover, old persons who have limited financial means or dependent on their children could face difficulties in post disaster recovery and reconstruction stages. Based on the common literature, children under age 5 and persons over age 64 were included in the vulnerability assessment criteria.

4.3.2. Gender

Gender (female) is an important aspect in vulnerability studies. Females are more susceptible to natural hazards than men (Rygel, O'Sullivan, & Yarnal, 2006), due to many reasons including, inherent biological characteristics and social & cultural dimensions. Pregnant & lactating women and single mothers are considered to be more vulnerable to disasters. Single mothers have lower income resources (Fekete, 2010). In Grenada, there are 51% households with women headed with dependents (Leisa, 2011) and most of them are poor. Women and young girls face special challenges during and post-disaster recovery phases. The post-disaster gender assessment report (ECLAC, 2005) of Hurricane Ivan, indicated that women had faced sever challenges during emergency, recovery, rehabilitation and reconstruction phases.

4.3.3. House ownership

Nature of house ownership is an important component in vulnerability studies. This factor explains socio-economic status of a family or household. For instance, those people who have their own house are considered to be wealthier than those who don't own a house. There is general agreement that lack of wealth is one of the contributors of social vulnerability (Cutter et al., 2003 ; Rygel, O'Sullivan, & Yarnal, 2006) and they suffer the most from hazards (Dewan, 2013). People rent house because they are either transient or have limited financial means to afford own house (Cutter et al., 2003). In certain circumstances, particularly after major disasters it gets difficult to even rent a house either because of lack of availability or price hike. Moreover, rented houses are usually less maintained and thus more susceptible to damage. Persons with very low income tend to live in informal settlements, which are often located in high risk areas.

House ownership categories include full ownership, ownership with mortgage, rent, squatting etc. (see annexure 1, question 4a for classes). These categories were grouped into 4 vulnerability classes (table 4.3) and percentages were calculated for each class at ED level.

4.3.4. Material of outer walls

The quality of housing is an important factor when assessing vulnerability in a particular area (Dewan, 2013). It is also a good indicator of socio-economic status as a person with fair income may own a house or live in relatively better housing. Material and construction type of a building plays important role in determining its physical vulnerability. For instance, 89% of building stocks in Grenada were damaged following the passage of Hurricane Ivan (World Bank, 2005).

There were 8 different types (see annexure 1, question 6a for classes) of wall material in the database. These types were classified into three vulnerability classes in each ED; low, moderate, and high subject to their fragility and potential damage in case of a hazard event. These classes and related description are presented in table 4.3. The total number of houses and related percentages falling in each category are calculated which were then used as input in the SMCE criteria tree.

4.3.5. Period/year of construction

Age of a building is also an important factor in vulnerability assessment. It is a general understanding that the older a builder the weaker it is, due to ageing process. However, it can be argued, as it will depend on maintenance and construction type of a building. Nonetheless, in absence of such information, it can be assumed that older a building, weaker to withstand hazard effects. After the passage of Hurricane Ivan, building codes in the Grenada were reviewed and guidelines were prepared, therefore; it is expected that buildings constructed after 2004 are relatively stronger than earlier buildings. All buildings in each ED were grouped into three vulnerability classes; 1) houses constructed before 1980, 2) houses built between 1980 and 2006, and 3) 2007 to 2011 (see annexure 1, question 6c for classes). These groups and related description is presented in table 4.3. The total number of houses and corresponding percentages falling in each category were calculated which were then supplied as input for SMCE.

4.3.6. Education

Education has multiple effects on social vulnerability assessment. On the one side it can be linked with awareness on disaster risk reduction and access to information (Fekete, 2010) on the other hand it provides an indication of socio-economic status (Cutter et al., 2003). It is considered that a higher educated person is more aware of prevailing hazards and its consequences as compared with an uneducated or less educated person. Similarly, there are more earning opportunities if a person is highly educated as compared to illiterate or less educated individual. They can earn more money and live in relatively safer place or arrange insurance. In the census database, there were 16 different types (see annexure 1, question 63 on education) of educational levels (not only enrolment in specific course but also successfully completed particular course) ranging from school leaving certificate to PhD. level. These educational levels were grouped into 4 groups; 1) no education, 2) primary level, 3) tertiary level, and 4) higher level (table 4.3).

4.3.7. Insurance (dwelling, contents, health)

Insurance is an important factor to consider in determining vulnerability of a person or a society. It is basically a measure of resilience and mechanism for recovery. Insurance (annexure 1, 3a, 3b, and 58 for insurance related questions) pertaining to dwellings, (valuable) household items, and personal health all are social protection arrangements necessary for the fast recovery following a disaster. For each insurance type total number of persons and corresponding percentages were calculated for each enumeration district.

4.3.8. Disability

Disability is a major fragility indicator. It is important in the sense that in case of any emergency a physically challenged person may face problems in evacuation and during search & rescue operation. Moreover, it may also be difficult to participate in disaster preparedness programs (particularly, such programs where disability is not included). Also, disability has negative effects on household income. There were different 7 types of disabilities; seeing, walking, speaking, hearing, self care, upper body function, and remembering (annexure 1, question 54 on disability) were recorded in the census data and each disability was further classified into three classes based on the severity of each problem. For each type of disability and sub-class number of persons and percentages were calculated.

4.3.9. Health problems

Similar to disability illnesses also increases human susceptibility to natural disasters, particularly if an illness is chronic type such as cancer, asthma, arthritis, HIV/AIDS etc. It has severe implications on household income. There were 15 different types (annexure 1, question 57 on health) of health conditions. All illnesses summed up for each ED and percentages were calculated.

4.3.10. Internet connection

Communication is important before and after a hazard event. Internet is an important source of communication and accessing on early warning information. It is also proxy indicator on disaster awareness and literacy. Total number of houses which have access to internet was computed in each ED.

4.3.11. No. of bedrooms

Bedrooms are rooms used mainly for sleeping excluding makeshift and temporary sleeping quarters (annexure 1, question 14). No. of bedrooms is a proxy indicator of socio-economic status. It is assumed that households with many bedrooms are financially stronger and resilient than those with single bedroom households. Three classes were formed to represent this notion; single bedroom households (low socio-economic status), 2 and 3 bedroom households (moderate socio-economic status) and more than 3 bedroom households (good socio-economic status).

4.3.12. Vehicles

Vehicles (motor cars, station wagon, jeep, and van) are those kept at home for the private use by the household (annexure 1, question 20). It is indicator of socio-economic status and personal wealth. Also, ownership of a vehicle indicates the potential mobility in times of any major hazard event for evacuation. Total number of vehicles in each ED added and percentage was calculated.

4.3.13. Livelihood source

Since, household income data was not available this variable used as proxy to get an indication of socio-economic status of a household. A permanent and viable livelihood is crucial for household income and recovery following a disaster. It is also important for taking appropriate risk reduction measures at the household level e.g., insurance, retrofitting and maintaining house.

There were 11 livelihood options (annexure 1, question 86) in the census data. These sources were classified into two groups; stable income sources (resilience) and weak/unstable income (susceptibility). Details of livelihood groups are presented in the table 4.3.

Input dataset	**Indicator**	**Criteria/class**	**Expression/ unit (at ED level)**
Age	Children	Under age 5	Percent of children
Age	Children	Over age 64	Percent of elderly
Gender	Women	Female	Percent of female
Material of outer walls	Type of wall (material)	**3 classes:** Strong walls (concrete/ concrete blocks, stone, brick)	Percent of dwellings falling in a defined category
		Weak walls (wood, wood & concrete)	
		Very weak walls (plywood, plywood & concrete, makeshift, other)	
Constructi on period	House age	**3 classes:** New houses (2007 to 2011)	Percent of dwellings falling in each category
		Old houses (1980 to 2006)	
		Very old houses (Before 1980)	
Dwelling insurance	Insurance	More dwellings with insurance in a ED; more resilient (fast recovery)	Percent of dwellings with insurance
Content insurance	Insurance	More households with items (household) with insurance in a ED; more resilient	Percent of dwellings with insurance of household

			items
Health insurance	Insurance	More persons with health insurance in a ED, more resilient (fast recovery)	Percent of persons with health insurance
Disability	Disability (7 types)	More persons with health problems in a ED; higher fragility	Percent of all disabled persons in each ED
Health	Illness (14 types)	More persons with disability in a ED; higher fragility	Percentage of persons with illness
Education	Educational level	**4 categories based on level of education attained** Higher level (Bachelors and higher including related certifications /diploma)	Percent of persons having certain level of education
		Tertiary level (under graduation and related certifications/diploma)	
		Primary level	
		None - no education/certification	
Internet	DRR awareness, communication	More households access to internet more resilient (hazard anticipation)	percent of dwellings with internet facility
Nature of dwelling ownership	Building ownership / tenure	**4 classes:** Full ownership	Percent of households with ownership type
		Owned with mortgage	
		Renters & leased	
		Squatted	
Livelihood source	Income: A proxy indicator of socio-economic status/ personal wealth based on stable/high livelihood means and relatively unstable/low livelihood options.	**2 classes:** Stable income sources (employment, overseas pension, money from abroad, investment, savings)	Percent of persons in each category
		Unstable income sources (pension local, disability benefits, social security benefits, local contribution from friends/relatives, overseas contribution from friends/relatives)	
Bedrooms	Income: A proxy indicator of socio-economic status/ personal wealth, Sleeping space (crowdedness)	**3 classes:** Dwellings with 4 or more bedrooms	Percent of dwellings in each category
		Dwellings with 2 to 3 bedrooms	
		Dwellings with 1 bedroom	
Vehicle	Income: A proxy indicator of socio-economic status/ personal wealth and potential mobility during emergency	More dwellings with vehicles for private use in a certain ED considered wealthy area and thus lower vulnerability.	percentage of dwellings (relative to HH ED) with vehicles in ED

Table 4.3: Vulnerability assessment indicators and criteria

4.4. Formulation of SMCE criteria tree

Spatial Multi-Criteria Evaluation (SMCE) is a technique that helps users in making improved decisions with respect to a given goal. It is based on Analytical Hierarchical Process (AHP) introduced by Thomas L. Saaty in 1980 (Dewan, 2013; Van Westen et al., 2011). Because of its flexibility many organizations are using AHP in the decision making process (Ramanathan, 2001) and it is already been used for risk assessments (Van Westen et al., 2011).

In ILWIS software, a special module is available to implement SMCE. It guides users when performing multi-criteria evaluation in a spatial manner (Van Westen et al., 2011). The input for the module is a number of raster maps and/or attribute tables of a certain area (so-called 'criteria'), and a criteria tree that contains the way criteria are grouped, standardized and weighed. The output is a composite raster map (s) that indicates the realization of defined criteria (ILWIS help)

To construct criteria tree an overall goal is needed. Then, there are sub-goals (optional) composed of groups, sub-groups and related factor maps for criteria, thus; a tree like structure continues like this. The conceptual flow of formulation of complete criteria tree is presented in the figure 4.4 and main sections are explained further in this section. This criteria tree is formulated to construct vulnerability indices.

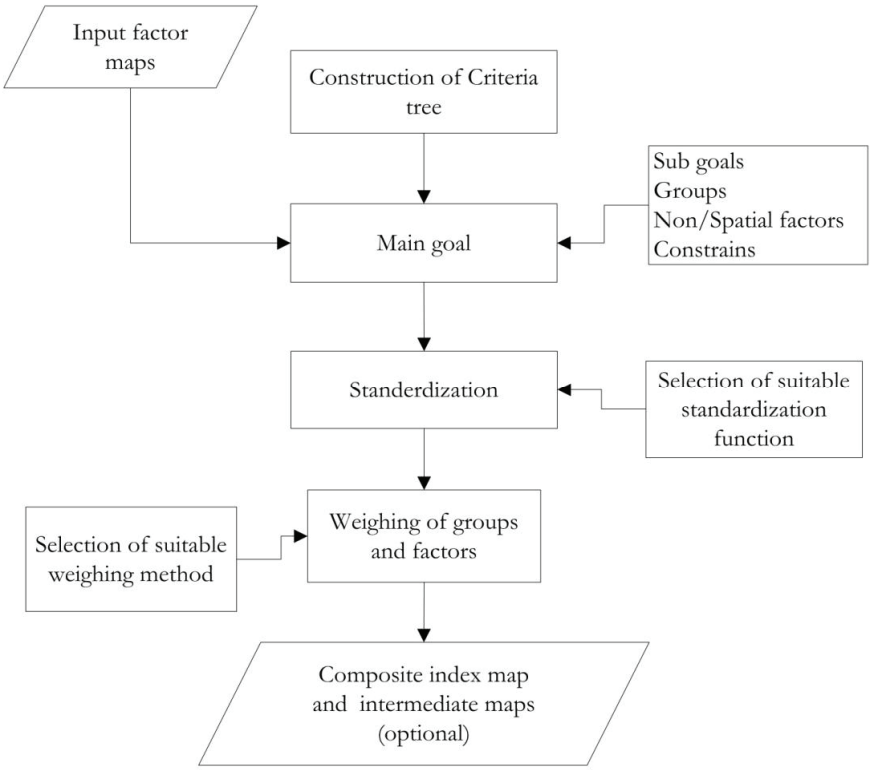

Figure 4.4: Conceptual flow of SMCE criteria tree formulation in ILWIS

In case of this study there were three main goals. One was related to generating fragility (social vulnerability) index, second was resilience index, and third goal related to qualitative risk map. Therefore, three criteria trees were constructed. The implementation of criteria trees for fragility index and resilience index using selected indicators and criteria (see section 4.3) are presented in the figures 4.6 and 4.7 respectively along with weighing scheme.

After completing criteria tree structure including assigning input raster maps for each criteria (spatial factor), the next stage was standardization/normalization of all input maps. Standardization is a process in which values of input maps are scaled between 0 and 1. Since the output values of SMCE are always between 0 and 1, however, the values of each input maps may range differently (e.g. 10 to 90, 100 to 10000, 0 to 2 etc.) or represent different measurement scale such as height, distance, slope etc, through normalization all input values brought into scale 0 to 1 as illustrated in the figure 4.5 as an example. In ILWIS, there are many methods available for this purpose e.g., maximum, goal, convex and concave and they are applied subject to nature of data and goal.

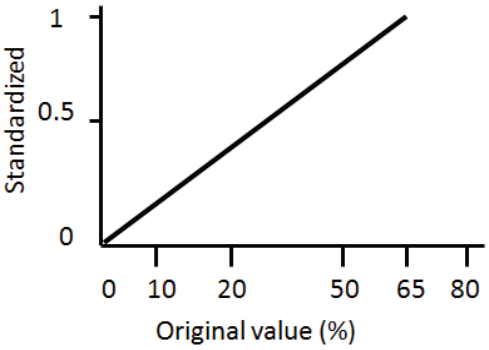

Figure 4.5: Conceptual illustration of the standardization process

All input maps for each criterion were standardized using 'Goal' function. This function standardizes the input values with a linear function that uses a specified minimum and maximum value. Any value specified as 'minimum' value will be standardized to 0 (including any smaller numbers) and any value specified as 'maximum' will get 1 (including any larger numbers). All other values will be standardized between 0 and 1. The basic reason for using 'Goal' function was the fact that percentage for most of the criteria values were not started at 0 or ended at 100. Also, this way, it was possible to control possible outliers, which may over shoot or undershoot the goal. After carefully analyzing values of each criterion minimum and maximum values were set in the function for the standardization.

In the next stage, weighing of factor and groups was completed. Assigning weights is needed in order to indicate the relative importance of factors with respect to the main goal and sub goals. In ILWIS SMCE module, there are three methods for assigning weights namely; Direct method, Pair-wise comparison, and Rank order. In the Direct method, the user manually supplies weights between 0 and 1 based on expert judgment. However, in the Pair-wise method factors under each group are compared each other through a qualitative comparison process and forms a pair-wise comparison matrix. The application calculates weights for each factor using this matrix. Similarly, groups are then compared under each goal. In the following table (4.4) scale of Pair-wise relative comparison based on AHP is presented. Users compare two factors using descriptive statements like one factor is equally important to second towards the goal/sub-goal. Based on the statements matrix is formed taking corresponding numerical value e.g., 1,6

Comparative importance	Definition	Description
1	Equal importance	Two indicators equally influence the parent decision
3	Weak importance	One factor is moderately influential over the other
5	Essential or strong importance	One factor is strongly favoured over the other
7	Demonstrated importance	One decision factor has significant over another
9	Absolute importance	Evidence favouring one decision factor over the other is the highest order of affirmation
2,4,6,8	Intermediate	When compromise is needed, values between two adjacent judgments are used.

Table 4.4: Semantic weighing scale of the AHP (Ramanathan, 2001)

In the Rank ordering method, user orders factor and groups under the main goal and any sub-goal with respective importance for the realization of main/sub-goal. The most important item is placed at the top. The application calculates weights for each item accordingly.
Both Direct and Pair-wise comparison methods were employed for weighing subject to requirement. For instance, three sub-goals under fragility; physical, social, and economical were directly assigned weights. Economical aspect is given a higher priority over other two (figure 4.6), because, a person with low income may not be able to invest in disaster risk reduction interventions (such as insurance, retrofitting house etc), or will inhibit in recovery process following a disaster. Similarly, wall material of a building is far more important than its age. Irrespective of the age, the building will collapse if material is not strong enough to withstand force of nature. Very old houses are considered to be weaker, especially if they are not well maintained thus more likely that they get damage in case of any hazard event such as earthquake, hurricane. Disability and other illnesses were treated more or less the same. However, disability is a permanent vulnerability, which merits relatively higher weight. There were 7 different types of disabilities recorded in the survey. Children are more vulnerable than aged due to their limited physical strength, experience etc. They were weighted 0.65 as compared to elderly (0.35).

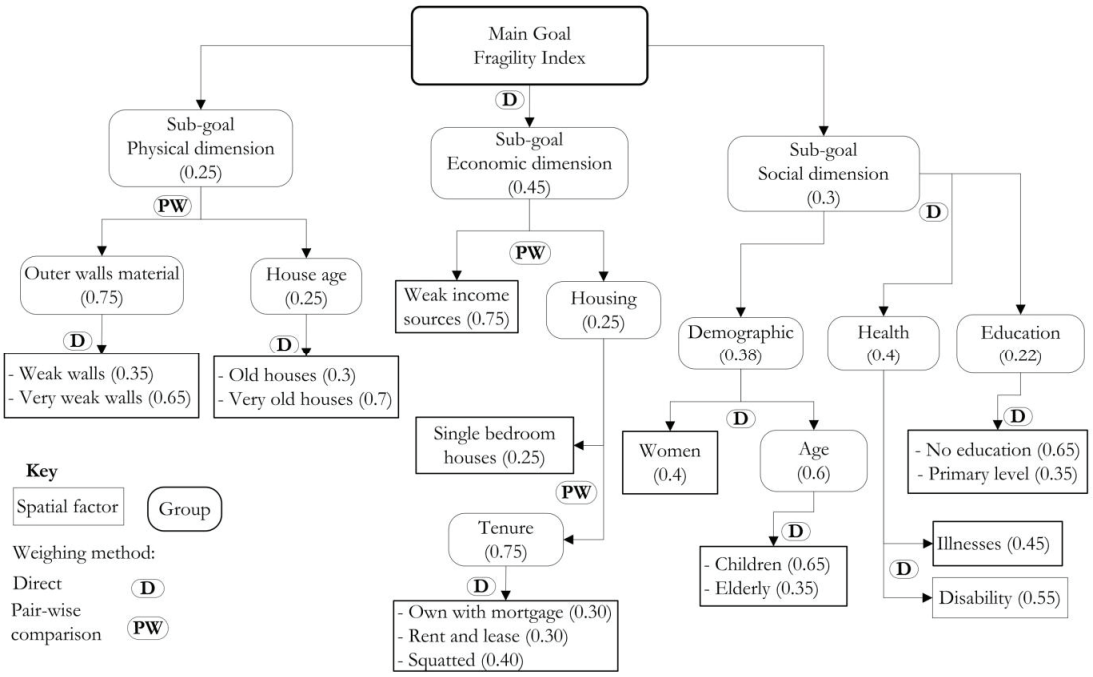

Figure 4.6: Implementation of SMCE criteria tree including weighing scheme (methods and actual weights assigned to each factor and group) for fragility index

Nature of house ownership and livelihood options are stronger factors that influence vulnerability. Those people who own house are less vulnerable as compared to people paying rents/lease or living in informal settlements. Moreover, weak or unstable income sources (consist of; local pension, disability benefits, social security benefits, local contribution from friends/relatives, and overseas contribution from friends/relatives) are indication of low socio-economic status, which results increased vulnerability. Housing is awarded 0.4 and weak livelihood options 0.6 weights.

With the respect to resilience index, economic resilience was assigned higher weight (0.6) than social resilience (0.4) as shown in the figure 4.7, since to bring social resilience it is important to have adequate level of economic prosperity. A stable income and better housing facility are two important factors in this regard. Different livelihood options such as employment, overseas pension, money from abroad, investment, savings were grouped together as stable income source as opposed to weak income options, which were included in the fragility index. Stable income assigned 0.45 weights as opposed to 0.4 for housing. In Grenada, over 75 % people owns house, but still there is poverty due to unemployment. In this context, good stable income source merits relatively higher weight. The physical vulnerability of a building will be minimal if it is constructed from good building material such as concrete, brick or stone. Insurance under social resilience is given higher priority over anticipation (comprises: education and access to internet) and assigned higher weight (0.6). Insurance is an important instrument with respect to fast recovery following a major disaster. Education has its own significance. However, having a higher degree does not automatically mean that necessary risk reduction measures are in placed at the household level. Education level was awarded 0.75 points through a pair-wise comparison with internet

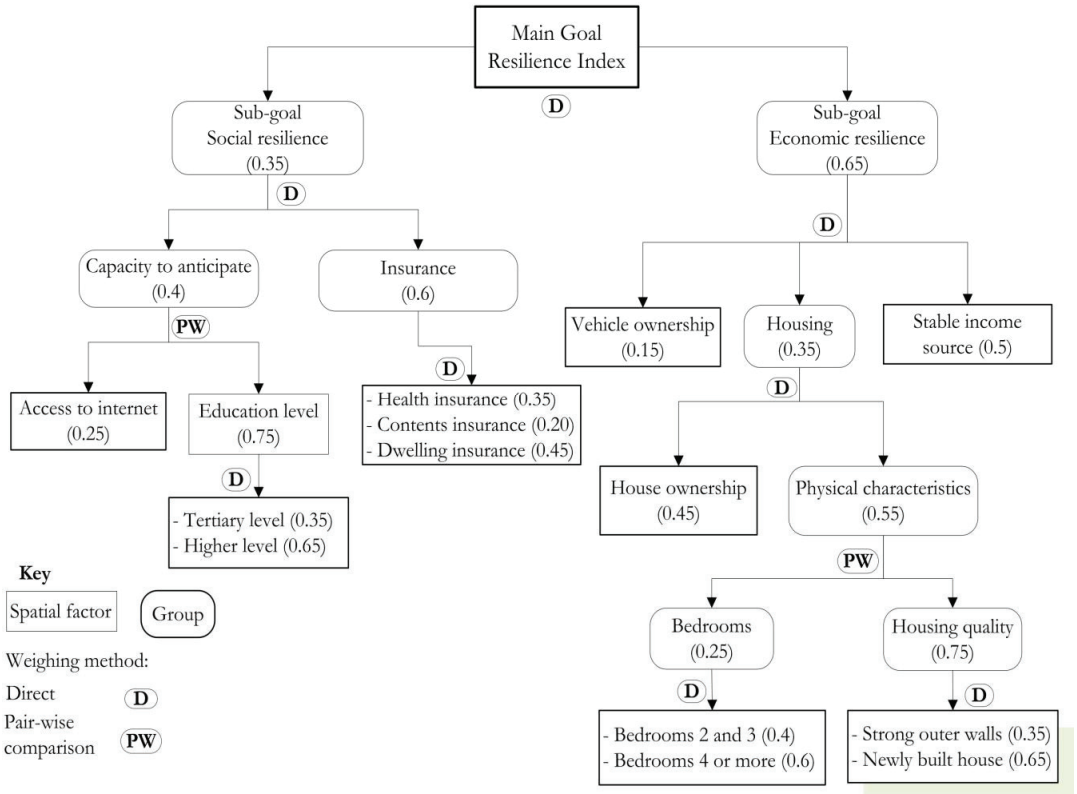

Figure 4.7: Implementation of SMCE criteria tree including weighing scheme (methods and actual weights assigned to each factor and group) for resilience index.

4.5. Analysis results

- The fragility and resilience indices presented in the figure 4.8, provide an overview of the vulnerability of Grenada based on indicators derived from the census data. Both maps are classified based on Z-values as proposed by Cutter et al., (2003). The Z-score or Z- value indicates how many standard deviations (Std Dev) an observation is above or below the mean. The mean and standard deviation values were 0.39 & 0.076 and 0.40 & 0.109 for fragility and resilience respectively.

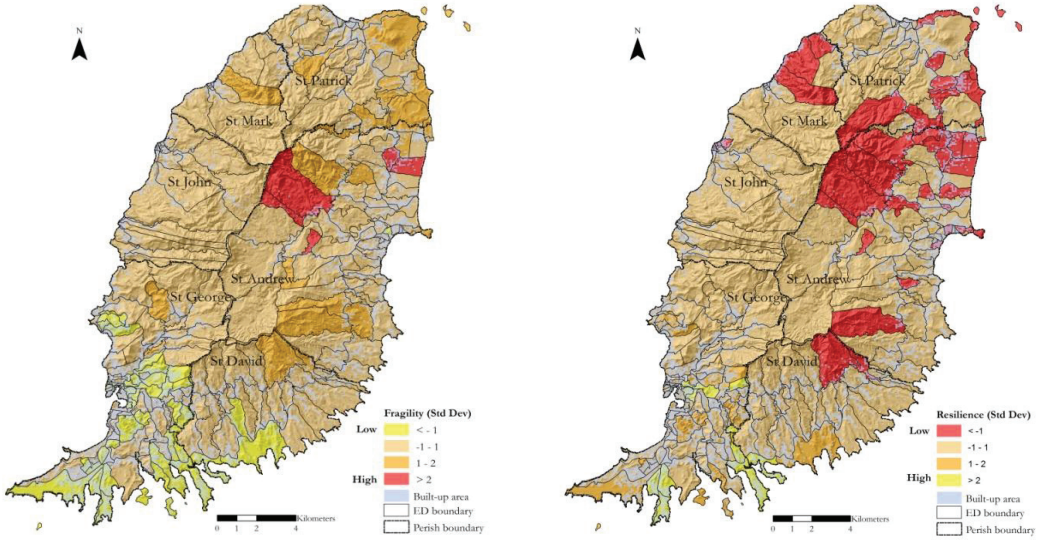

Figure 4.8: Vulnerability analysis results. Fragility index (left) and resilience index (right). Full page copies of the same are attached as annexure 3 and 4

- What do these maps convey and what interpretation can possibly be made? It is reflected from the resilience index that overall household's resilience in Grenada is relatively low (mean value small) except very few enumeration districts in the south of the Island. There is overall uniformity in the resilience. About 14 % (37) EDs are falling in the red zone as their standard deviation is larger than negative 1. Similarly, only about 16 % EDs (42) are in the yellow zone, with a positive standard deviation larger than 1. Whereas, the majority (70%) of the EDs are between -1 to +1 Std Dev. The histogram based on actual index values is also presented in the figure 4.9 (right). Over 100 EDs with resilience index in the range 0.40

- On the contrary, the overall fragility (figure 4.8, left) is also not high. They are not resilient and at the same time not very fragile with respect to given data. Over 69 % of EDs (185) are in the range of -1 and +1 Std Dev., 30 EDs (11%) are between 1 and 2, whereas, only 2 % (6 EDs) are more than 2 Std Dev. (red color) being more vulnerable households. Relatively less fragile or relatively more resilient EDs are in the south (St. David and St. George parishes). They are only about 17 % (46). The histogram of actual index values (figure 4.9, left) shows that most ED have fragility index between 0.4 and 0.5.

- Above indices were derived based on percentages for each variable with respect to total number (either total number of households or total population) in the respective ED. It was also possibility to take the absolute number of each variable instead of calculating percentages. Because it is quite likely that an ED with small households get higher index as compared to a large ED. For instance there is one ED with only 3 households and only one person in each household. Three of them are age over 65. In this context vulnerability based on age will be 100 %. Whereas, another ED with population of around 950 and 123 elderly persons, this ED will not be categorized as most vulnerable due to low

percentage (13%). But when we take the absolute number the second ED will be the most vulnerable. The notion of selecting absolute numbers is based on the assumption that a block group with more people and housing units has high potential of damage as compared with fewer households and people, whereas, with respect to use of percentage, the composition of a block is more important than size of a block (Rygel et al., 2006). However, in order to check the sensitivity of the model and get an idea of how results might change with respect to change in unit of input data; both resilience and fragility indices were derived again taking absolute numbers for each variable. Results of both indices are presented in the figure 4.10.

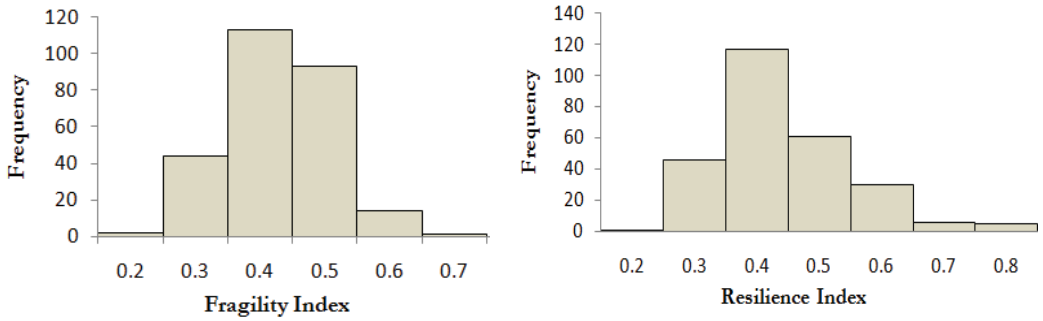

Figure 4.9: Histograms based on actual index values

- There is large difference between both results. The mean and standard deviation for fragility and resilience are 0.25 & 0.145 and 0.22 & 0.141 respectively. Apparently, results reflect that there is very low fragility and at the same time very low resilience, which seems bit contradictory. Again, both indices indicate that there is uniformity in household resilience and fragility across the island as over 70% of EDs are in the range of -1 and +1 Std Div. The histogram (figure 4.11) based on actual pixel values indicate index for fragility spread over 0.2 to 0.4, whereas, for resilience most values are in the range of 0.2

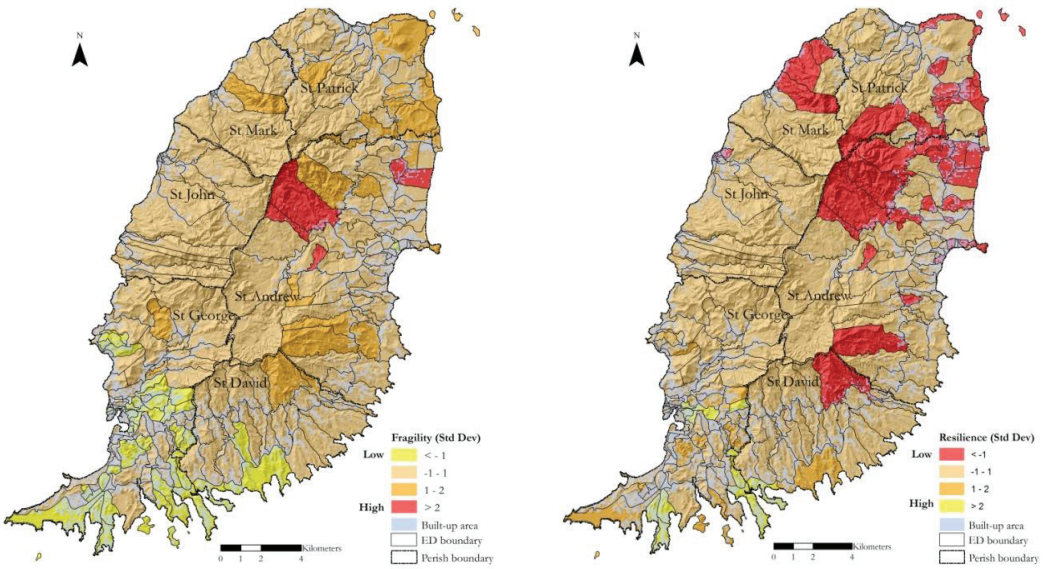

Figure 4.10: Results of vulnerability analysis using census data taking absolute values of each variable as input to the model. Fragility index (left) and resilience index (right). Full page copies of the same are attached as annexure 5 and 6

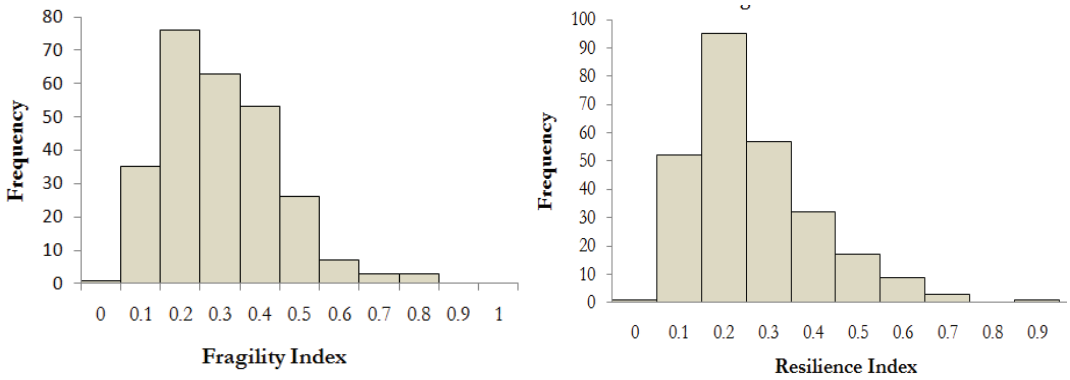

Figure 4.11: Histograms based on actual pixel values (index) derived taking absolute values

- It appears that size of ED has an influence on the index when using absolute values. For instance some EDs in the extreme south whose fragility is highest are also highest in terms of their resilience index. Similarly, some EDs with lowest fragility are also lowest in the resilience. To evaluate this relationship 15 largest and 15 smallest EDs with respect to number of households (dwellings) were selected and their index vales were checked (table 4.5). Both resilience and fragility values are very low (figure 4.12) (close to 0 and quite smaller than overall average values; 0.25 and 0.22) for small size EDs when variable values were taken as absolute numbers. Whereas, in percent, it seems they were lesser influenced due to their smaller size as both indexes are spread over and closer to series mean (0.40 and 0.38) and clear deviation in resilience index and respective fragility index or vice-versa.

ED	HH	Index for absolute values		Index for percent	
		Res_abs	Fra_abs	Res_per	Fra_per
77	3	0.01	0.01	0.58	0.32
201	6	0.01	0.01	0.18	0.65
161	7	0.01	0.01	0.41	0.44
106	13	0.04	0.02	0.60	0.27
274	14	0.02	0.04	0.34	0.51
57	15	0.03	0.02	0.53	0.24
135	19	0.04	0.03	0.38	0.41
173	20	0.05	0.08	0.36	0.58
12	22	0.05	0.03	0.54	0.30
194	23	0.07	0.03	0.70	0.21
146	24	0.04	0.03	0.53	0.37
222	25	0.05	0.06	0.39	0.39
32	29	0.09	0.04	0.76	0.24
130	30	0.05	0.05	0.52	0.26
242	30	0.07	0.05	0.39	0.34

ED	HH	Index for absolute values		Index for percent	
		Res_abs	Fra_abs	Res_per	Fra_per
67	468	0.81	0.79	0.4	0.37
265	445	0.6	0.78	0.37	0.38
31	391	0.67	0.72	0.40	0.37
123	316	0.5	0.62	0.37	0.39
15	309	0.49	0.49	0.36	0.38
40	301	0.47	0.2	0.52	0.3
243	295	0.42	0.58	0.37	0.38
172	283	0.7	0.45	0.48	0.29
58	278	0.39	0.54	0.33	0.43
74	278	0.34	0.43	0.37	0.31
170	275	0.6	0.48	0.42	0.32
195	270	0.24	0.52	0.25	0.5
189	258	0.69	0.39	0.53	0.27
279	253	0.42	0.44	0.39	0.34
64	248	0.45	0.46	0.38	0.38

Table 4.5: Fragility and resilience index values for smallest size (left) and largest size (right) ED when they were derived taking absolute variable values and in percent

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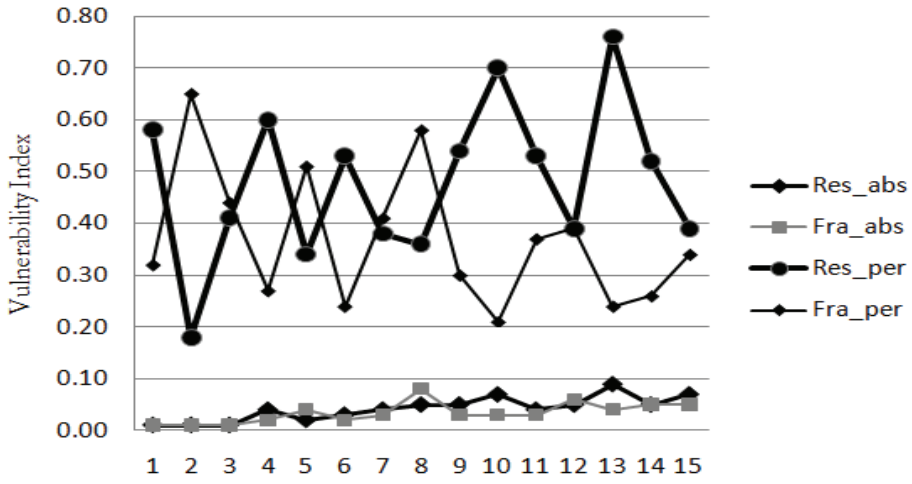


Figure 4.12: Fragility (fra) and resilience (res) index of 15 smallest size enumeration districts when taken as absolute (abs) and percent (per)

With respect to large size EDs, it seems they were over influenced because of their large size and thereby potentially higher absolute values (figure 4.13). Most of them have index quite larger than series mean. However, when values were taken in percent for large EDs, It seems, they were not over or under influenced due to their size and most of them have index close to series mean.

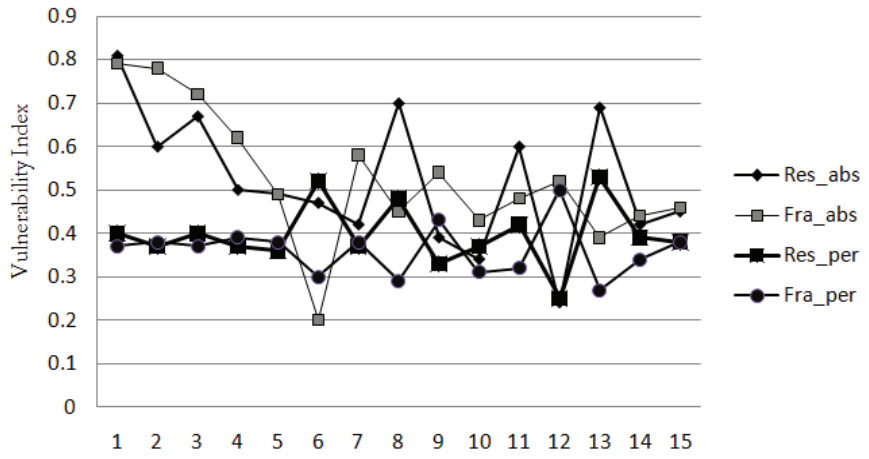


Figure 4.13: Fragility (fra) and resilience (res) index of 15 largest size enumeration districts when taken as absolute (abs) and percent (per)

- Moreover, average pixel values for 50 smallest and 50 largest sizes of EDs were calculated in order to determine further the influence of type of input data on results with respect to ED size. The average index for both resilience and fragility were 0.08 for top 50 smallest enumeration districts, whereas, average for top 50 largest enumeration districts was 0.41 and 0.45 respectively, when variable values were taken in absolute numbers to create index. However, when compared with index derived using percent, the results were different. For instance the average for smallest EDs was 0.43 & 0.38 for resilience and fragility respectively, whereas; for largest EDs they were 0.39 & 0.37. It indicates that absolute values are greatly influenced with the size of ED.

- However, to balance out influence (either over or under) of type of input data on indices, average of both indices were calculated. The index of fragility derived based on percent is added with fragility derived based on absolute numbers of each variable and then average calculated.

  Fragility = fragility index (percent) + fragility index (absolute) / 2

  Similarly for resilience, the index of resilience derived based on percent is added with resilience derived based on absolute numbers and average calculated.

  Resilience = resilience index (percent) + resilience index (absolute) / 2

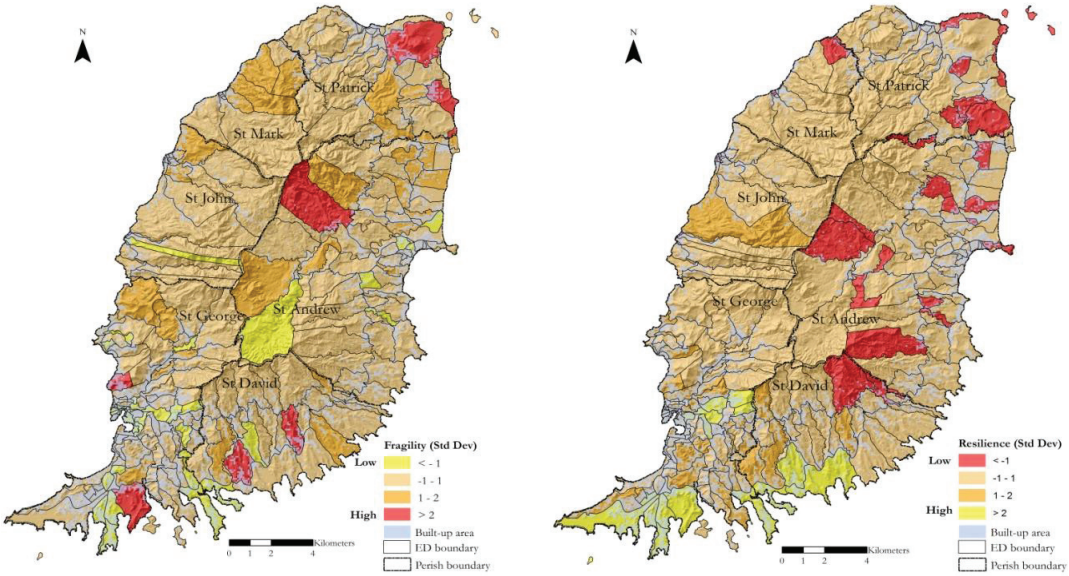


Figure 4.14: *Results of vulnerability analysis using average values of both indices. Fragility index (left) and resilience index (right). Full page copies of the same are attached as annexure 7 and 8*

- The mean and standard deviation of averaged fragility indices is now 0.32 (as opposed to 0.39 & 0.25 for percent and absolute respectively) and 0.090 respectively. The result of averaged indices for fragility (4.14 left) shows that 70 % of the values are within -1 and +1 standard deviation. About 3 % EDs were found to be relatively more fragile (Std Dev > 2), and whereas only 1 % EDs are relatively less fragile (Std Dev < - 2)
- With respect to average resilience, mean and standard deviation is 0.31 (as opposed to original 0.40 & 0.22 for percent and absolute respectively) and 0.10 respectively. About 73% (194) EDs are found to between -1 and +1 standard deviation (figure 4.14, right). Only 6% (16) EDs are over 2 Std Dev and thereby relatively higher resilient. Whereas 11 % (31) EDs classified as being relatively less resilient (Std Dev less than -1)

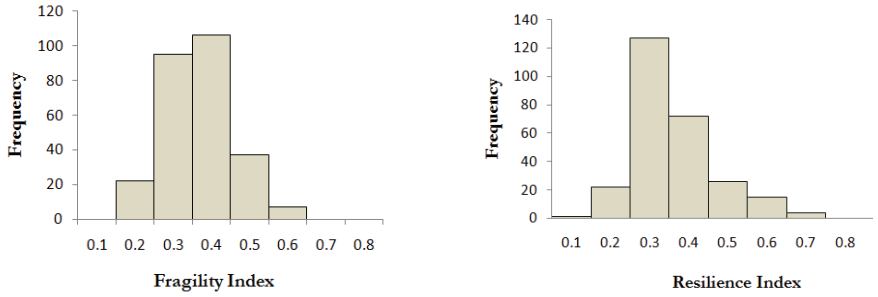


Figure 4.15: histograms of averaged fragility (left) and resilience (right) based on actual pixel values

- The histograms of both averaged fragility and resilience reflects (figure 4.15) that most of the pixel values are falling in the range 0.3 to 0.4. It presents that there is uniformity in vulnerability across the country. Moreover, overall resilience is low and at the same time fragility is also not too high.
- In order to get a broad indication of resilience in Grenada across EDs, a simple resilience framework proposed by Simpson and Katirai in their working paper on indicator issues (Simpson & Katirai, 2006) is adopted. The framework is:
  Disaster Resilience Index (DRi) = Preparedness Index (Pi) / Vulnerability (V)
  Where,
  DRi > 1, the community is more resilient
  DRi < 1, the community is less resilient

Final resilience for Grenada was determined by dividing resilience index with fragility index

DRi = Resilience / Fragility

The resultant map was then classified into four resilience classes (figure 4.16); very low (DRi < 0.6), Low (1.0 > DRi > 0.5), Moderate (1.5 > DRi > 1.0), High (DRi > 1.5)

Since overall resilience index is low (mean 0.31), 'High' EDs are only those areas where there is large difference between resilience and fragility indices, whereas; 'Very low' EDs are those EDs where there is large difference between fragility and resilience. Based on the DRi result, it can be concluded that the southerner part of the Island is relatively more resilient as compared to northern region, particularly north-east parts (St. Andrew and St. Patrick). .

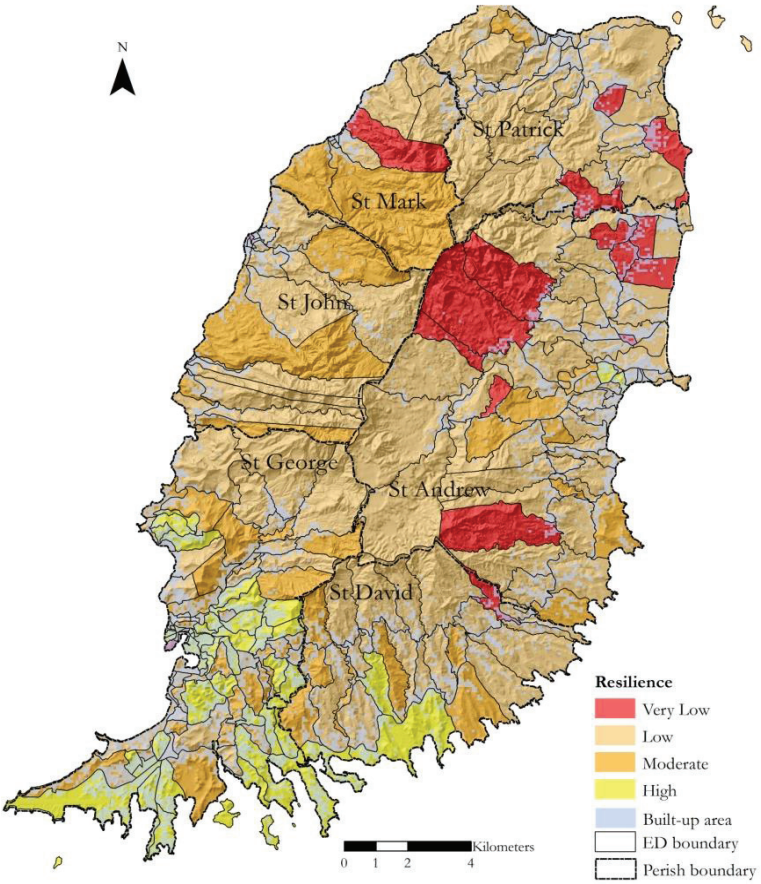


Figure 4.16: Final disaster resilience index (DRi) derived based on average fragility and resilience indexes

5. EXPOSURE ANALYSIS

Exposure analysis is an important step in risk analysis. It is basically spatial relationship of hazard footprints and elements-at-risk (figure 5.1) such as buildings. It is usually carried out to identify elements that are exposed to a particular hazard and subsequently determine the physical vulnerability of exposed elements. Results of such analysis are being used in risk management and planning.
In this research one important component was how to use hazard and vulnerability information in the spatial planning. To accomplish this, it was necessary to have information on both hazard and elements-at-risk. With respect to hazard footprints, national scale flood and landslides maps were available which were recently produced by the ITC, whereas regarding elements at risk, only buildings and population is considered. Building footprints were available for the physical planning unit and population was available from the census database as explained in chapter 4. However, no spatial information (coordinates) of households were collected for census data, thereby actual population distribution over the Island was missing. Therefore, in the first step, elements-at-risk map of buildings and population was produced and then hazard footprints and elements-at-risk map were combined to identify exposure information. Elements-at-risk maps were produced at two levels; 1) national level population distribution map by dasymetric mapping and; 2) ED level building map by geo-locating census data

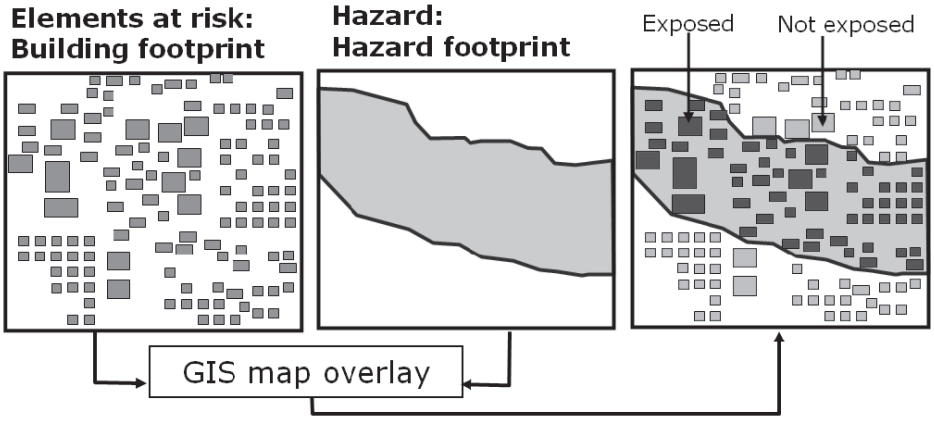


Figure 5.1: Spatial overlay of hazard map and elements-at-risk (Van Westen et al., 2011)

5.1. Geo-locating census data

The Census office of Grenada collected a large amount of census data at household level. It is a crucial source of information on many aspects including, demographics, housing, socio-economic, crime, health etc. and this could be used in the development planning, disaster risk management, education, health, social welfare etc. However, there is one major drawback of this survey, as geographic coordinates of buildings were not collected while collecting census data. For instance, for dwellings mentioned in the survey forms, it is not clear where those buildings were physically located within the enumeration district on the Island.
The physical planning unit of Grenada has building footprints for the whole country. However, no attribute information was available to determine, whether a certain building is a dwelling, market, hospital, a school, or some other structure. Without any attribute information the usefulness of such data becomes restricted.

In order to apply census data for exposure analysis and determine vulnerability directly at household level, census data was geo-located in two enumeration districts as test by combining building footprints and census data. Census in Grenada has basically two parts; one part is population census and second part is housing census. In housing census, they record buildings and then maintain information on dwellings and households. A 'building' is the main structure where dwellings and households are physically located and 'dwelling' in a building or part of a building (attached or within the building), which is specifically being used for living purpose (i.e. occupancy type is residential), whereas; a 'household' is a compound of persons living in that particular dwelling.

Prior to start of population census the Central Statistics Office (CSO) conducts housing census and records requisite information in, what is called "Visitation Record" (figure 5.2, top). They record building number, dwelling number, household number, name of head of household, address, and other information related to one building. When assigning these numbers the enumerators are neither collecting building coordinates nor physically marking buildings with respective to building code they put in their visitation record. The only possibility of locating a building is with enumeration district number, street name, and possibly head of household. And if occupants of a household shift to another place, the name of the head of household becomes less relevant. Tracing of buildings and household is only possible with the support of the same enumerators who were involved in the census in that particular ED.

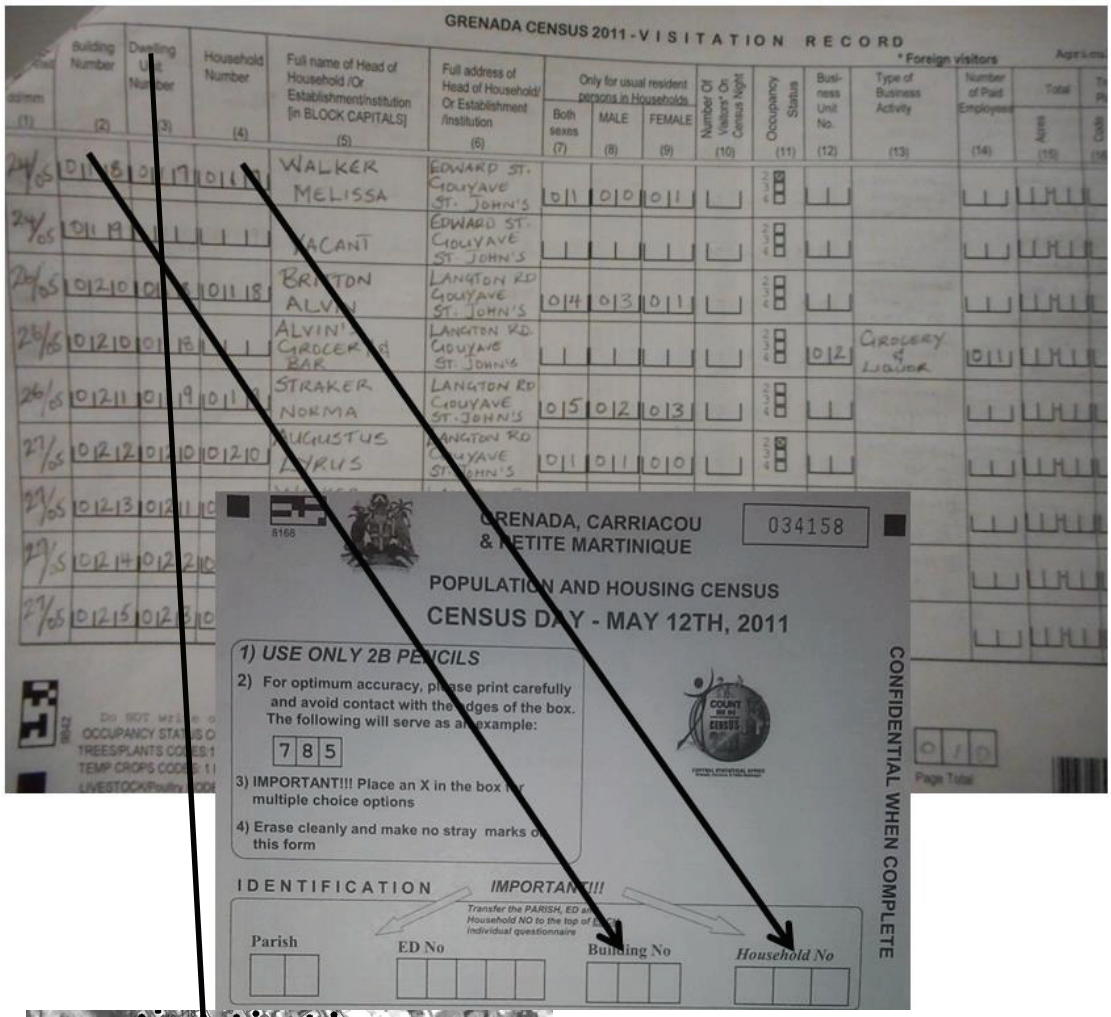
5.1.1. Target area

Gouyava, which is located in the north-west (latitude: 12.166926°, Longitude: -61.730131°) is one of the towns on the Island. The town is located in Gouyava watershed. Downstream population in this watershed is vulnerable to flooding. They are also threatened of coastal flooding. This town was affected in 2011 due to flash flooding. It washed away part of one house and damaged household items of many houses in the town. The flood height was raised about 1 meter in some locations.

5.1.2. Methodology

Census office provided visitation records for EDs in Gouyava town. These EDs were selected because they are particularly vulnerable to flooding and they were also affected in the 2011 flood. In a notepad laptop with ILWIS software, building footprints and pansharpened Pléiades high resolution images of these ED were loaded. Small size maps with image and buildings were also printed for easy reference of geo-locating buildings. For the characterization of buildings, some attributes (use type, occupancy type, no. of floors, construction type, building code, household code) were added in the building footprint map.

Support of two local residents was secured for guidance and to identify respective buildings. One of them was earlier involved in the census in the same area. The primary task was to link buildings and household codes from visitation records to the respective building footprints with the support of satellite imagery and knowledge of local guides. With the help of street name and name of household head, the local guides (figure 5.3) were able to locate the house of that person in that particular street from where building numbers were potentially started as per visitation record. Once we found the starting point physically for ED with respective visitation record, from there on, we had to reconstruct survey the path of Enumerators they may have taken in 2011 for housing census. For each physically identified building on a particular street with respect to visitation record, same building and household numbers were entered in the corresponding building footprint table directly in the laptop. By assigning same building number from housing census to corresponding building footprint from physical planning unit, we were able to link two datasets and geo-locate census data with buildings. Enumerators in the course of population census they use same building and household numbers to collect population information on specially designed data collection forms as shown through arrows in the figure 5.2 (center). Complete census form is attached as annexure 2.



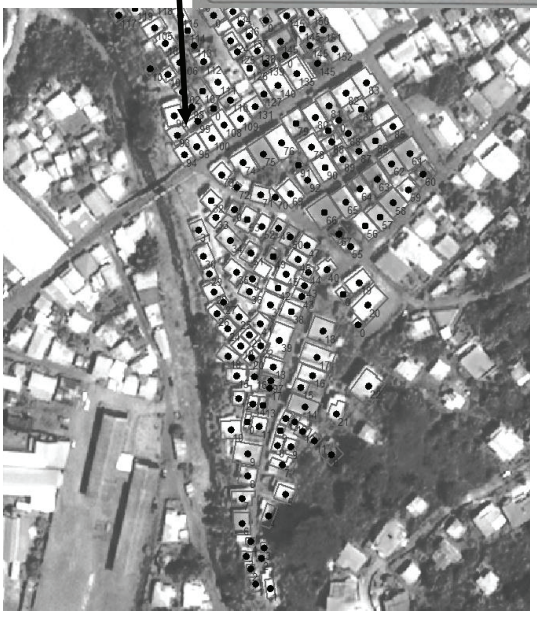


Figure 5.2: A snapshot of part of visitation record (top) small part of front page population census data collection form (centre), and linking census visitation record with building footprint (bottom) by building and household numbers.

The overall accuracy of geolocating census is satisfactory and can be expected that over 75 % of the houses have been correctly geo-located. There were many difficulties as well. For example, some houses were vacant at the time of survey and now people are living in those houses. Similarly, at the time of this survey, many houses were vacant but at the time of survey they were occupied. Moreover, in certain houses the occupancy of family was different even the occupancy type was changed. Also, there are many shack houses (make shift), which they just move around. There was fire in the area and 3-4 houses were burnt as a result. Some mistakes were also found in visitation record related to numbering buildings and households for example duplicate numbering, mistakes related to household head etc.

Figure 5.3: Checking in visitation record (left). Cluster of irregular houses (right)

5.2. Preparation of a population distribution map (Daysmetric mapping)

As aforementioned about the problem related to missing coordinate information of dwellings in the census data, the other associated concern was how population is physically distributed within an enumeration district. Census office collected data at the household level and they provided aggregated data at the ED level. It gives the impression that all dwellings and population are uniformly distributed across each ED. However, in reality it is not the case as shown in the figure 5.4 as an example. Large part of this ED is uninhabited. Particularly EDs in the rural part of the country, built-up area exists only in smaller portions, mainly along the coast, and large part is other land use type. To perform an exposure analysis, this data will not be useful in the current state unless population is redistributed over inhabited areas on;y.

Figure 5.4: Snapshoot of an enumeration district (red boundary)

To resolve this problem, a population distribution map is produced by using census data as the main source of population and building footprint as auxiliary source employing basic concepts of dasymetric mapping. The principal concept of dasymetric mapping involves the process of disaggregating spatial data to a finer unit of analysis, using supplementary (ancillary) data to help refine locations of population or other phenomenon being mapped (Maantay & Andrew, 2009). In order to use both census data (population) and building footprints to produce a population distribution map for exposure analysis it was imperative to combine both datasets in some-way. In other words, the task was attaching household population with building footprints. However, the challenge was that there was no key or common attribute to join them in some form. The conceptual flow for the preparation of population distribution map based on 2011 census data is presented is the figure 5.5.

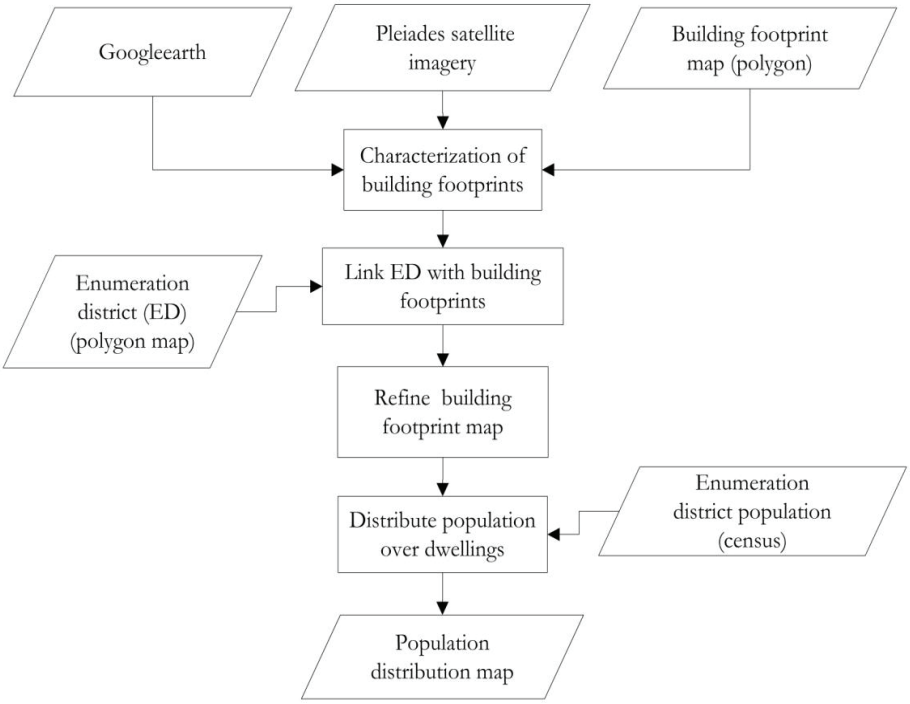


Figure 5.5: Conceptual flow diagram of preparation of population distribution map

5.2.1. Characterization of building footprints

The first main step in preparation of a population distribution map was the characterization of buildings by classifying them based on their possible use. It was necessary to separate residential buildings from all other buildings so that census derived population data is attached only with residential buildings. Since, no attribute information was attached with building footprints to make this distinction; the only possible option was make use of latest available satellite imagery and Google Earth. Also, there was fair impression of the island due to the field visit, which could supplement in recognizing certain structures or features in visual image interpretation. High resolution imagery of the French satellite Pléiades was available for the whole island. The resolution of multi-spectral image is 2 meters whereas, panchromatic is 0.5 meters. Both images were fused to get the highest possible resolution with colour. This provided a good quality data that could be used together with building footprints to characterize buildings. Building footprints were overlaid on Pléiades satellite imagery in ArcGIS for visual interpretation. Two attributes; 'Use type' (i.e. commercial, residential, resort etc) and 'occupancy' (i.e. supermarket, shop, restaurant, dwelling, hotel, cottage etc) were added in the buildings table to add relevant information. Similarly, the building footprint

map was exported to KML (Keyhole Markup Language) format to view with Google Earth. Luckily, for many parts of the country, high resolution images existed in Google earth.
Obviously, it was not possible to easily distinguish residential buildings from other buildings even on very high resolution imagery. So, the strategy was to identify and isolate large buildings, which could potentially be hotels, industry, schools, churches, offices, business centres, or supermarkets etc. Snapshots of some examples of buildings identified using Google Earth are presented in figure 5.6. After identifying these visible and known structures, the remaining buildings will potentially be residential establishments. In Grenada, over 85 % of the residential houses are separate houses, therefore; one cannot expect large population living in big buildings or apartments. Through, the visual inspection all large buildings and other obvious buildings like schools, forts, churches etc. were identified and characterized (table 5.1) manually. The remaining buildings were considered as residential houses and attributed them 'residential'.

Use type	**Occupancy type**	**Use type**	**Occupancy type**
Resort	Hotel, beach resort, cottage, holiday apartments, villa	Religious	Church, Mosque
Commercial	Supermarket, market, shop, restaurant, mixed commercial area, commercial, car rental, fuel station, Fish market, Mechanic, material lab	Airport	Airport
Combined commercial and residential	Combined commercial and residential	Recreational	Sports, cricket Stadium, movie palace, Yacht club
Educational	School, college, university	Port	Port, marina, port authority
Health	Hospital, elderly nursing home, medical centre, ambulance service	Residential	Dwelling,
Institutional	Government offices, Post office, mix office space, fire stations, police station	Cultural heritage	Fort
Community centre	Community centre	Graveyard	Graveyard
Industrial	Industrial, spice estate, power station, Agro industries,	Transport	Bus terminal

Table 5.1: Key for the characterization of building footprints

5.2.2. Linking census data with building footprints

In the next step, after initial characterization of buildings, it was essential to geographically link all these buildings with Census Enumeration Districts. In ArcGIS, using spatial overlay techniques all buildings located inside the boundary of a particular ED were selected one by one for each ED and assigned unique Enumeration District ID (which was introduced earlier - section 2.2) to the respective buildings. This way a relation is built between census data and building footprint map.

5.2.3. Refining building footprint map

I had information on the number of households in each ED and now I have also information on the number of potential residential buildings (dwellings) in each ED. However, the number of dwellings in each ED was much higher the than actual households reported through census. The simple reason was that the quality of the building footprint was not very good. Many buildings were digitized in several small pieces (polygons) thus; one single building was composed of many polygons and some of them really

Figure 5.6: Snapshot of examples of various buildings identified

1) supermarket & mall 2) Beach hotel
3) University of Grenada 4) Industry 5) Hospital 6) School 7) National cricket stadium 8) Beach resorts
9) Sea port area, and 10) Church (left) and Cemetery (right) (Source: Google Earth)

small ones. To build some kind of relation between the number of households in each ED as reported in the census data and residential houses from the building footprint map, it was imperative to clean multiple small polygons and other temporary small structures from the database without deleting main polygons. With careful observation on sizes of buildings on the satellite imagery in each ED and analyzing the average polygon size from the building footprint map for each ED, thresholds were set to remove small polygons from each building. Polygons smaller than $10m^2$, $17m^2$, $26m^2$, $37m^2$, $50m^2$, and $100m^2$ were removed depending on the average size of buildings in each ED

5.2.4. Population distribution map

A separate file was created only for the residential buildings (dwellings). The objective was to assign population to each dwelling. It was impossible to determine the exact number of persons living in each residential building since there was no any common attribute between household information from the census data and building footprint map from the physical planning unit. Making any rule based on the size of the residential building was not practical as well, because buildings were not very well digitized. The obvious choice was to distribute (equally) population of each ED from the census to the total number of dwellings in the same ED. Therefore, finally, the population distribution map (figure 5.7) for Grenada was generated by dividing the total ED population with the total number of residential buildings in the respective ED.

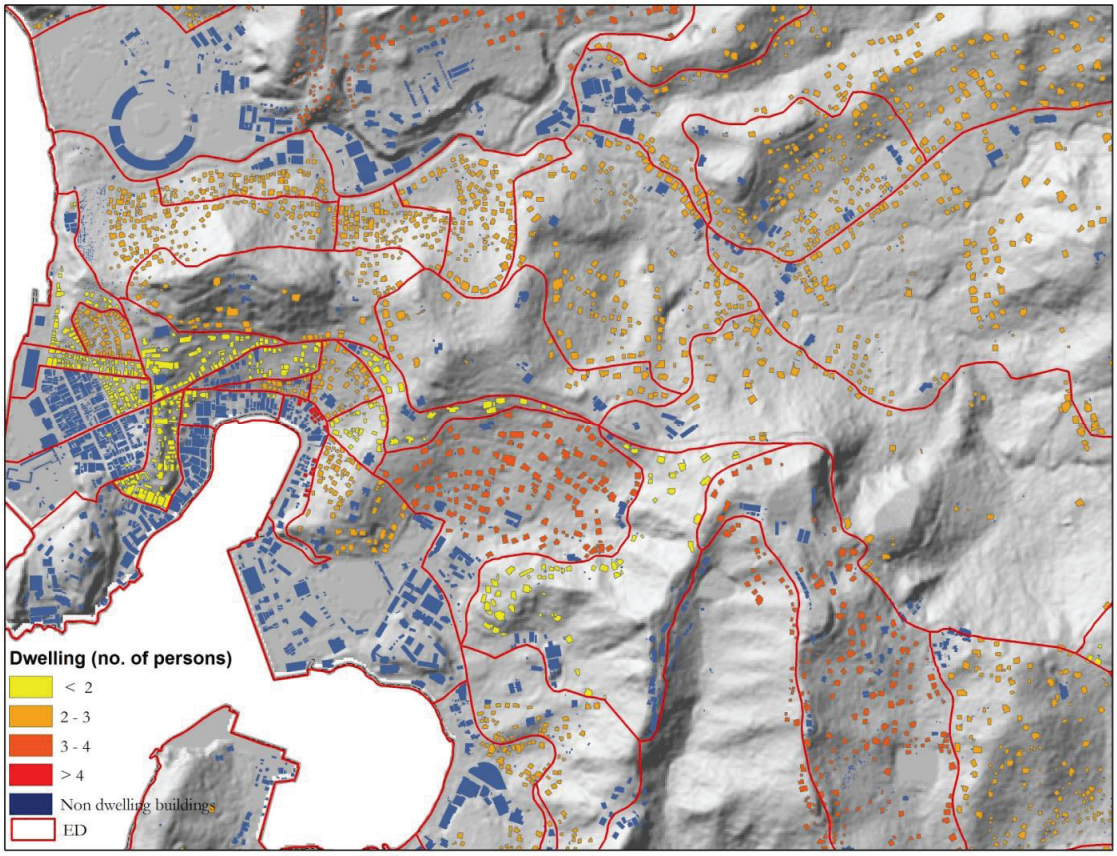


Figure 5.7: A snapshot of population distribution map showing St. George's main town

5.3. Establishing flood hazard matrix for spatial planning and risk analysis

In section 2.1 a list of required hazard information is presented that is potentially needed by spatial planning. However, in the context of Grenada and other target countries in the Caribbean, currently, they don't possess hazard maps that included intensity or magnitude information. ITC is currently producing national level flood and land slide maps for Islands under CHARIM project. These flood maps are being generated for 5, 10, 20, and 50 years return periods using OpenLISEM software. OpenLISEM is a deterministic model that is especially good for run-off modelling for small to medium size catchments. These maps provide information on flood height, velocity and flood extent. Such maps are indispensible in designing structure such as culverts, bridges, building control, and allocation of future space for physical development etc. As these products should be used by the planners, the various return period maps will be combined based on intensity i.e. using flood height information, and recurrence interval. This can be done using a so called hazard matrix, which is usually constructed based on probability i.e. likelihood of occurrence of an event (hazard) in a certain area in a given timeframe and magnitude or intensity. For example, in Switzerland they have established a magnitude-probability matrix (figure 5.8) for flooding, which combines intensity (inundation depth or product from depth and velocity) and related probability.

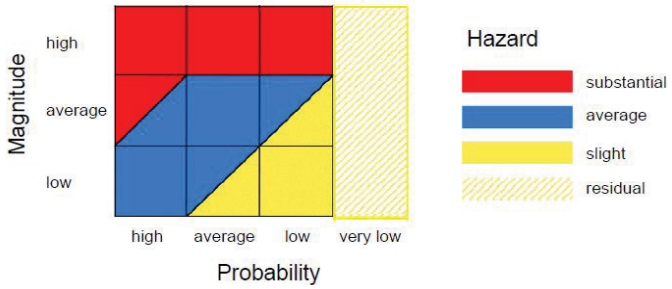


Figure 5.8: Flood hazard matrix as function of probability and intensity (Roberto, 2010)

Flood hazard maps are being classified with this scale and applied as a basis for spatial planning and formulating regulations (Roberto, 2010). Red is the elevated danger thus, prohibited area, Blue is moderate danger where buildings are allowed with specific restrictions (conditional use area), Yellow is low danger it implies that construction is allowed, however, critical infrastructures are allowed with specific conditions and awareness is needed. Rest of the area is a residual risk and usually not being considered for spatial planning (i.e. not evaluating area for rare events such as more than 300 years return period)

Following Swiss risk management concept, a hazard matrix was established (figure 5.9) based on probability and flood intensity. This is established by taking appropriate thresholds of flood heights (in meters) and probability of occurrence of flood of certain return period (i.e. 5, 10, 20, 50, 100), once in a 50 years. The return periods of 5, 10, 20, and 50 are selected because current hazard maps were available at this interval.

Return periods

Intensity (flood height in meters)	5 yrs.	10 yrs.	20 yrs.	50 yrs.	100 yrs.
2 > h	VH	VH	VH	H	H
h < 2	H	H	M	M	L
h < 0.5	M	L	L	L	L

Probability

VH: Very High
H: High
M: Moderate
L: Low

Figure 5.9: Hazard matrix based on flood intensity (height) and probability for various return periods

Following a mathematical expression (equation 1)(Roberto & Armin, 2008 ; Van Westen, 2013) was applied to calculate the probability that a flood of a certain return period event may occur at least once in the next 50 years. Probability is a quantitative measure that describes the likely occurrence of a particular event. It is conventionally expressed on a scale from 0 (very rare event has probability close to 0) to 1 (very common event has probability close to 1) (Valerie & John, 1997). Based on the percentage of chance of occurrence a specific class is assigned (table 5.2). For example, probability of occurrence over 90 % is classified as frequent. It means that there is high chance of occurrence of 5 or 10 or 20 years flood in next 50 years. The calculation of the probability of occurrence is subject to uncertainty, thus; the probability given to a certain event can never be precisely determined (Roberto & Armin, 2008)

$$P = 1-(1-1/T)^n \qquad \text{Equation 1}$$

Where n is given period of use (i.e. 50 years), T is the return period, and P is the probability of occurrence

Return period	Probability (P)	P (%)	Class
5	0.999	99.9	Frequent
10	0.994	99.4	Frequent
20	0.923	99.2	Frequent
50	0.635	63.5	Moderate
100	0.394	39.4	Low

Table 5.2: Probability of occurrence of a certain event with classification

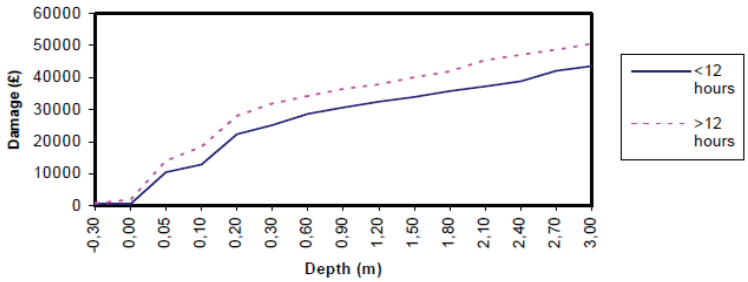
Regarding the selection of thresholds for hazard classes, the flood heights proposed in the Swiss system for spatial planning (Papathoma-Köhle et al., 2010; Roberto & Armin, 2008) were adopted, which was indicated under section 2.1 (table 2.2). A slightly different intensity scale at the regional level planning was proposed under ARMONIA project (Del 5.1) (ARMONIA, 2006). They defined three ranges based on depth namely; Low (< 0.5 m), Medium (0.5 – 1.25 m), and High (> 1.25 m). A flood hazard mapping exercise of Grenada (Cooper & Opadeyi, 2006a) classified flood map into three hazard classes by taking thresholds of; $h < 0.91$ m (low), $0.91 \text{ m} < h < 1.37$ m (medium), and $h > 1.37$ m (high).

For selection of a suitable threshold, it was also essential to know what is the dominant construction type in Grenada? An analysis (table 5.3) of census data indicates that over 52 % houses are concrete (it is assumed based on material of outer walls of buildings since direct construction type was not available), similarly, around 40 % of the houses made of wood. It reflects that predominant construction types in Grenada are concrete and wooden.

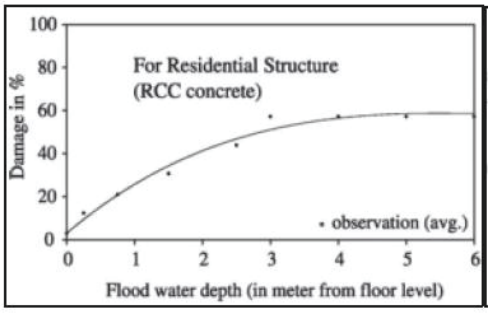
Outer wall material	**% age**	**Outer wall material**	**% age**
Concrete	52.23	Plywood	5.705
Stone	0.13	Plywood & concrete	1.253
Brick	0.183	Makeshift	0.233
Wood	28.29	Other	0.369
Wood & concrete	11.6		

Table 5.3: Main material of the outer buildings walls in Grenada (analysis based on census data)

Flood risk encompass two dimensions i.e. hazard characteristics (intensity, velocity, probability etc) and vulnerability of elements-at-risk (Kreibich et al., 2009). By using stage damage functions or vulnerability curves, potential flood damage to buildings is usually determined. Vulnerability curves (figure 5.10) from different studies were studied (for a general overview and no detailed analysis was made) to check if above



(A)



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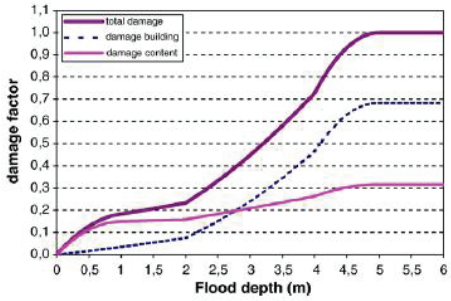

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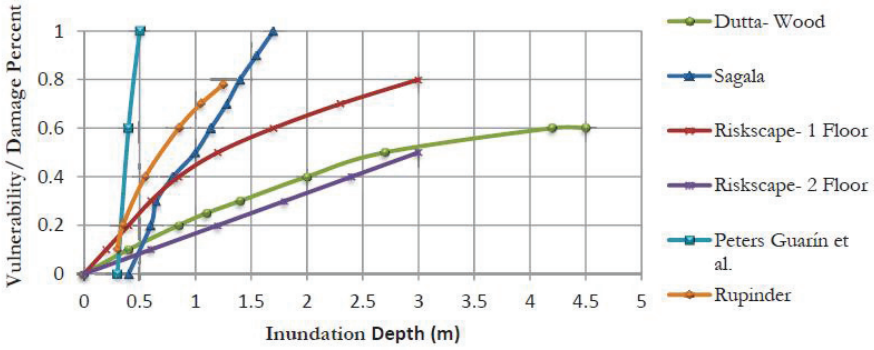

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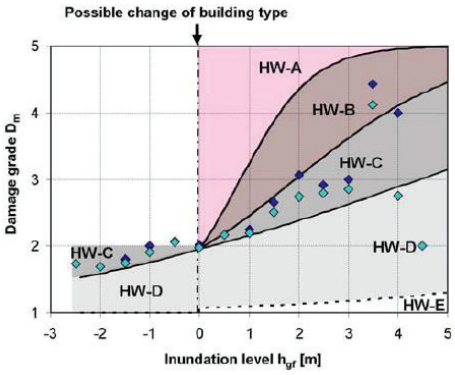

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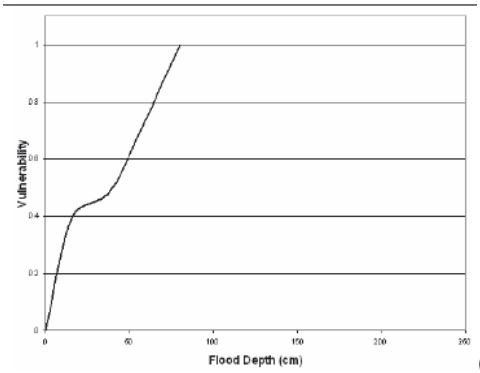

(F)

(A) UK (depth-duration-damage, direct damage value) (B) Japan (for residential RCC structures) (C) Netherlands (damage factor for houses; damage to buildings and house contents (D) reconstructed curves from different studies for wooden structures (E) Germany (damage grade and intensity based on actual flood events (F) Philippines (for Plywood walls and wooden floor)

Figure 5.10: Examples of stage-damage functions for flood

Source: A (Floodsite, 2007), B & D (Godfrey, 2013), C (Jonkman, Bočkarjova, Kok, & Bernardini, 2008) E (Schwarz & Maiwald, 2008), F (Sagala, 2006)

thresholds are relevant. It is evident that there is no uniformity in the damage factors of buildings. It is because they were constructed by employing different approaches and for different places. The broad construction type of structures might be the same e.g. wooden, but quality of housing significantly varies from one place to another; therefore, the damage factor of buildings also changes.
One main reason for selecting the Swiss thresholds was the fact that in Grenada and other target countries, residential houses are usually being built on stilts elevating about 0.3 - 1.0 meters from the ground or foundation is being elevated, or boundary walls constructed. Moreover, in some parts, people have tendency of constructing houses top down (figure 5.11).

Figure 5.11: (Left) a residential house built top-down (no construction at ground level) in Gouyave watershed. (Right) a residential house built on stilts at St. John watershed, Grenada

It is quite understandable that construction quality and type is different both in Switzerland and in the Caribbean and flood may behave differently to these structures. The main difficulty is that there is no building damage information vis-à-vis flood intensity to build a relationship and define thresholds and apply them in classification. Additionally, the local planning department has no such system or criteria of granting building permits based on locally defined thresholds for flood hazard. This resulted in adapting known thresholds from other regions.
By combining both intensity and probability classes hazard matrix is established, presented in the figure 5.2. Taking this matrix, available flood hazard maps are classified into 4 classes; no risk, low risk, moderate risk, high risk, and very high risk. What does this mean for planners is explained hereunder:

- Very high risk: Danger of human life inside and outside of buildings and danger of collapse of buildings. The intensity is high and very high possibility of occurrence of such an event. No any construction will be permitted. Needed intensive awareness programmes for people currently living in those areas. The relevant government department (s) may take necessary steps for mitigation. The residents may be encouraged to take possible protective measures

- High risk: Danger of human life outside and inside of buildings and possible damage to buildings. There is high chance of occurrence of such an event. No any building construction will be

permitted. Needed intensive awareness programmes for people currently living in those areas. The residents may be encouraged to take possible protective measures.

- Medium risk: Danger of human life outside of buildings is still possible. Building construction is permitted with specific conditions. Critical buildings such as hospitals, schools, elderly homes etc are not suggested to be allowed. Awareness raising programmes for general public is important.
- Low risk: Danger of human life outside of buildings is limited either due to low intensity or less frequent event. Building construction is permitted with some conditions. Critical buildings such as hospitals, schools, elderly homes etc are allowed with specific conditions. Awareness raising programmes for general public are encouraged.

5.4. Estimating exposed population and buildings to flooding

To undertake exposure analysis we have now information on flood and building footprints from the dasymetric mapping procedure with estimated population at each building level. In ILWIS, flood hazard maps were classified based on above defined hazard matrix to get flood hazard zones. Using spatial overlaying GIS techniques, number of buildings and corresponding population were estimated for each hazard zone. Results of exposure analysis are presented in table (5.4). They are organized similar to matrix. For example there are 27 dwellings (dw) exposed to very high hazard level. Similarly, there are approximately 111 people at high risk. In a total of 1830 dwellings are at flood risk.

	5 years		10 years		20 years		50 years	
	Dw	Pop	Dw	Pop	Dw	Pop	Dw	Pop
h > 2m	27	68	33	79	34	79	48	111
2m > h > 0.5 m	124	293	124	298	139	336	299	717
h < 0.5 m	550	1273	639	1498	710	1684	1483	3491
Total	**701**	**1634**	**796**	**1875**	**883**	**2099**	**1830**	**4319**

Table 5.4: Estimated number of buildings and population exposed to different flood hazard zones classes

In two EDs of Gouyave (1102, 1101) no buildings are potentially exposed to very high and high flood class (table 5.5). However, during the field visit of the area, people indicated (figure 5.12) that flood level in 2011 was about 1 meter in some locations. It appears that flood model has under estimated flood height in some locations. This may be the result of poor quality of DEM.

Gouyava	5 years	10 years	20 years	50 years
	Buildings			
h > 2m	0	0	0	0
2m > h > 0.5 m	0	0	0	0
h < 0.5 m	16	27	27	173
Total	**16**	**27**	**27**	**173**

Table 5.5: Number of exposed buildings to flooding in two EDs of Gouyava

Figure 5.12: Local residents indicating flood level of 2011 in Gouyava town

Landslide maps of Grenada were also available which were recently produced by ITC. One was landslide susceptibility map and another landslide inventory map derived from post hurricane Ivan satellite imageries. (Multi-hazard map of landslides and flood map is attached as annexure 9). Landslide susceptibility map had three classes, low, moderate and high. Number of buildings and population (table 5.6) that was exposed to specific susceptibility class were identified for each parish. Only 1020 dwellings and estimated 2,427 people are potentially exposed to high susceptible class and nearly half of them belong to St. George.

	Susceptibility						**Total**	
	Low		Moderate		High			
Parish	Dwelling	Pop	Dwelling	Pop	Dwelling	Pop	Dwelling	Pop
St. Andrew	9061	22444	1438	3541	67	174	10,566	26,160
St. David	3719	8418	1836	4103	156	338	5,711	12,859
St. George	9260	22794	5538	13255	546	1307	15,344	37,356
St. John	1834	4418	1508	3633	148	352	3,490	8,403
St. Mark	1104	2663	571	1537	51	137	1,726	4,337
St. Patrick	3789	8696	742	1646	52	119	4,583	10,461
Total	28,767	69,433	11,633	27,715	10,20	2,427	41,420	99,575

Table 5.6: Number of exposed dwellings and estimated population to landslide (susceptibility)

Similarly, the number of dwellings and population that is exposed to landslide inventory is presented in the table 5.7. They are separated for landslides and debris flow (stream floods). Only in parishes of St John and St. Mark buildings are exposed to debris flow.

	Landslides		Debris flow	
Perish	Dwelling	pop	Dwelling	pop
St. Andrew	52	131	0	0
St. David	25	62	0	0
St. George	67	166	0	0
St. John	49	112	36	90
St. Mark	40	102	23	53
St. Patrick	14	34	0	0
Total	**247**	**607**	**59**	**143**

Table 5.7: *Number of exposed dwellings and estimated population to landslide (inventory)*

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Physical planning process and use of hazard and risk information

- Physical planning in 5 target countries is taking place broadly at two levels; development planning and development control. However, overall, development approach is reactive and limited forward planning is taking place. Only Grenada has formally approved national level physical development plan. St. Vincent, St. Lucia and Dominica are currently in the process of developing such a plan for their respective countries. Whereas, Belize has no Central Authority physically exists to take such an initiate and develop a plan.
- The use of hazard maps in planning is limited in all these countries. Use of risk information is virtually absent. Only physical planning unit of Grenada has substantive example to present, where they introduced the concept of "development limitation map", that is part of Grenville area development plan. Conceptually, it is very good idea, but in the context of its practical applications, there are many foreseeable limitations/challenges.
- There are many reasons of limited use of hazard information in the planning including;
  - No specific legal requirement to use them;
  - Usefulness of most of the available maps is limited (in terms of scale, currency, substance) to be effectively incorporate them in planning with certainty;
  - Limited technical know-how of staff about hazard and risk information and their specific applications in planning;
  - There are no specific government agencies in these countries to produce such information and provide them for planning. Also, it is not their primary responsibility of planning units to undertake mapping exercises. They have to use them when they are made available by other agencies. It is similar in Europe as, one of the main conclusions of the ARMONIA project (Fleischhauer et al., 2006) was also that the spatial planning is not responsible for undertaking risk assessments, rather; it is an end-user of assessment results provided by other sectors.
- Considering current planning situation, availability of hazard information and other related resources, it may not be practical and possible for directly integrating hazard maps into development work in all the target countries. However, it is important to consider them at each level of planning; plot level, local, regional, and national level for risk management. This can be achieved rather lose arrangement by independently consulting available hazard maps when making decisions on space. Direct binding arrangement will be difficult due to many practical reasons including;
  - They don't have legal cover i.e. no specific legislation exists;
  - In all these countries no organization is locally generating such information to supply them timely. They are heavily depending on external assistance for such information
  - Most of the available hazard maps are qualitative and missing important information that is needed for planning decisions
  - Hazard maps are to be revised/updated regularly to current conditions, which then require resources. It would be dangerous to use maps that are not revised to the current terrain conditions
  - Some of these countries, most of the land is privately owned. For instance, in Grenada over 80 % of land tenure is in private hands and government has to work very closely with the local community to secure their ownership and support in implementation of such decisions
  - In a nutshell, a holistic, an integrated system that is required for a full integration is lacking in all these countries.
- In this study, a flood hazard matrix is proposed for Grenada following Swiss risk management approach that is based on flood intensity (height) and probability. The typical classes proposed here

are; very high, high, moderate, and low risk. Since there was no information available on damages caused by various flooding events for Grenada, it was difficult to define significant thresholds that are relevant with respect to different buildings types. Therefore, Swiss criteria were employed to define intensity levels. The physical planning unit of Grenada may use this classification scheme for their planning purpose. The classified flood hazard maps could directly be applied for both development planning and control. For example, when they wanted to prepare physical development plan for a new region or planning to revise their existing national physical development plan this map will be indispensible source of information to decide on future space and make differentiated decisions on space allocations, which is typically called risk priority zoning (Greiving & Fleischhauer, 2006; ITC & CNN, 2012). Currently, the planning unit doesn't have any quantitative flood hazard map and specific classification scheme. The building permit department could utilize this product as basis to decide on whether to allow with or without conditions for construction of a building in a particular flood prone area. Moreover, for the sub-division of lots and subsequent development in an area, the planning unit will be able to better negotiate with potential developers on possible risk reduction measures. Furthermore, existing development limitation map for Grenville area could also be revised taking into account flood hazard matrix and new flood information from these maps.

- Through an exposure analysis, number of dwellings and population were estimated that are at risk of certain flood class and landslide. Since, we don't know the individual characteristics of each buildings, we cannot make any statement whether these buildings will be damaged or not in case of an event. However, the planning unit or other more concerned government department make use of this information to prioritize sites for implementing any type of mitigation measure.

6.2. Vulnerability analysis

- Latest census data was used to examine the vulnerability by producing fragility & resilience indices (vulnerability index). Although, the assessment was undertaken at the national level by using aggregated data of enumeration districts (ED), the results provide insight on household vulnerability and they are basically reflection of household's resilience and fragility. Since, no other auxiliary data was included to define indicators, therefore, results could also be called as social vulnerability of households (i.e. fragility index) and social resilience of households (i.e. resilience index)
- Census data in Grenada is a good source of information on various aspects that are particularly needed to produce a social vulnerability index. The data is available on housing, socioeconomic, health, and education apart from demographic information. The major drawback of this dataset is that it is not geo-located i.e. no spatial information of buildings were collected. Overall quality of census data was fine. It was complete but is difficult to make any statement about actual content (substance) of the data because it is difficult to ascertain how accurately data was collected by survey team. Some inconsistencies were found in some datasets. For example, the number of households on rent/lease was not matching with the number of households paying rent/lease or those on mortgage. In some EDs, people didn't reply to specific questions, so large number of "not stated" figures noticed. Similarly, there were visible differences in some EDs, where number of households (dwellings) in census data for a particular ED was not matching with the building footprints for the respective ED. It was also evident when cross checked with satellite imagery and Googleearth. In this context, there will always be some uncertainties when using census data.
- I adopted an indicator based approach to produce both indices (vulnerability index) by using ILWIS SMCE module to combine various variables based on defined criteria and weighing scheme. The proxy variables that were selected from the census data were; Age (elderly, children); Gender (female); housing (nature of ownership of dwelling, quality, bedrooms); livelihood sources; education; health (general illness, disability); access to internet; insurance (health, contents, dwellings); and vehicles used for private use. Most of these variables are in consistent with what one could often find in the social

vulnerability literature. According to the Cutter et al., (2003), " there is general consensus within the social science community about some of the major factors influencing social vulnerability" they are included, lack of access to resources (information, knowledge, technology); restricted access to political power and representation; social capital; building stock and age; physically limited individuals; and type and density of infrastructures and lifelines. Conflicts arise when selecting variables to represent these broader themes (Cutter et al., 2003). Further, Cutter (2003) complied a detailed list of variables that are frequently found in the literature and pointed that among generally accepted factors are age, gender, race, and socioeconomic status. A research (Catherine, 2010) on vulnerability analysis to volcanic hazards for St. Vincent (Caribbean) selected similar variables for social vulnerability analysis based on interview with the local community. The suggested variables were disability; poverty; health; livelihood; education; house; Isolation; proximity; transport; and dependents (elderly and children).

- By evaluating both fragility and resilience indices it can be concluded that generally there is uniformity in household's vulnerability and underlying conditions across Grenada. In general there is no higher resilience and fragility is also not high. They are in a state of intermediate condition. There is implicit assumption that communities low in resilience are also high in vulnerability (Bergstrand et al., 2014). It seems this assumption is not fitted well here as there is no large difference between resilience and social vulnerability. However, the final disaster resilience index (DRi) indicates EDs in the south, mostly in St. George's are doing better in terms of resilience as ratio between resilience to fragility is quite high compared to EDs in the north. This may be the fact that south part is relatively better developed due to tourism and socio-economically relatively more stable.
- What message planners can take from these indices and how this information could possibly be used to inform planning? The results of vulnerability assessment are important as they can be used to identify communities that are susceptible to suffer damage (Müller et al., 2011) and identifying underlying factors contributing in vulnerability conditions (Dewan, 2013; Tate, 2012). However, it is pertinent to note that they can't provide any direct solution of any underplaying vulnerability issue, rather they are only indicators of possible presence of vulnerability, which may be required to consider in the planning (Dunning & Durden, 2011). Moreover, such instruments are particularly useful to initiate discussions on prioritizing areas for possible risk management and development planning. For instance In Grenada, the physical planning unit has main responsibility of development planning and producing national level and region-wise plans for future development. These maps are good source for starting their discussions in-house and with stakeholders for prioritizing vulnerable regions for future development and thereby vulnerability reduction. Also, each indicator or group of indicators (sub-theme) could be analysed independently for each community and more specific actions can be taken for vulnerability reduction. For example, one ED is identified as most vulnerable with respect to squatted dwellings. The physical planning unit may take note of it and determine underlying cause of high concentration of squatted dwellings in this specific area. Similarly, fragility with respect to physical vulnerability (sub-theme), there are many EDs found in the north, where relatively physical vulnerability is quite high. It implies that dwellings are old and building walls are very weak. In those communities, government may investigate further and take some kind of targeted measures to reduce their vulnerability. Also, with respect to emergency planning, one could expect that those communities may affect relatively more in case of a hazard event such as hurricane.
- The big question is what is the validity of these indices? Are they reflecting actual vulnerability of households? It is not an easy question to reply directly. Indices present level of vulnerability that was measured indirectly by combining various proxy variables, by assuming that they are representing those factors that influence vulnerability. For instance, age (children and elderly) as proxy for lack of strength, lack of mobility, lack of self care, lack of participation in disaster preparedness activities and higher education as proxy for disaster awareness, good socio-economic status etc. However, they do

not represent actual nature of a hazard or vulnerability (Simpson & Katirai, 2006). Therefore, one of the main limitations of using indices is that there is no simple way to get scientific validation of a particular index (Simpson & Katirai, 2006). Nevertheless, the quality of output depends on many factors including selection of variables, weighing, quality of input data etc. The selected variables for this study were mostly similar to what are commonly agreed by the social science community as mentioned earlier. Weighing of indicators and groups were the most difficult part because it involves lot of subjectivity and weighing is subjective in nature (Simpson & Katirai, 2006). I applied both personal judgment and weighting scheme of SMCE tool (Pair-wise comparison) for consistency in weighing factors, where possible. The main consideration for weighing was the fact that how specific variable is important in the context of Grenada. For example, assigning relatively higher weights to weak livelihood sources as compared to housing. Because, in Grenada, over 75% people own house but still there is certain level of poverty because of limited options of livelihood. The results of both indices are presenting more or less the similar picture of vulnerability. This indicates that the overall construction and arrangement of model was logical and uniform. Inspite of the fact that in both indices some of the variables were different from one another. For instance, disability, health, and demographic were not included in the resilience. Whereas, insurance, vehicles, internet were not part of fragility index. Rest of the variables were different but they were of the same nature for instance weak income source and strong income sources, strong wall material and weak wall material etc. Simpson & Katirai (2006) in their working paper on Indicator issues mentioned that "the only way that any sort of metrics related to the disaster field could be validated would be to continually test them after major events and refine them accordingly" of course, this would take long time. For instance, to validate the SoVI, Cutter (2003) conducted a correlation between the frequency of presidential disaster declarations by county and SoVI index scores. In Grenada the major disaster was in 2004 after the passage of hurricane Ivan. There was colossal damage of housing and other infrastructure across the country. An assessment report (World Bank, 2005) indicated that major damages were in the parishes of St. George, St. David, and St. Andrew, and St. John where damage was over 90 %, whereas; the northern part of the country was relatively less affected (only 20% damage).

- Initially, indices were derived using percent as input data type, however; in order to check the sensitivity of the model, indices were created again by taking absolute numbers of each variable. Results were quite different. It appeared that taking absolute number is hugely influencing result with respect to ED size. EDs with larger household size got higher pixel values and smaller size EDs got smaller pixel values. In other words, those EDs were mostly influenced which were on the tail and head in terms of household size. Whereas, with respect to percent, EDs will smaller sizes were bit over influenced. It can be concluded that when there is large difference in sizes (in this case number of households) across EDs taking percent as input unit would give more balanced result. It may also be wise to find some approach whereby a combination of both units can be taken, where variables are independent of size, for example, squatting in an area.
- In order to counter the issue of over/under influence with respect to type of input data and potential influence due to ED sizes, fragility and resilience were calculated again by taking average of both indices. Fragility index derived by taking percent and fragility index derived by taking absolute numbers were added and average calculated. Average resilience was similarly calculated. This approach provided a balanced index. Since, mean of original indices were very low, once can't expect a major change in the results. Final disaster resilience was derived by dividing resilience with fragility. The result indicated that EDs in the south are relatively more resilient compared to EDs in the north aand north-east.

6.3. Strengths and weaknesses of the measuring vulnerability using indices

6.3.1. Strengths

- The indicator based approach is widely being used within the framework of disaster risk management to visualize and determine the relatively vulnerability of communities. The good thing is that it can be implemented at the various levels to compare different communities/countries for instance, UNDP's DRI (at the global level), The Prevalent Vulnerability Index & Local Disaster Index (regional level for Latin America & the Caribbean), SoVl (for the USA), and several other models exists at the local level.
- Indices can be quickly constructed by combining various types of datasets including biophysical and social variables by employing techniques ranging from simple to more sophisticated approaches. It has diverse applications including disaster management, planning
- An index combines various group of indicators to produce snapshot of reality (Simpson & Katirai, 2006), which otherwise not possible by using individual indicator alone (Cutter et al., 2010). Moreover, they are attractive to policy makers because they provide a set of metrics which allow for comparison across communities (Cutter et al., 2003).
- Constructing vulnerability index using SMCE approach is particularly useful because it involves stakeholders in making decisions and building consensus, for example; deciding on the relative importance of variables that influence vulnerability and assigning weights accordingly. Both spatial and non spatial factors can conveniently be combined to produce an index.
- Census data was used to produce fragility and resilience indexes. By using this dataset many important variables can easily be extracted such as age, gender, disability, education, socio-economic status etc to generate vulnerability index and there is no need to undertake any special survey, which will be very resource demanding. Census office provides data and regularly new survey takes place every 10 years. Moreover, a historical reconstruction (Cutter et al., 2003) of vulnerability (how vulnerability changed over the period of time) is possible if standard method is applied by employing similar indicators from the census data over a period of time.
- It is handy technique because a complex problem (main goal) is decomposed into sub-themes and variables are grouped accordingly in a hierarchal order. By comparing and combining variables and sub-themes goal is achieved in a relatively simple manner. This process not only helps in simplifying a complex problem but also helps in better understanding of the phenomenon and interrelation of the variables and their relative importance. Moreover, each driver (variable) or group of drivers (sub-theme) can be looked into individually and analyze which communities are most susceptible with respect to a specific driver that influences vulnerability
- Measuring vulnerability at ED level is itself quite a detailed work, which provides a good snapshot of vulnerability at household level. In the context of Grenada it is particularly useful due to its relatively smaller size and also small sizes of EDs (average is 126 households).

6.3.2. Weaknesses/Limitations

- Indices can't be applied directly to design any solution related to vulnerability reduction. They are merely indicators of possible presence of a problem that needs further elaboration. Moreover, they are relative measure of vulnerability across communities. It is not possible to make interpretation of each index. For instance, we cannot say that a community with vulnerability index of 0.4 is two times more vulnerable to a community of index 0.2.
- The important step in the creation of indices is selection of suitable variables because the quality of indices is depends on the quality of input variables. Who should decide which variable should be included in the model? Are they really subject to the context and relevant with respect the community under study? In this regard clear understanding of the local vulnerability conditions is crucially important for the selection of variables and subsequently assigning weights.
- The most challenging part in measuring vulnerability using indices is weighing factors with respect to

relative importance of each factor. There is subjectivity involved in the process. Some experts even do not apply weighing. They are of the opinion that there is no defensible theoretical or practical justification for assigning different weights across variables (Cutter et al., 2010). I assigned weights based on personal judgment and understanding about the phenomenon and using AHP. Weighting by expert judgment is not reproducible.

- The major weakness of using indices is that there is no easy way to get scientific validation of a particular index (Simpson & Katirai, 2006). It is particularly difficult because social vulnerability is not a directly observable characteristic (Tate, 2012). Validation can be done based on case studies (Cutter et al., 2003; Eidsvig et al., 2014; Simpson & Katirai, 2006) of past hazard events. In many cases, they may not be available.
- Indicator based approach is very sensitive with respect to type of data (absolute values, percent, ratio etc) that is being used as input to the model and scaling method employed.
- One of the main issues in using census data is that we don't have any control over the quality of the data. We have to use it whatever someone has collected. The data may be complete, but it will be uncertain that how accurately enumerators have collected this data and how overall data has been processed and organized. Moreover, census data becomes available only after every 10 years (or even more because of its processing time) and dataset becomes less accurate with the passage of time, typically called "data decay" (Simpson & Katirai, 2006). The other limitation of using aggregated census data is that it is not possible to make criteria based on joint variables. For example, number of elderly (e.g. over 65 age) persons and disabled (or other health problem) in an ED. Similarly, single parent women and poor. This type of information is handy and clarifies the actual vulnerability conditions of households. In absence of a refine data, there will always be some level of biasness in the input data for the model. For instance, it is not necessary that all elderly persons are frail and weak. Similarly, it is quite possible that single parent woman has good socio-economic status.
- One of the main shortcomings in my approach is that I relied mainly on census data to construct indices. Census data is collected for a different purpose and it lacks some of the important information that is needed to measure vulnerability. For instance information on social and organizational systems, community networks, community preparedness all are important factors to consider for measuring resilience (Cutter et al., 2010).
- No statistical analysis was undertaken for selecting variables to test any potential multicollinearity among the variables. Some literature on indices suggests performing statistical analysis such as factor analysis to simplify complex variables and group them based on common characteristics. Some of the variables which I have included may essentially are measuring the same aspect, particularly variables related to socio-economic status. By carrying out such tests data could be refined thereby improving overall result.
- These indices are generalized as they are not specific to a particular natural hazard. However, most of the variables included are equally relevant for most of the common hazards in the area.
- There was no break-down of available population information based on age to separate girls (children under age 5) and above. Therefore, total female population was also included girls as well as women in the analysis. It essentially double counted girls since they were already included in the children group.
- The Pair-wise weighing technique in ILWIS is not flexible.

6.4. Recommendations

- Physical development planning/Town country planning Acts in all countries needs legislative strengthening for risk considerations in development planning and control.
- With respect to development control at plot level, it might be good to build capacity of Development Control Officers (DCO) in basic hazard assessment techniques, particularly related to landslides and flooding because they visit sites for feasibility of location with respect to designs and drawing. A

simple DRR check list may be designed and included for assessment purpose. It is handy in absence of large scale hazard maps.

- Grenada and other target countries being Small Island Developing States (SIDS), they have limited resources and relatively higher vulnerability. Structural mitigation measures should get less priority. Risk management using non-structural measures particularly through spatial planning is crucially important. In this, regard, the role of respective national disaster management agencies of all countries is important. They have to take a proactive role in mainstreaming DRR in their national development work. Currently, they are predominantly involved in disaster preparedness and response work.
- The physical planning unit of Grenada can improve population distribution map that I prepared by using other auxiliary data they may have and importantly their local knowledge. They may employ same daysmetric mapping approach. This will be very good source of information for their development planning
- Currently, Grenada has no record of historical hazard events and associated damages. In the absence of such information it becomes challenging to undertake hazard and vulnerability assessments. There is as such no concrete information to undertake any frequency-magnitude analysis and validate any model. For instance, to develop flood hazard matrix, I had to adopt Swiss criteria because information was lacking on past flood events and damages of buildings. The national disaster management agency of Grenada has leading role to play in maintaining such a database.
- Improvement in the available spatial data. The quality of current available data is not good. They are in different coordinate systems, their positional accuracy is low and as a result GIS layers are not sitting on top each other precisely. The quality of Digital Elevation Model (DEM) is not good, which is a basic requirement for any terrain related analysis and modeling. They have building footprints for the whole country but without a single attribute information. All related organizations in Grenada may work collectively to improve and standardize spatial data.
- It would be very good to develop accurate building footprint maps with attributes that can be used for hazard and risk assessment s but also for other purposes.
- The Central Statistics Office of Grenada conducted survey in 2011 but they didn't collect geographical coordinates of buildings where households live. The utility of census data becomes limited to other applications such as risk assessment. In the next census they should plan to collect building coordinates as well. Alternatively, through a joint effort of all concerned organizations in the country, they recollect building footprints with better quality and in the time of census the field enumerators will just assign unique code from the building footprint to the respective household. The third option could be the census department geo-locate buildings in each ED on phase-wise by employing the approach I adopted for Gouyave area. However, before taking such an initiative they have to improve the quality of existing building footprints or freshly digitize buildings with latest high resolution satellite imageries, which they have already available

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APPENDICES

ANNEXURE 1

INTERVIEW QUESTIONNAIRE

Disclaimer:
This questionnaire has been prepared as part of an MSc. research being carried out in 5 countries in the Caribbean. Information collected through this questionnaire will be strictly used for this research and will not be shared with anyone without prior approval of the respective authority in the physical planning department.

GENERAL SECTION	
Chief Physical Planner:	Country:
Filling date & location:	Signature:
Researcher: Mujeeb Alam, Applied Earth Sciences, Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, The Netherlands E-mail: m.alam@studnet.utwente.nl	

Working definitions or Key	
Name	**Explanations**
A) Hazard maps (products)	a) Hazard (danger) map b) Susceptibility map c) Intensity map d) Index/Extent map e) Inventory map (g) Other
B) Hazard information (parameters)	intensity, magnitude, frequency, depth, volume, velocity, impact pressure, slope gradient, probability of occurrence, other (this is not an exhaustive list, please add additional parameters in the respective fields)
C) Risk information	i) (hazard name) Risk map (qualitative), ii) (hazard name) Risk map (quantitative) iii) Loss (monetary) iv) Loss (count) v) Annualize risk (monetary)
D) Vulnerability maps	Vulnerability maps such as vulnerability index
E) Hazard and risk information	Includes A, B, C, and D
F) Hazard product scale	1) Small scale map (1:50,000 – 1:100,000) or may be smaller 2) Medium scale map (1:25,000 -1:50,000) 3) Large scale map (1:5,000 -1:25,000) 4) Detailed map (1:200 – 5,000)
G) Hazard criteria	What hazard specific parameters are relevant to consider for specific spatial development problem, for example, potential flood prone areas having flood **depth > 2** meters is not suitable for siting of any building, Locations with slope **gradient > 20°** are not suitable for settlement etc The hazard criteria may involve a single parameter or a combination of parameters such as depth and velocity etc.; however, it is indispensible to indicate value (or range of values) for each relevant parameter considered relevant

SECTION 1: LEGAL & INSTITUTIONAL FRAMEWORKS FOR SPATIAL PLANNING

1) Is there a national land use policy in place?
   a) Developed and approved b) Developed and in approval stage c) Not developed yet

2) Is consideration of disaster risk management addressed in the national land use policy (in case, policy is developed or in the process of development)? Yes/No

3) What type of disaster risk management related considerations taken into account in the national land use policy (in case, policy is developed or in the process of development)?

4) What are the legal frameworks (acts/ordinances) that govern spatial planning in the country? Please indicate the names of the concerned legal documents.

5) Is the consideration of risk mitigation (natural hazards) incorporated in the Physical Planning Act? Yes/No

6) What are the specific considerations taken into account in relation to risk mitigation in the Physical Planning Act?

7) Is there a national physical development plan in place?
   a) Developed and approved b) Developed and in approval stage c) Not developed yet

8) Is consideration of risk mitigation (natural hazards) included in the national physical development plan (in case, the plan is developed or in the process of development)? Yes/No

9) What are the specific considerations taken into account in relation to risk mitigation (natural hazards) in the national physical development plan (in case, the plan is developed or in the process of development)?

SECTION 2: HAZARD AND RISK INFORMATION

Q2.1.What natural hazards are considered to be relevant (in the context of physical planning), which may occur and cause damage (injury, death, economic losses) in your country?
Please tick (√), on all significant hazards

a) In land (flash) flooding	b) Landslides	c) Coastal floods	d) Hurricane
e) Volcanic eruption	f) Earthquake	g) Tsunami	Other

Q2.2.What types of hazard products are currently available for physical planning on above hazards?

Hazard	**Hazard products**	**Scale**	**Produced/provided by**
In land (flash) flooding			
Coastal floods			
Landslides			
Volcanic eruption			
Earthquake Other			

Q2.3. Does the physical planning department use above hazard products (Q2.2) for planning? Please indicate which products are you using and for what purpose.

Map	**Hazard products**	**Specific planning use of the available products**

In land (flash) flooding		
Coastal floods		
Landslides		
Volcanic eruption Earthquake		
Other		

Q2.4. Do you consider above available products (Q2.2) relevant (in terms of content, scale, currency etc) for planning? Please indicate which products are relevant

Map	**Hazard products**	**Why yes or why not**
In land (flash) flooding		
Coastal floods		
Landslides		
Volcanic eruption		
Earthquake		
Other		

SECTION 3: INSTITUTIONAL CAPACITY IN HANDLING AND PRODUCING HAZARD AND RISK INFORMATION:

3.1. Is there in-house capacity in the physical planning department to conduct hazard assessments and produce different hazard products and other related information for planning purpose? Yes/No

If yes, for which hazard (s)? What type of products do you usually produce and what is its specific planning use?

Hazard	**Type of products produce**	**Specific planning use of the product**
In land (flash) flooding		
Coastal floods		
Landslides Volcanic eruption		
Earthquake		
Other		

3.2. Are there specific organizations/institutions in the country that has expertise in risk assessments and may provide hazard and risk information to physical planning department on demand basis?

Yes/No If yes, for which hazard (s)

3.3. Is there in-house capacity in the physical planning department to integrate different hazard products (to combine maps of different hazards such as flash flood, landslides, earthquake) and use as an integrated product for spatial planning? Yes/No

3.4. Is there trained staff (e.g. hazard specialists, geologists, planners having background/experience in hazard assessments etc) in the physical planning department for handling hazard related information? Please mark (√) if statement is true.

(a) No (no specific trained staff available)	(b) Yes (with basic understanding about different hazards)
(c) Yes (but not sufficiently trained in hazard assessments)	(c) Yes (sufficiently trained staff available)

SECTION 4: INTEGRATION OF HAZARD AND RISK INFORMATION IN THE SPATIAL PLANNING

Q4.1. At what level, does spatial planning taking place in the country?

a) National level planning) b) Regional level c) Local level (general land use planning) d) local level (detailed land use planning / zoning)

Q4.2. Is risk management being considered an important concern for physical planning to address?

Q4.3. Is there defined protection goals against natural hazards in relation to different objects (elements-at-risk)? Yes / No If yes, what type of protection goals are defined for different objects?

Q4.4. Is there specific tools or mechanism defined to evaluate the suitability of land (against potential effects of natural hazards) for specific use? Yes / No If yes, what types of tools or mechanisms are in place?

Q4.5. Are physical development plans developed at each level (Q4.1) and risk management is addressed in these plans? Please indicate how risk management is addressed and what hazards related information has been considered?

Physical development plan	Plan developed (√/X)	If yes, what type of hazard information included? Indicate hazard and specific hazard information from the **Key (A and B)**
National development plan		
Regional development plan (at least for one region)		
Local land use plan (general) for at least one part		
Local land use plan (zoning) for at least one part		

Q4.6. Does the physical planning department include risk information in their planning process? Yes / No, If yes, what planning purpose and what type of risk information considered?

Q4.7. What are the stages of physical development planning (how does the planning process work)?

Q4.8. At what stage (s) hazard and risk information is being integrated?

SECTION 5: PLANNING INSTRUMENTS

Q5.1. What are the development control mechanisms (instruments/tools) at the national and regional level where hazard and risk information could be included for risk mitigation?

National/regional development control instruments	Hazard name	What hazard information is considered to be relevant? (see Key A, B)	What hazard criteria are considered to be relevant? (see Key G)

Q5.2. What are the development control mechanisms (instruments/tools) at the local level and what type of hazard related information is being included?

Local development control instruments	Hazard name	What hazard information is considered to be relevant?	What hazard criteria is considered to be relevant

		(see Key A, B)	(see Key G)

SECTION 6: REQUIREMENTS AND CHALLENGES FOR INTEGRATION OF HAZARD AND RISK INFORMATION IN THE SPATIAL PLANNING:

Q6.1. What policy requirements you are considering important for inclusion of hazard and risk information in the spatial planning?

Q6.2. What institutional mechanisms (internal and external) you are considering important for inclusion of hazard and risk information in the spatial planning?

Q6.3. What data requirements are you considering relevant for the integration of hazard and risk information in the spatial planning?

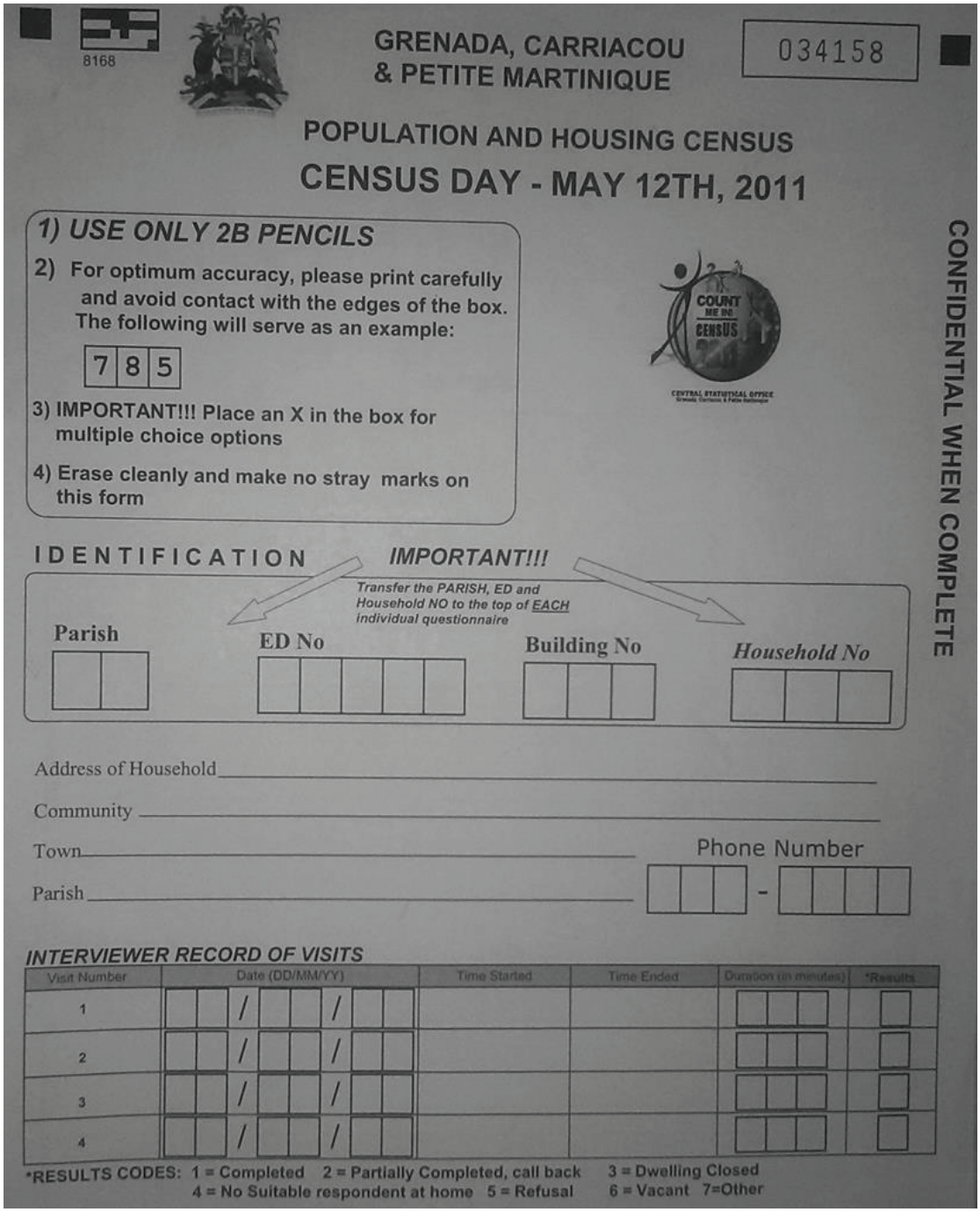
Data type	Specifications / description

Q6.4. What other resources are you considering important for the integration of hazard and risk information in the spatial planning?

Q6.5. What challenges your department is facing in integrating hazard and risk information in the spatial planning?

Q6.6. Any general remarks/information regarding inclusion of hazard and risk information in the spatial planning in your country?

ANNEXURE 2 – POPULATION CENSUS FORM



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GRENADA, CARRIACOU & PETITE MARTINIQUE

034158

POPULATION AND HOUSING CENSUS

CENSUS DAY - MAY 12TH, 2011

CONFIDENTIAL WHEN COMPLETE

1) USE ONLY 2B PENCILS

2) For optimum accuracy, please print carefully and avoid contact with the edges of the box. The following will serve as an example:

7	8	5

3) IMPORTANT!!! Place an X in the box for multiple choice options

4) Erase cleanly and make no stray marks on this form

COUNT ME IN CENSUS

CENTRAL STATISTICAL OFFICE

IDENTIFICATION

IMPORTANT!!!

Transfer the PARISH, ED and Household NO to the top of EACH individual questionnaire

Parish ☐☐

ED No ☐☐☐☐☐

Building No ☐☐☐

Household No ☐☐☐

Address of Household _____

Community _____

Town _____

Parish _____

Phone Number ☐☐☐ - ☐☐☐☐

INTERVIEWER RECORD OF VISITS

Visit Number	Date (DD/MM/YY)	Time Started	Time Ended	Duration (in minutes)	*Results
1	☐☐/☐☐/☐☐			☐☐☐	☐
2	☐☐/☐☐/☐☐			☐☐☐	☐
3	☐☐/☐☐/☐☐			☐☐☐	☐
4	☐☐/☐☐/☐☐			☐☐☐	☐

*RESULTS CODES: 1 = Completed 2 = Partially Completed, call back 3 = Dwelling Closed
4 = No Suitable respondent at home 5 = Refusal 6 = Vacant 7=Other

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INTERVIEWER SAY: Now I would like to ask a few questions about the dwelling which your household occupies and the facilities that you have.

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SECTION 2 HOUSING Con't

Remember to mark multiple choice boxes like this ☒

8a. What type of toilet facilities does this household have?

- ☐ 1 W.C. (flush toilet) linked to sewer
- ☒ 2 W.C. (flush toilet) linked to Septic tank/Soak-away
- ☐ 3 Pit-latrine/Ventilated and elevated
- ☐ 4 Pit-latrine not ventilated
- ☐ 5 Pit latrine ventilated and not elevated
- ☐ 6 None *(Go to 9a)*
- ☐ 7 Other (Specify) _____
- ☐ 8 Don't Know
- ☐ 9 Not Stated

8b. Is the toilet shared with any other household?

☐ 1 Yes ☒ 2 No ☐ 3 Don't Know ☐ 9 Not Stated

9a. Are your bathing facilities indoors or outdoors?

☒ 1 Indoors ☐ 2 Outdoors(Private) ☐ 3 None ☐ 4 Don't Know ☐ 9 Not Stated

If No, Go 10a

9b. Are your bathing facilities shared with another household?

☐ 1 Yes ☒ 2 No ☐ 3 Don't Know ☐ 9 Not Stated

10a. Is your main kitchen inside the dwelling unit or outside?

☒ 1 Inside ☐ 2 Outside ☐ 3 None ☐ 4 Don't Know ☐ 9 Not Stated

If None, Go 11

10b. Is your main kitchen shared with another person not of this house?

☐ 1 Yes ☒ 2 No ☐ 3 Don't Know ☐ 9 Not Stated

11. What is the main source of lighting for this household?

- ☒ 1 Electricity - Public
- ☐ 2 Electricity - Private Generator
- ☐ 3 Gas Lantern
- ☐ 4 Kerosene
- ☐ 5 Solar
- ☐ 6 None
- ☐ 7 Other (Specify) _____

12. What type of fuel does this household use most for cooking?

- ☐ 1 Coal
- ☐ 2 Wood
- ☒ 3 Gas/LPG/Cooking gas
- ☐ 4 Kerosene
- ☐ 5 Electricity
- ☐ 6 Biogas
- ☐ 7 Solar Energy
- ☐ 8 None
- ☐ 9 Other (Specify) _____

13. How many rooms does this household unit have?

(A room is enclosed by walls of at least 2m (6.5ft) high, and at least 4 square metres (43 square feet) in area. Do not count bathrooms and porches).

Number of Rooms

0	4

14. How many bedrooms does this household unit have? -

(Bedrooms are rooms used mainly for sleeping and exclude makeshift and temporary sleeping quarters. Count all bedrooms including spares not occupied.)

Number of Bedrooms

0	2

15. What is your main method of garbage disposal?

- ☐ 1 Dumping on land
- ☐ 2 Compost
- ☐ 3 Burning
- ☐ 4 Dumping/throwing in river/sea/pond
- ☐ 5 Burying
- ☒ 6 Garbage truck/Skip/Bin - Public
- ☐ 7 Garbage truck/Skip/Bin - Private
- ☐ 8 Other (Specify) _____

16. How many "Desk-top" computers does this household have in use?

0

use 8 for 8 or more
9 Not Stated

17. How many "Lap-top" computers does this household have in use?

2

use 8 for 8 or more
9 Not Stated

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Mark multiple choice boxes like this ☒

18. What type of internet connection does this household use? *(X all that apply)*

- ☐ 1 DSL/ADSL (Digital Subcriber Line (LIME)
- ☒ 2 Cellular Wireless Internet or Mobile Broadband (Cellphone)
- ☐ 3 Cable Internet Connection (FLOW)
- ☐ 4 Wireless (AISLECOM)
- ☐ 5 No Internet Connection at Dwelling

19. Which of these appliances/household equipment does your household have in use *(X all that apply)*

	Yes	No
(a) Solar Water Heater	☒ 1	☐ 2
(b) Electrical Water Heater	☒ 1	☐ 2
(c) TV	☒ 1	☐ 2
(d) Cable TV/Satellite	☒ 1	☐ 2
(e) Refrigerator	☒ 1	☐ 2
(f) Freezer	☐ 1	☒ 2
(g) Microwave Oven	☒ 1	☐ 2
(h) Stove	☒ 1	☐ 2
(i) Washing Machine	☐ 1	☒ 2
(j) Land-Line Telephone	☐ 1	☒ 2
(k) Cellular Phone	☒ 1	☐ 2
(l) Air Conditioning Unit	☒ 1	☐ 2
(m) Water Pump	☐ 1	☒ 2
(n) Water Tank	☒ 1	☐ 2
(o) Dishwasher	☐ 1	☒ 2
(p) Clothes Dryer	☐ 1	☒ 2

20. How many vehicles (motor cars, station wagons, jeeps and vans) are kept at home for private use by this household (excluding motorcycles)?

[0]

use 8 for 8 or more
9 Not Stated

21. Was any member of this household a victim of any crime during the past twelve months?

☒ 1 No *(skip to Question 22)*

If Yes, *(X all that apply)*

	Yes
(a) Murder	☐
(b) Kidnapping	☐
(c) Shooting	☐
(d) Rape/Abuse	☐
(e) Wounding	☐
(f) Larceny - Housebreaking	☐
(g) Larceny - Auto theft	☐
(h) Larceny - Other	☐
(i) Other (specify)	☐

22. Did any member of this household die during the past 12 months?

☐ 1 Yes ☐ 2 No *If No,Go to Section 3*

23. Please provide me with the age and sex of the person(s) who died during the past twelve months?

Age		
[ ][ ]	☐ 1 Male	☐ 2 Female
[ ][ ]	☐ 1 Male	☐ 2 Female
[ ][ ]	☐ 1 Male	☐ 2 Female
[ ][ ]	☐ 1 Male	☐ 2 Female

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SECTION 3 MIGRATION

Mark multiple choice boxes like this ☒

24. Did anyone from this household move <u>to live abroad since May 2001</u> and is still living abroad?

☐ 1 Yes (if Yes, continue)

☒ 2 No (Go to Section 4)

25. How many persons? ☐☐

Remember to mark multiple choice boxes like this ☒

(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)
Person Number	**Year moved 2001 - 2011** *Write year properly inside the boxes provided*	**Highest Education attained when moved** 1 None 2 Primary 3 Secondary 4 Post Secondary non-tertiary 5 University 6 Other	**Sex M =1 F = 2**	**Age when moved** 0 if less than 1, 98 for 98 and over	**Occupation when moved** Describe as clearly as possible the person(s) occupation when he/she moved. **[For persons 15 years and over when moved]**	**Name of Country of Migration** ***<u>Boxes provided are for offical use</u>***	**Main Reason for Migration** 1 More Income 2 Employment 3 Study 4 Medical 5 Marriage 6 Other Family reason 7 Crime Rate 8 Other Specify
1.	☐☐☐☐	☐1 ☐2 ☐3 ☐4 ☐5 ☐6	☐1 ☐2	☐☐		Name of Country	☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8
2.	☐☐☐☐	☐1 ☐2 ☐3 ☐4 ☐5 ☐6	☐1 ☐2	☐☐		Name of Country	☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8
3.	☐☐☐☐	☐1 ☐2 ☐3 ☐4 ☐5 ☐6	☐1 ☐2	☐☐		Name of Country	☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8
4.	☐☐☐☐	☐1 ☐2 ☐3 ☐4 ☐5 ☐6	☐1 ☐2	☐☐		Name of Country	☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8
5.	☐☐☐☐	☐1 ☐2 ☐3 ☐4 ☐5 ☐6	☐1 ☐2	☐☐		Name of Country	☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8
6.	☐☐☐☐	☐1 ☐2 ☐3 ☐4 ☐5 ☐6	☐1 ☐2	☐☐		Name of Country	☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8
7.	☐☐☐☐	☐1 ☐2 ☐3 ☐4 ☐5 ☐6	☐1 ☐2	☐☐		Name of Country	☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8

Remember to mark multiple choice boxes like this ☒

INTERVIEWER:

Whenever a dotted line (...) appears in a question, call the name of the person to whom the information relates, if it is not the respondent himself/herself. Else say "You"/"Your". X the appropriate box. Please do not write over the responses:

Remember to mark multiple choice boxes like this ☒

SECTION 4 PERSONAL CHARACTERISTICS FOR ALL PERSONS

34. Please fill in this person's name and assigned number.

Krystal Polak | 0 1

35. What is your/ .....'s relationship to the head of household?

- ☒ 1 Head
- ☐ 2 Spouse of Head (Husband/Wife)
- ☐ 3 Partner of Head
- ☐ 4 Child of head and Spouse/Partner
- ☐ 5 Child of head only
- ☐ 6 Child of Spouse/Partner only
- ☐ 7 Spouse/Partner of child of head/Spouse/Partner
- ☐ 8 Grandchild of Head/Spouse/Partner
- ☐ 9 Parents of Head/Spouse/Partner
- ☐ 10 Other relative of Head/Spouse/Partner(Specify)_____
- ☐ 11 Domestic Employee
- ☐ 12 Other Non-Relative

36. INTERVIEWER: X the appropriate box. FOR PERSONS NOT SEEN ASK:

Is....male or female?

☐ 1 Male ☒ 2 Female

37. What is your/.....'s date of birth?

Day / Month / Year

11 / 08 / 1980

If not known, ask:
How old was.....on his/her last birthday?

AGE: 02 1

If age is not stated please estimate age if you see the person. Otherwise ask the respondent to estimate the person's age. If age is not known use code 999.

☐ If estimated please put an X in the box.

38. To which ethnic, racial or national group do you/does..... belong?

- ☐ 1 African Descent/Negro/Black
- ☐ 2 Indigenous People (Amerindian/Carib)
- ☐ 3 East Indian
- ☐ 4 Chinese
- ☐ 5 Portuguese
- ☐ 6 Syrian/Lebanese
- ☒ 7 White/Caucasian
- ☐ 8 Mixed
- ☐ 9. Hispanic
- ☐ 10 Other (Specify) _____

39. What is your/....'s religious affiliation/denomination?

- ☐ 1 Anglican
- ☐ 2 Baptist
- ☐ 3 Bahai
- ☐ 4 Brethren
- ☐ 5 Church of God
- ☐ 6 Evangelical
- ☐ 7 Hindu
- ☐ 8 Jehovah Witnesses
- ☐ 9 Methodist
- ☐ 10 Moravian
- ☐ 11 Muslim
- ☐ 12 Pentecostal
- ☐ 13 Presbyterian
- ☐ 14 Rastafarian
- ☒ 15 Roman Catholic
- ☐ 16 Salvation Army
- ☐ 17 Seventh Day Adventist
- ☐ 18 Lutheran
- ☐ 19 None
- ☐ 20 Other (Specify) _____

SECTION 5 MIGRATION (BIRTH PLACE AND RESIDENCE) FOR ALL PERSONS

40. Where do you/does.....usually live?

☒ 1 At this address
Parish: St. George's Community: Mount Tamie

☐ 2 Elsewhere in this Parish
Parish _____ Community _____

☐ 3 In another Parish
Parish _____ Community _____

☐ 4 Abroad
Name of Country _____

Remember to mark multiple choice boxes like this ☒

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Remember to mark multiple choice boxes like this ☒

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41. Where were you/was.....born?
INTERVIEWER: For persons born in Grenada what is required is the mother's usual residence at the time of birth.

☐ 1 In this country
Parish _____
Community _____ *(Go to Q.43)*

☒ 2 Abroad
Name of Country U.S.A

42. In what year did you/..... last come to live in Grenada?
Year ☐☐☐☐

43. In which Parish did you/..... last live?
☐ 1 Never Moved (Go to Q.45)
☒ 2 Parish St. George's Community Mount Tom

44. In what year did you/..... last come to live in this Parish?
Year ☐☐☐☐ **Foreign Born Go to Q49**

Q45 to Q48 are for local borns only

45. Have you/has .....ever lived in another country?
☒ 1 Yes ☐ 2 No (Go to Q.49)

46. In which country did you/.....last live?
Name of Country _____

Questions 47 and 48 are for local borns who answered yes in Q45

47. In what year did you/..... return to live in Grenada?
Year ☐☐☐☐

48. What is the main reason why you/.....returned to live in Grenada?
☐ 1 Regard it as home
☐ 2 Family is here
☐ 3 Involuntary Return/Deported
☐ 4 To start a business/Employment
☐ 5 Retired
☐ 6 Homesick
☐ 7 Other (Specify) _____

Q49 to Q50 for Population five years and over

49. Did you/.....live at this address five years ago?
☐ 1 Yes (Go to Q.51) ☒ 2 No

50. If 'NO' in which country or Parish and community did you/..... live five years ago?
Parish _____ Community _____
Country _____

Q51 and Q52 for Population Ten years and over

51. Did you/.....live at this address in 2001?
☐ 1 Yes (Go to Q.53) ☒ 2 No

52. If 'NO' in which country or Parish and community did you/..... live in 2001?
Parish _____ Community _____ *Go to 54*
Country U.S.A *Go to 53a*

53.a Of which country (ies) are you a citizen? (List up to two countries).
1. U.S.A 2. _____

53.b What is the main reason for your present residence in this country?
☐ 1 Skilled National
☐ 2 Service Provider
☐ 3 Rights of Establishment
☐ 4 Employee of Non-wage earner
☐ 5 Other Economic Activity
☐ 6 Dependent
☐ 7 Other (Specify) _____
☐ 9 DK/NS

SECTION 6 DISABILITY FOR ALL PERSONS

DISABILITY STATUS : *Respond only if you have a permanent disability or where the disability has been continuous for six months or more.*

54. Do you/does..... have difficulty with any of the following?
Rate responses as follows:
1 No - No Difficulty **3 Yes - Lots of Difficulty**
2 Yes - Some Difficulty **4 Cannot do (it) at all**

1. Seeing (even with glasses)?	☐ 1	☒ 2	☐ 3	☐ 4
2. Hearing (even using hearing aid)?	☒ 1	☐ 2	☐ 3	☐ 4
3. Walking or climbing stairs?	☒ 1	☐ 2	☐ 3	☐ 4
4. Remembering or concentrating?	☒ 1	☐ 2	☐ 3	☐ 4
5. Self care?	☒ 1	☐ 2	☐ 3	☐ 4
6. Upper body function?	☒ 1	☐ 2	☐ 3	☐ 4
7. Communicating and speaking?	☒ 1	☐ 2	☐ 3	☐ 4

If No Difficulty for all options, Skip to Q57.

55. What is the origin of your/..... disability?
Rate responses as follows:
1. From Birth **2. Illness** **3. Accident**
4. Other (Specify)

		Specify
1. Seeing (even with glasses)?	2	
2. Hearing (even using hearing aid)?	☐	
3. Walking or climbing stairs?	☐	
4. Remembering or concentrating?	☐	
5. Self care?	☐	
6. Upper body function?	☐	
7. Communicating and speaking?	☐	

Remember to mark multiple choice boxes like this ☒

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Remember to mark multiple choice boxes like this ☒

56. Are you/..... using any of the following aids? *(X all that apply).*

- ☐ 1 Wheelchair
- ☐ 2 Walker
- ☐ 3 Crutches
- ☐ 4 Brailler
- ☐ 5 Adapted Car
- ☐ 6 Cane
- ☐ 7 Prosthesis/artificial body part
- ☐ 8 Orthopedic Shoes
- ☐ 9 Hearing Aid
- ☐ 10 Other (Specify) _____
- ☒ 11 None

SECTION 7 HEALTH FOR ALL PERSONS

57. Do you/does .....have any of the following illnesses? *(X all that apply)*

- ☐ 1 Arthritis
- ☐ 2 Kidney Disease (Renal)
- ☐ 3 Asthma
- ☐ 4 Diabetes
- ☐ 5 Hypertension/High Blood Pressure
- ☐ 6 Carpal Tunnel Syndrome
- ☐ 7 Cancer
- ☐ 8 Heart Disease
- ☐ 9 Glaucoma
- ☐ 10 Sickle Cell
- ☒ 11 Anemia
- ☐ 12 Lupus
- ☐ 13 HIV/AIDS
- ☐ 14 Other _____
- ☐ 15 None

58. Which of the following insurance do you/does..... have? *(X all that apply)*

- ☐ 1 NIS (National Insurance Scheme)
- ☐ 2 Group Health Insurance
- ☐ 3 Individual Health
- ☐ 4 Life with health
- ☐ 5 Endowment with health
- ☒ 6 School Accident Insurance
- ☐ 7 Other (Specify) _____
- ☐ 8 None

SECTION 8 EDUCATION AND INTERNET ACCESS FOR ALL PERSONS

59. Are you / is _____ currently attending an Educational Institution?

- ☒ 1 Yes (Full Time)
- ☐ 2 Yes (Part Time)
- ☐ 3 No (Go to Q62)

60. What type of school or institution are you/is..... attending?

- ☐ 1 Daycare/Nursery
- ☐ 2 Preschool
- ☐ 3 Infant/Kindergarden
- ☐ 4 Primary
- ☐ 5 Special Education
- ☐ 6 Post Primary (NonSecondary Tech/Voc)
- ☐ 7 Secondary (General)
- ☐ 8 Home Schooling
- ☐ 9 Post Secondary - A Level
- ☐ 10 Post Secondary - Professional Tech/Voc
- ☒ 11 Post Secondary Tertiary - UWI Other
- ☐ 12 Adult Education
- ☐ 13 Other _____

61. Please give the name and address of the school or institution.

Name S.G.U

Address Grand Anse Tivo Blue 10094

62. What is the highest level of education that you have/.....has completed?

- ☐ 1 Daycare/Nursery
- ☐ 2 Pre-school
- ☐ 3 Pre-primary (Infant) or Primary
- ☐ 4 Lower / Junior Secondary (Forms 1-3) / Senior Primary
- ☐ 5 Upper Secondary (Forms 4 & 5)
- ☐ 6 Post Secondary, non-tertiary (diploma or associate degree)
- ☐ 7 Tertiary level - Bachelor Degree
- ☐ 8 Tertiary level - Masters Degree
- ☐ 9 Doctorate level programmes
- ☒ 10 Other (Specify) _____
- ☐ 11 None

63. What is the highest examination that you have/...passed?

- ☐ 1 School leaving (e.g. Standard 6 or 7 School Leaving exam)
- ☐ 2 Cambridge School Certificate
- ☐ 3 CXC Basic
- ☐ 4 GCE 'O' Levels or CXC General
- ☐ 5 High School Certificate
- ☐ 6 GCE 'A' Levels, CAPE
- ☐ 7 Associate Degree
- ☐ 8 College Certificate
- ☐ 9 College Diploma
- ☐ 10 Professional Certificate eg RSA, City and Guilds etc.
- ☐ 11 Bachelor's Degree
- ☐ 12 Post Graduate Certificate
- ☐ 13 Post Graduate Diploma
- ☐ 14 Higher Degree (Master's)
- ☐ 15 Higher Degree (Doctoral)
- ☒ 16 Other (Specify) _____
- ☐ 17 None

64. Have you/ has ..... /had access to the Internet within the past 3 months?

- ☒ 1 Yes
- ☐ 2 No (Skip to Q.66)

Remember to mark multiple choice boxes like this ☒

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Remember to mark multiple choice boxes like this ☒

65. Where did you /..... mainly use the Internet in the past 3 months?

- ☐ 1 Home
- ☐ 2 Work
- ☐ 3 School
- ☐ 4 Internet Cafe'
- ☐ 5 Cellular Phone / PDA
- ☐ 6 Family or Friend's House
- ☐ 8 Did not use
- ☐ 7 Other (Specify) _____

66. INTERVIEWER: X the appropriate box (see Q.37)

☐ 1 Under 15 (GO TO Q.100) ☒ 2 15 years and over

SECTION 9 TRAINING FOR PERSONS 15 YEARS AND OVER

67a. Have you/has.....ever received/attempted any skills training to equip you/.....for employment or occupation/profession?

☐ 1 Yes ☒ 2 No (Go to Q71)

67.b Which category of training status applies to you/(N)?

- ☐ 1 Completed Training
- ☐ 2 Undergoing Training Currently
- ☐ 3 Attempted Training but did not complete
- ☐ 9 DK/NS

67c. What is the field for which the highest level of training was completed/attempted or is undergoing by you/.....?

Field Trained _____

68. What was the main method used by you /..... to train in this field?

- ☐ 1 On the job
- ☐ 2 Private Study
- ☐ 3 Apprenticeship
- ☐ 4 Correspondence Course
- ☐ 5 Secondary School
- ☐ 6 Vocational/Trade School/Technical Institution
- ☐ 7 Commercial/Secretarial School
- ☐ 8 Business/Computer School
- ☐ 9 University (on campus)
- ☐ 10 Distance Learning
- ☐ 11 On-line/Virtual Learning
- ☐ 12 Other (Specify) _____

69. How long was the period of your /..... highest level of training? ☐☐ Months

70.a What type of qualification /certification did you/..... receive on completion of the training at the highest level?

- ☐ 1 None
- ☐ 2 Certificate with examination
- ☐ 3 Certificate without examination
- ☐ 4 Diploma
- ☐ 5 Advanced Diploma
- ☐ 6 Associate Degree
- ☐ 7 First Degree
- ☐ 8 Post Graduate Degree
- ☐ 9 Professional Qualification
- ☐ 10 Other (Specify) _____

70.b Is your recent training related to your/.... present job?

☐ 1 Yes ☐ 2 No ☐ 3 DK/NS

SECTION 10 ECONOMIC ACTIVITY FOR PERSONS 15 YEARS AND OVER

71. How many months did you/..... work in the past 12 months?

Number of months

0	1	2	3	4	5	6	7	8	9	10	11	12
☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

72. What did you/....do most during the past 12 months -for example, did you/he/she work, look for a job, keep house or carry on some other activity?

- ☐ 1 Worked
- ☐ 2 Had a job but did not work
- ☐ 3 Looked for work
- ☐ 4 Wanted work and available
- ☐ 5 Home Duties
- ☒ 6 Attended School
- ☐ 7 Retired - did not work
- ☐ 8 Disabled, unable to work
- ☐ 9 Other (Specify) _____

73. Did you/..... work for pay, profit or family gain, during the past week? Note: Exclude Domestic Work at home

If, YES, Did you?

- ☐ 1 Work
- ☐ 2 Had a job but did not work

If, No What did you do MOST in the past week?

- ☐ 3 Seeking first job
- ☐ 4 Seek job which was not first
- ☐ 5 Wanted work and available
- ☐ 6 Home Duties
- ☒ 7 Attended School
- ☐ 8 Retired - did not work
- ☐ 9 Disabled, unable to work
- ☐ 10 Other (Specify) _____

Go to Q82

74. What category of worker are you /..... in your job?

- ☐ 1 Paid Employee - Government
- ☐ 2 Paid employee - Private Establishment
- ☐ 3 Paid employee - Statutory body
- ☐ 4 Paid Employee - Private Home

Go to Q77

- ☐ 5 Self-Employed with paid employees/Own business
- ☐ 6 Self Employed without paid employee/Own business
- ☐ 7 Apprentice/Learners
- ☐ 8 Unpaid worker/Volunteer
- ☐ 9 Unpaid family worker
- ☐ 10 Other (Specify) _____

Go to Q77

Remember to mark multiple choice boxes like this ☒

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Remember to mark multiple choice boxes like this ☒

75. What kind of accounts do you keep for this activity/business?

- ☐ 1 Complete set of written accounts
- ☐ 2 Only through informal records of orders, sales, purchases
- ☐ 3 Simplified written accounts
- ☐ 4 No records are kept.

76. Are you registered with the National Insurance Scheme as a self-employed person or an employer?

☐ 1 Employer ☐ 2 Self-Employed ☐ 3 Not Registered

77. What kind of work were you/.....doing during the past week? (Give brief description of main duties)

Occupation _____

_____

78. What kind of business is carried out at your/.....'s workplace (Industry)?

Industry _____

79. How many hours did you/..... work during the past week ? (All jobs).

Number of hours ☐☐☐

80. Where is your/.....'s place of work? (Main Job)

- ☐ 1 Work at home
- ☐ 2 No fixed workplace
- ☐ 3 A fixed workplace outside the home

81. What is the name and address of your/..... present workplace?

Name _____

Address _____

☐ 1 No Present Workplace

(All employed persons go to Q.84)

82. What steps did you/..... take during the past month to look for work?

- ☒ 1 Did Nothing
- ☐ 2 Direct Application (Sent out letters) (Go to 86)
- ☐ 3 Checking at work sites, factory gates etc. (Go to Q.86)
- ☐ 4 Seeking assistance from friends (Go to Q.86)
- ☐ 5 Register at public/private employment exchange(Go to Q.86)
- ☐ 6 Other (Go to Q.86)

83. Why did you/....not seek work during the past month?

- ☐ 1 Own illness, disability, injury, pregnancy
- ☐ 2 Home duties, Personal, family responsibilities
- ☒ 3 In school, training
- ☐ 4 Retirement/old age
- ☐ 5 Already found work to start later
- ☐ 6 Already made arrangements for self employment
- ☐ 7 Awaiting recall to former job
- ☐ 8 Awaiting replies from employers
- ☐ 9 Awaiting busy season
- ☐ 10 Believe no suitable work available
- ☐ 11 Could not find suitable work
- ☐ 12 Not yet started to seek work
- ☐ 13 Do not know how or where to seek work
- ☐ 14 Discouraged
- ☐ 15 Other(Specify) _____

(All go to Q.86)

SECTION 11 INCOME AND LIVELIHOOD FOR PERSONS 15 YEARS AND OVER

84. How often do you/does..... get paid from your main job?

- ☐ 1 Weekly
- ☐ 2 Fortnightly
- ☐ 3 Monthly
- ☐ 4 Quarterly
- ☐ 5 Annually
- ☐ 6 Other (Specify) _____
- ☐ 7 Not applicable

85. What was your/.....'s gross pay/income during the last pay period from your current job,that is before income tax or other deductions? (PRESENT FLASH CARD)

INTERVIEWER: For self-employed persons obtain "net income" i.e., receipts less business expenses.

Income Group ☐☐

86. What is your/.....'s main source of livelihood?

- ☐ 1 Employment
- ☐ 2 Pension (Local)
- ☐ 3 Pension (Overseas)
- ☐ 4 Money from Abroad
- ☐ 5 Investment
- ☒ 6 Savings/Interest on savings
- ☐ 7 Disability benefits
- ☐ 8 Social Security Benefits
- ☐ 9 Other Public Assistance
- ☐ 10 Local contributions from friends/relatives
- ☐ 11 Overseas contributions from friends/relatives
- ☐ 12 Other _____

87. Approximately how much money did you/..... receive last year (2010) from family and/or friends abroad in cash or in kind e.g. barrels containing food etc., clothing, electronics.

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Remember to mark multiple choice boxes like this ☒

SECTION 12 MARITAL AND UNION STATUS FOR ALL PERSONS 15 YEARS AND OVER

88. What is your/....'s marital status?

☐ 1 Never Married ☒ 2 Married ☐ 3 Divorced
☐ 4 Widowed ☐ 5 Legally Separated

89.a What is your / ..... present union status?

☐ 1 Never had a spouse or common-law partner *Skip to Q91*
☐ 2 Married and living with spouse *Skip to Q90*
☐ 3 Married and not living with spouse *Skip to Q90*
☐ 4 Common Law *Skip to Q90*
☐ 5 Visiting Partner *Skip to Q90*
☐ 6 Not in union

89b. Have you ever been in a common-law union?

☐ 1 Yes
☐ 2 No *SKIP TO SECTION 12*

90. How old were you/ was ..... when you were/..... was first married or in a union for the first time?

Age in years 2 1

ALL MALES Go to Q100

SECTION 13 FERTILITY FOR ALL FEMALES 15 YEARS AND OVER

91. How many live born children have you/has....ever had and how many are males and females? (If ZERO, enter 00 & Go To Q.100)

Total	M	F
0 0		

92. How many of your/.....'s live born children are still alive?

Total	M	F

93. How old were you/was..... when you/..... had the first live born child?

94. How old were you/was..... was when you/..... had the last live born child?

95. What is the date of birth of the last child born alive?

Day / Month / Year

Q. 96 TO Q. 99 APPLY ONLY TO FEMALES UNDER 50. ALL OTHERS GO TO Q.100

96. How many live births did you/..... have in the last 12 months?

☐ 1 None (Go to Q.100) ☐ 4 Twins
☐ 2 One Birth ☐ 5 Three or more
☐ 3 Two separate births

97. What is/are the sex(es) of this child/these children? (Born within the last 12 months)

A. Number of Boys: ☐0 ☐1 ☐2 ☐3 ☐4 ☐5
B. Number of Girls: ☐0 ☐1 ☐2 ☐3 ☐4 ☐5

98. How many of the children who were born in the last 12 months have died? If 00 Go To Q.100

Total

99. Of what sex and age, in months, were the children who died in the past 12 months?

Child Number	Sex	Age in Months
1.	☐1 M ☐2 F	
2.	☐1 M ☐2 F	
3.	☐1 M ☐2 F	
4.	☐1 M ☐2 F	

SECTION 14 WHERE SPENT CENSUS NIGHT

100. Where did you/.....spend census night?

☒ 1 At this address
☐ 2 Elsewhere in this country
☐ 3 Abroad

101. What part of the country was that? If known, Specify?

Grand Anse Mount Tour, ST. Geo

Remember to mark multiple choice boxes like this ☒

INTERVIEWER:

Whenever a dotted line (...) appears in a question, call the name of the person to whom the information relates, if it is not the respondent himself/herself. Else say "You"/"Your". X the appropriate box. Please do not write over the responses:

Remember to mark multiple choice boxes like this ☒

SECTION 4 PERSONAL CHARACTERISTICS FOR ALL PERSONS

34. Please fill in this person's name and assigned number.

Kevin Polak 02

35. What is your/ .....'s relationship to the head of household?

- ☐ 1 Head
- ☒ 2 Spouse of Head (Husband/Wife)
- ☐ 3 Partner of Head
- ☐ 4 Child of head and Spouse/Partner
- ☐ 5 Child of head only
- ☐ 6 Child of Spouse/Partner only
- ☐ 7 Spouse/Partner of child of head/Spouse/Partner
- ☐ 8 Grandchild of Head/Spouse/Partner
- ☐ 9 Parents of Head/Spouse/Partner
- ☐ 10 Other relative of Head/Spouse/Partner(Specify)_____
- ☐ 11 Domestic Employee
- ☐ 12 Other Non-Relative

36. INTERVIEWER: X the appropriate box. FOR PERSONS NOT SEEN ASK:

Is....male or female?

☒ 1 Male ☐ 2 Female

37. What is your/.....'s date of birth?

Day 20 / Month 10 / Year 1979

If not known, ask:
How old was.....on his/her last birthday?

AGE 032

If age is not stated please estimate age if you see the person. Otherwise ask the respondent to estimate the person's age. If age is not known use code 999.

☐ If estimated please put an X in the box.

38. To which ethnic, racial or national group do you/does..... belong?

- ☐ 1 African Descent/Negro/Black
- ☐ 2 Indigenous People (Amerindian/Carib)
- ☐ 3 East Indian
- ☐ 4 Chinese
- ☐ 5 Portuguese
- ☐ 6 Syrian/Lebanese
- ☒ 7 White/Caucasian
- ☐ 8 Mixed
- ☐ 9. Hispanic
- ☐ 10 Other (Specify) _____

39. What is your/....'s religious affiliation/denomination?

- ☐ 1 Anglican
- ☐ 2 Baptist
- ☐ 3 Bahai
- ☐ 4 Brethren
- ☐ 5 Church of God
- ☐ 6 Evangelical
- ☐ 7 Hindu
- ☐ 8 Jehovah Witnesses
- ☐ 9 Methodist
- ☐ 10 Moravian
- ☐ 11 Muslim
- ☐ 12 Pentecostal
- ☐ 13 Presbyterian
- ☐ 14 Rastafarian
- ☒ 15 Roman Catholic
- ☐ 16 Salvation Army
- ☐ 17 Seventh Day Adventist
- ☐ 18 Lutheran
- ☐ 19 None
- ☐ 20 Other (Specify) _____

SECTION 5 MIGRATION (BIRTH PLACE AND RESIDENCE) FOR ALL PERSONS

40. Where do you/does.....usually live?

- ☒ 1 At this address — Parish St. George's — Community Mark's Town
- ☐ 2 Elsewhere in this Parish — Parish _____ — Community _____
- ☐ 3 In another Parish — Parish _____ — Community _____
- ☐ 4 Abroad — Name of Country _____

Remember to mark multiple choice boxes like this ☒

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Remember to mark multiple choice boxes like this ☒

41. Where were you/was.....born?
INTERVIEWER: For persons born in Grenada what is required is the mother's usual residence at the time of birth.

☐ 1 In this country
Parish _____
Community _____ *(Go to Q.43)*

☒ 2 Abroad
Name of Country U.S.A

42. In what year did you/..... last come to live in Grenada?
Year ☐☐☐☐

43. In which Parish did you/..... last live?
☐ 1 Never Moved (Go to Q.45)
☐ 2 Parish _____ Community _____

44. In what year did you/..... last come to live in this Parish?
Year ☐☐☐☐ **Foreign Born Go to Q49**

Q45 to Q48 are for local borns only

45. Have you/has .....ever lived in another country?
☐ 1 Yes ☐ 2 No (Go to Q.49)

46. In which country did you/.....last live?
Name of Country _____

Questions 47 and 48 are for local borns who answered yes in Q45

47. In what year did you/..... return to live in Grenada?
Year ☐☐☐☐

48. What is the main reason why you/.....returned to live in Grenada?
☐ 1 Regard it as home
☐ 2 Family is here
☐ 3 Involuntary Return/Deported
☐ 4 To start a business/Employment
☐ 5 Retired
☐ 6 Homesick
☐ 7 Other (Specify) _____

Q49 to Q50 for Population five years and over

49. Did you/.....live at this address five years ago?
☐ 1 Yes (Go to Q.51) ☒ 2 No

50. If 'NO' in which country or Parish and community did you/..... live five years ago?
Parish _____ Community _____
Country _____

Q51 and Q52 for Population Ten years and over

51. Did you/.....live at this address in 2001?
☐ 1 Yes (Go to Q.53) ☒ 2 No

52. If 'NO' in which country or Parish and community did you/..... live in 2001?
Parish _____ Community _____ *Go to 54*
Country _____ *Go to 53a*

53.a Of which country (ies) are you a citizen? (List up to two countries).
1. U.S.A 2. _____

53.b What is the main reason for your present residence in this country?
☐ 1 Skilled National
☐ 2 Service Provider
☐ 3 Rights of Establishment
☐ 4 Employee of Non-wage earner
☐ 5 Other Economic Activity
☐ 6 Dependent
☐ 7 Other (Specify) _____
☐ 9 DK/NS

SECTION 6 DISABILITY FOR ALL PERSONS

DISABILITY STATUS : *Respond only if you have a permanent disability or where the disability has been continuous for six months or more.*

54. Do you/does..... have difficulty with any of the following?
Rate responses as follows:
1 No - No Difficulty 3 Yes - Lots of Difficulty
2 Yes - Some Difficulty 4 Cannot do (it) at all

1. Seeing (even with glasses)?	☐ 1	☒ 2	☐ 3	☐ 4
2. Hearing (even using hearing aid)?	☒ 1	☐ 2	☐ 3	☐ 4
3. Walking or climbing stairs?	☒ 1	☐ 2	☐ 3	☐ 4
4. Remembering or concentrating?	☒ 1	☐ 2	☐ 3	☐ 4
5. Self care?	☒ 1	☐ 2	☐ 3	☐ 4
6. Upper body function?	☒ 1	☐ 2	☐ 3	☐ 4
7. Communicating and speaking?	☒ 1	☐ 2	☐ 3	☐ 4

If No Difficulty for all options, Skip to Q57.

55. What is the origin of your/..... disability?
Rate responses as follows:
1. From Birth 2. Illness 3. Accident
4. Other (Specify)

		Specify
1. Seeing (even with glasses)?	☐	
2. Hearing (even using hearing aid)?	☐	
3. Walking or climbing stairs?	☐	
4. Remembering or concentrating?	☐	
5. Self care?	☐	
6. Upper body function?	☐	
7. Communicating and speaking?	☐	

Remember to mark multiple choice boxes like this ☒

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Remember to mark multiple choice boxes like this ☒

56. Are you/..... using any of the following aids? *(X all that apply).*

- ☐ 1 Wheelchair
- ☐ 2 Walker
- ☐ 3 Crutches
- ☐ 4 Brailler
- ☐ 5 Adapted Car
- ☐ 6 Cane
- ☐ 7 Prosthesis/artificial body part
- ☐ 8 Orthopedic Shoes
- ☐ 9 Hearing Aid
- ☐ 10 Other (Specify) _____
- ☒ 11 None

SECTION 7 HEALTH FOR ALL PERSONS

57. Do you/does .....have any of the following illnesses? *(X all that apply)*

- ☐ 1 Arthritis
- ☐ 2 Kidney Disease (Renal)
- ☐ 3 Asthma
- ☐ 4 Diabetes
- ☐ 5 Hypertension/High Blood Pressure
- ☐ 6 Carpal Tunnel Syndrome
- ☐ 7 Cancer
- ☐ 8 Heart Disease
- ☐ 9 Glaucoma
- ☐ 10 Sickle Cell
- ☐ 11 Anemia
- ☐ 12 Lupus
- ☐ 13 HIV/AIDS
- ☐ 14 Other _____
- ☒ 15 None

58. Which of the following insurance do you/does..... have? *(X all that apply)*

- ☐ 1 NIS (National Insurance Scheme)
- ☐ 2 Group Health Insurance
- ☐ 3 Individual Health
- ☒ 4 Life with health
- ☐ 5 Endowment with health
- ☒ 6 School Accident Insurance
- ☐ 7 Other (Specify) _____
- ☐ 8 None

SECTION 8 EDUCATION AND INTERNET ACCESS FOR ALL PERSONS

59. Are you / is _____ currently attending an Educational Institution?

- ☒ 1 Yes (Full Time)
- ☐ 2 Yes (Part Time)
- ☐ 3 No (Go to Q62)

60. What type of school or institution are you/is..... attending?

- ☐ 1 Daycare/Nursery
- ☐ 2 Preschool
- ☐ 3 Infant/Kindergarden
- ☐ 4 Primary
- ☐ 5 Special Education
- ☐ 6 Post Primary (NonSeconday Tech/Voc)
- ☐ 7 Secondary (General)
- ☐ 8 Home Schooling
- ☐ 9 Post Secondary - A Level
- ☐ 10 Post Secondary - Professional Tech/Voc
- ☐ 11 Post Secondary Tertiary - UWI Other
- ☐ 12 Adult Education
- ☒ 13 Other S-G-U

61. Please give the name and address of the school or institution.

Name S-G-U 10094

Address Grand Anse Tour bleue

62. What is the highest level of education that you have/.....has completed?

- ☐ 1 Daycare/Nursery
- ☐ 2 Pre-school
- ☐ 3 Pre-primary (Infant) or Primary
- ☐ 4 Lower / Junior Secondary (Forms 1-3) / Senior Primary
- ☐ 5 Upper Secondary (Forms 4 & 5)
- ☐ 6 Post Secondary, non-tertiary (diploma or associate degree)
- ☐ 7 Tertiary level - Bachelor Degree
- ☐ 8 Tertiary level - Masters Degree
- ☒ 9 Doctorate level programmes
- ☐ 10 Other (Specify) _____
- ☐ 11 None

63. What is the highest examination that you have/...passed?

- ☐ 1 School leaving (e.g. Standard 6 or 7 School Leaving exam)
- ☐ 2 Cambridge School Certificate
- ☐ 3 CXC Basic
- ☐ 4 GCE 'O' Levels or CXC General
- ☐ 5 High School Certificate
- ☐ 6 GCE 'A' Levels, CAPE
- ☐ 7 Associate Degree
- ☐ 8 College Certificate
- ☐ 9 College Diploma
- ☐ 10 Professional Certificate eg RSA, City and Guilds etc.
- ☐ 11 Bachelor's Degree
- ☐ 12 Post Graduate Certificate
- ☐ 13 Post Graduate Diploma
- ☐ 14 Higher Degree (Master's)
- ☒ 15 Higher Degree (Doctoral)
- ☐ 16 Other (Specify) _____
- ☐ 17 None

64. Have you/ has ..... /had access to the Internet within the past 3 months?

- ☒ 1 Yes
- ☐ 2 No (Skip to Q.66)

Remember to mark multiple choice boxes like this ☒

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Remember to mark multiple choice boxes like this ☒

65. Where did you / ..... mainly use the Internet in the past 3 months?

- ☐ 1 Home
- ☐ 2 Work
- ☐ 3 School
- ☐ 4 Internet Cafe'
- ☐ 5 Cellular Phone / PDA
- ☐ 6 Family or Friend's House
- ☐ 8 Did not use
- ☐ 7 Other (Specify) _____

66. INTERVIEWER: X the appropriate box (see Q.37)

☐ 1 Under 15 (GO TO Q.100) ☒ 2 15 years and over

SECTION 9 TRAINING FOR PERSONS 15 YEARS AND OVER

67a. Have you/has.....ever received/attempted any skills training to equip you/.....for employment or occupation/profession?

☐ 1 Yes ☒ 2 No (Go to Q71)

67.b Which category of training status applies to you/(N)?

- ☐ 1 Completed Training
- ☐ 2 Undergoing Training Currently
- ☐ 3 Attempted Training but did not complete
- ☐ 9 DK/NS

67c. What is the field for which the highest level of training was completed/attempted or is undergoing by you/.....?

Field Trained _____

68. What was the main method used by you /..... to train in this field?

- ☐ 1 On the job
- ☐ 2 Private Study
- ☐ 3 Apprenticeship
- ☐ 4 Correspondence Course
- ☐ 5 Secondary School
- ☐ 6 Vocational/Trade School/Technical Institution
- ☐ 7 Commercial/Secretarial School
- ☐ 8 Business/Computer School
- ☐ 9 University (on campus)
- ☐ 10 Distance Learning
- ☐ 11 On-line/Virtual Learning
- ☐ 12 Other (Specify) _____

69. How long was the period of your /..... highest level of training?

☐☐ Months

70.a What type of qualification /certification did you/..... receive on completion of the training at the highest level?

- ☐ 1 None
- ☐ 2 Certificate with examination
- ☐ 3 Certificate without examination
- ☐ 4 Diploma
- ☐ 5 Advanced Diploma
- ☐ 6 Associate Degree
- ☐ 7 First Degree
- ☐ 8 Post Graduate Degree
- ☐ 9 Professional Qualification
- ☐ 10 Other (Specify) _____

70.b Is your recent training related to your/.... present job?

☐ 1 Yes ☐ 2 No ☐ 3 DK/NS

SECTION 10 ECONOMIC ACTIVITY FOR PERSONS 15 YEARS AND OVER

71. How many months did you/..... work in the past 12 months?

Number of months

0	1	2	3	4	5	6	7	8	9	10	11	12
☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

72. What did you/....do most during the past 12 months -for example, did you/he/she work, look for a job, keep house or carry on some other activity?

- ☐ 1 Worked
- ☐ 2 Had a job but did not work
- ☐ 3 Looked for work
- ☐ 4 Wanted work and available
- ☐ 5 Home Duties
- ☒ 6 Attended School
- ☐ 7 Retired - did not work
- ☐ 8 Disabled, unable to work
- ☐ 9 Other (Specify) _____

73. Did you/..... work for pay, profit or family gain, during the past week? Note: Exclude Domestic Work at home

If, YES, Did you?

- ☐ 1 Work
- ☐ 2 Had a job but did not work

If, No What did you do MOST in the past week?

- ☐ 3 Seeking first job
- ☐ 4 Seek job which was not first
- ☐ 5 Wanted work and available
- ☐ 6 Home Duties
- ☒ 7 Attended School
- ☐ 8 Retired - did not work
- ☐ 9 Disabled, unable to work
- ☐ 10 Other (Specify) _____

Go to Q82 ⇨

74. What category of worker are you /..... in your job?

- ☐ 1 Paid Employee - Government
- ☐ 2 Paid employee - Private Establishment
- ☐ 3 Paid employee - Statutory body
- ☐ 4 Paid Employee - Private Home

Go to Q77 ⇨

- ☐ 5 Self-Employed with paid employees/Own business
- ☐ 6 Self Employed without paid employee/Own business
- ☐ 7 Apprentice/Learners
- ☐ 8 Unpaid worker/Volunteer
- ☐ 9 Unpaid family worker
- ☐ 10 Other (Specify) _____

Go to Q77 ⇨

Remember to mark multiple choice boxes like this ☒

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75. What kind of accounts do you keep for this activity/business?

- ☐ 1 Complete set of written accounts
- ☐ 2 Only through informal records of orders, sales, purchases
- ☐ 3 Simplified written accounts
- ☐ 4 No records are kept.

76. Are you registered with the National Insurance Scheme as a self-employed person or an employer?

☐ 1 Employer ☐ 2 Self-Employed ☒ 3 Not Registered

77. What kind of work were you/.....doing during the past week? (Give brief description of main duties)

Occupation _____

78. What kind of business is carried out at your/.....'s workplace (Industry)?

Industry _____

79. How many hours did you/..... work during the past week ? (All jobs).

Number of hours ☐☐☐

80. Where is your/.....'s place of work? (Main Job)

- ☐ 1 Work at home
- ☐ 2 No fixed workplace
- ☐ 3 A fixed workplace outside the home

81. What is the name and address of your/..... present workplace?

Name _____

Address _____

☐ 1 No Present Workplace

(All employed persons go to Q.84)

82. What steps did you/..... take during the past month to look for work?

- ☒ 1 Did Nothing
- ☐ 2 Direct Application (Sent out letters) (Go to 86)
- ☐ 3 Checking at work sites, factory gates etc. (Go to Q.86)
- ☐ 4 Seeking assistance from friends (Go to Q.86)
- ☐ 5 Register at public/private employment exchange(Go to Q.86)
- ☐ 6 Other (Go to Q.86)

83. Why did you/....not seek work during the past month?

- ☐ 1 Own illness, disability, injury, pregnancy
- ☐ 2 Home duties, Personal, family responsibilities
- ☒ 3 In school, training
- ☐ 4 Retirement/old age
- ☐ 5 Already found work to start later
- ☐ 6 Already made arrangements for self employment
- ☐ 7 Awaiting recall to former job
- ☐ 8 Awaiting replies from employers
- ☐ 9 Awaiting busy season
- ☐ 10 Believe no suitable work available
- ☐ 11 Could not find suitable work
- ☐ 12 Not yet started to seek work
- ☐ 13 Do not know how or where to seek work
- ☐ 14 Discouraged
- ☐ 15 Other(Specify) _____

(All go to Q.86)

SECTION 11 INCOME AND LIVELIHOOD FOR PERSONS 15 YEARS AND OVER

84. How often do you/does..... get paid from your main job?

- ☐ 1 Weekly
- ☐ 2 Fortnightly
- ☐ 3 Monthly
- ☐ 4 Quarterly
- ☐ 5 Annually
- ☐ 6 Other (Specify) _____
- ☐ 7 Not applicable

85. What was your/.....'s gross pay/income during the last pay period from your current job,that is before income tax or other deductions? (PRESENT FLASH CARD)

INTERVIEWER: For self-employed persons obtain "net income" i.e., receipts less business expenses.

Income Group ☐☐

86. What is your/.....'s main source of livelihood?

- ☐ 1 Employment
- ☐ 2 Pension (Local)
- ☐ 3 Pension (Overseas)
- ☐ 4 Money from Abroad
- ☐ 5 Investment
- ☒ 6 Savings/Interest on savings
- ☐ 7 Disability benefits
- ☐ 8 Social Security Benefits
- ☐ 9 Other Public Assistance
- ☐ 10 Local contributions from friends/relatives
- ☐ 11 Overseas contributions from friends/relatives
- ☐ 12 Other _____

87. Approximately how much money did you/..... receive last year (2010) from family and/or friends abroad in cash or in kind e.g. barrels containing food etc., clothing, electronics.

_____

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Remember to mark multiple choice boxes like this ☒

SECTION 12 MARITAL AND UNION STATUS FOR ALL PERSONS 15 YEARS AND OVER

88. What is your/....'s marital status?

☐ 1 Never Married ☒ 2 Married ☐ 3 Divorced
☐ 4 Widowed ☐ 5 Legally Separated

89.a What is your / ..... present union status?

☐ 1 Never had a spouse or common-law partner *Skip to Q91*
☐ 2 Married and living with spouse *Skip to Q90*
☐ 3 Married and not living with spouse *Skip to Q90*
☐ 4 Common Law *Skip to Q90*
☐ 5 Visiting Partner *Skip to Q90*
☐ 6 Not in union

89b. Have you ever been in a common-law union?

☐ 1 Yes
☐ 2 No *SKIP TO SECTION 12*

90. How old were you/ was ..... when you were/..... was first married or in a union for the first time?

Age in years 2 4 *ALL MALES Go to Q100*

SECTION 13 FERTILITY FOR ALL FEMALES 15 YEARS AND OVER

91. How many live born children have you/has....ever had and how many are males and females? (If ZERO, enter 00 & Go To Q.100)

Total ☐☐ M ☐☐ F ☐☐

92. How many of your/.....'s live born children are still alive?

Total ☐☐ M ☐☐ F ☐☐

93. How old were you/was..... when you/..... had the first live born child? ☐☐

94. How old were you/was..... was when you/..... had the last live born child? ☐☐

95. What is the date of birth of the last child born alive?

Day ☐☐ / Month ☐☐ / Year ☐☐

Q. 96 TO Q. 99 APPLY ONLY TO FEMALES UNDER 50. ALL OTHERS GO TO Q.100

96. How many live births did you/..... have in the last 12 months?

☐ 1 None (Go to Q.100)
☐ 2 One Birth
☐ 3 Two separate births
☐ 4 Twins
☐ 5 Three or more

97. What is/are the sex(es) of this child/these children? (Born within the last 12 months)

A. Number of Boys ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ 0 1 2 3 4 5

B. Number of Girls ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ 0 1 2 3 4 5

98. How many of the children who were born in the last 12 months have died? If 00 Go To Q.100

Total ☐☐

99. Of what sex and age, in months, were the children who died in the past 12 months?

Child Number	Sex	Age in Months
1.	☐ 1 M ☐ 2 F	☐☐
2.	☐ 1 M ☐ 2 F	☐☐
3.	☐ 1 M ☐ 2 F	☐☐
4.	☐ 1 M ☐ 2 F	☐☐

SECTION 14 WHERE SPENT CENSUS NIGHT

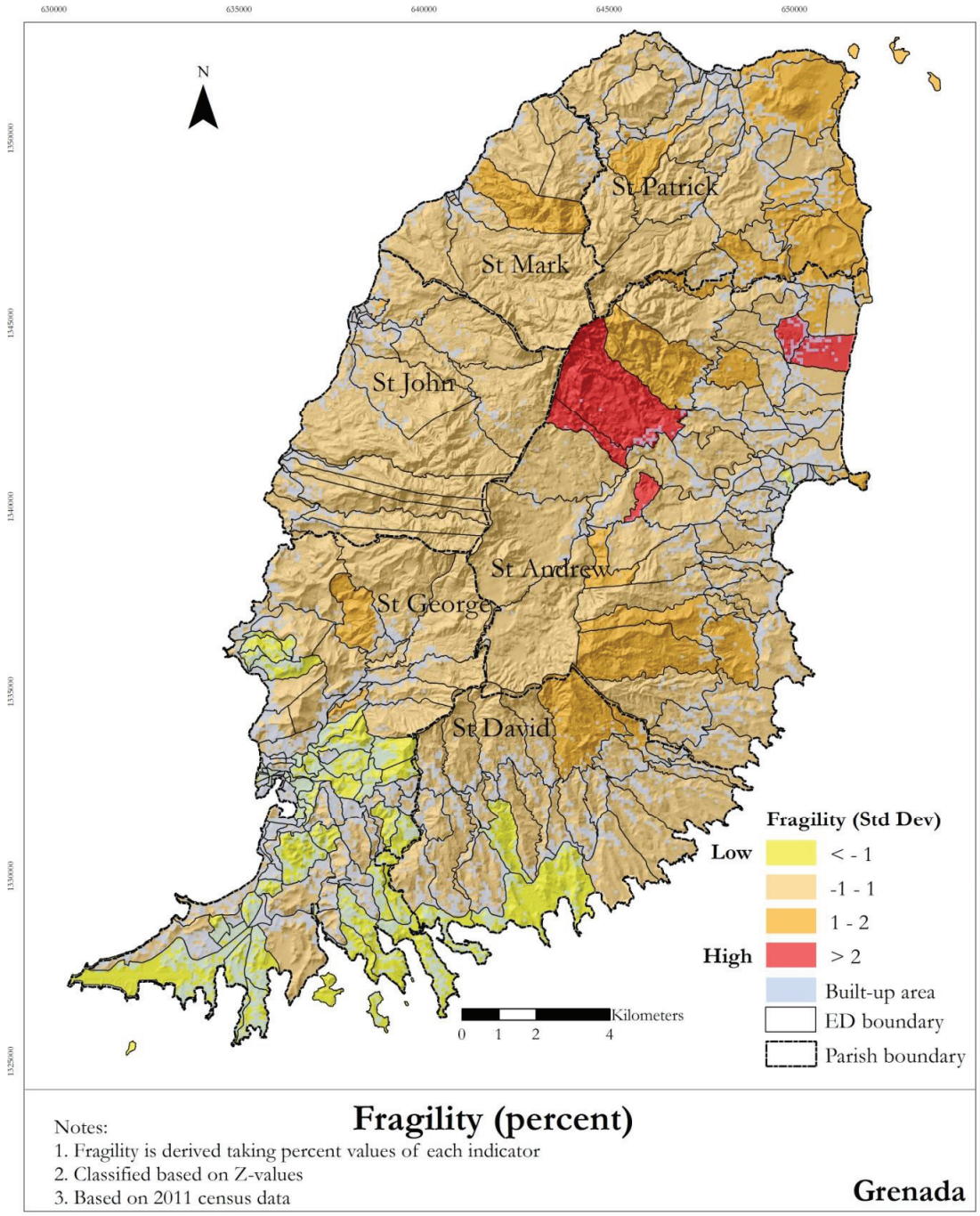
100. Where did you/.....spend census night?

☒ 1 At this address
☐ 2 Elsewhere in this country
☐ 3 Abroad

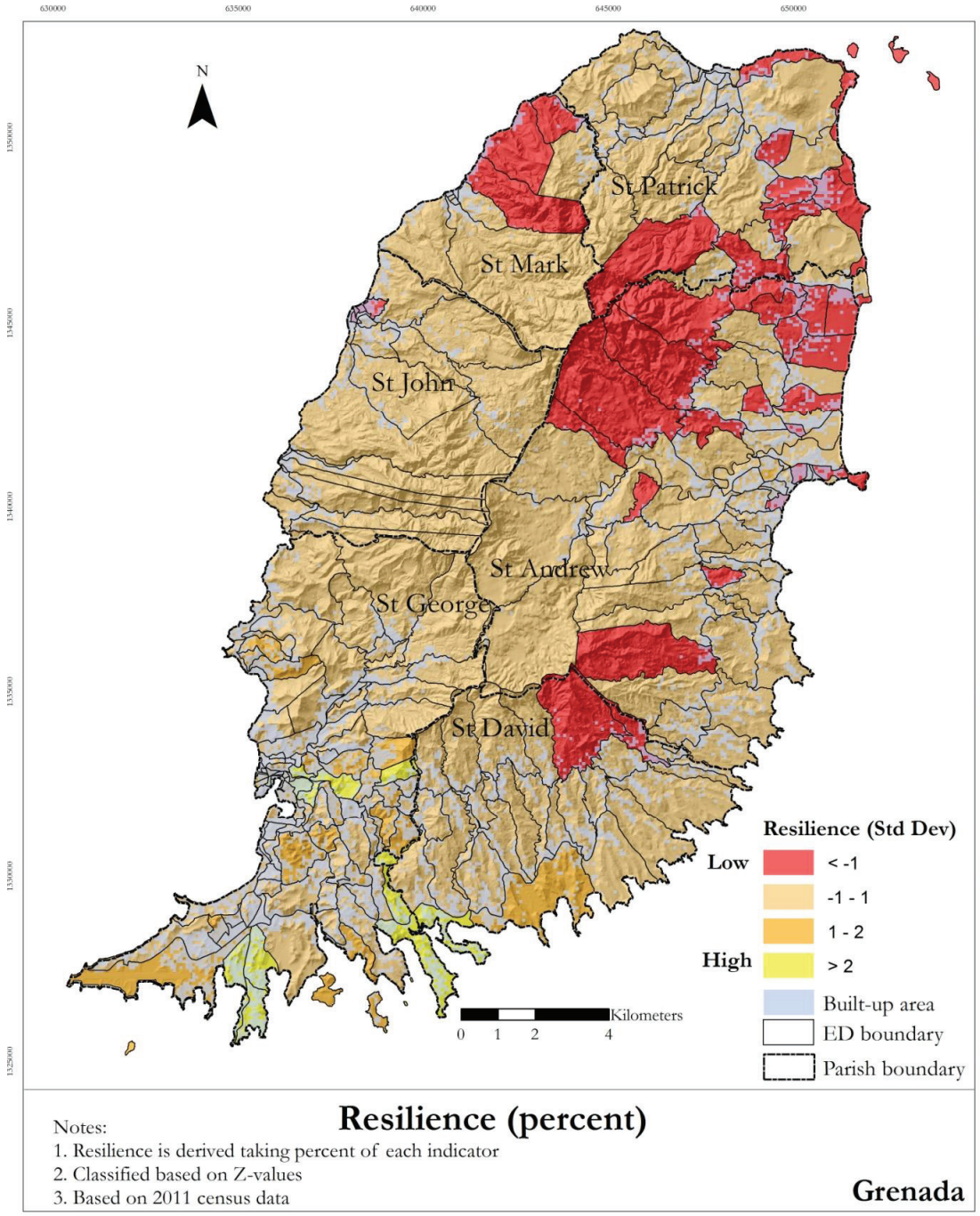
101. What part of the country was that? If known, Specify?

Remember to mark multiple choice boxes like this ☒

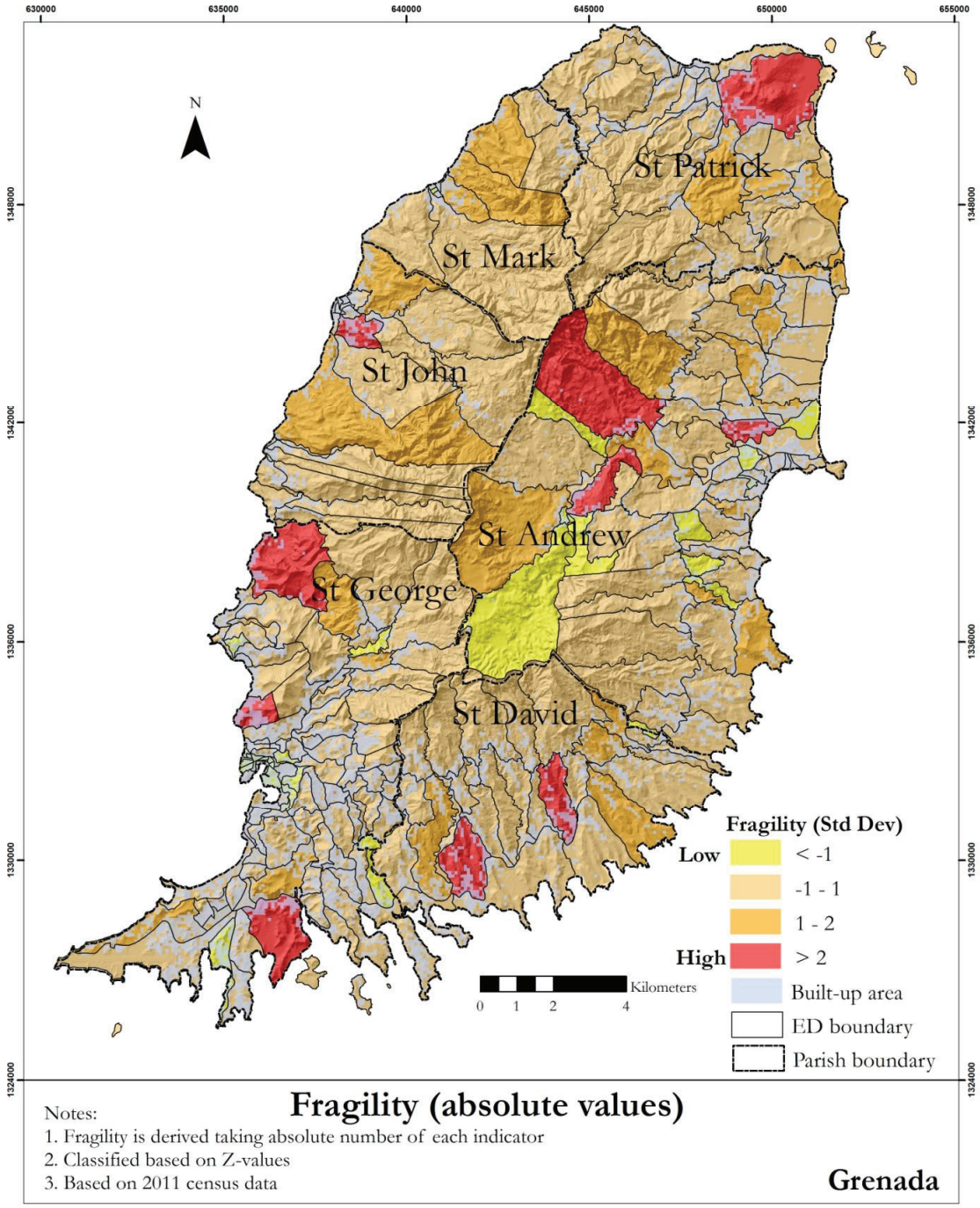
ANNEXURE 3: FRAGILITY MAP BASED ON PERCENT



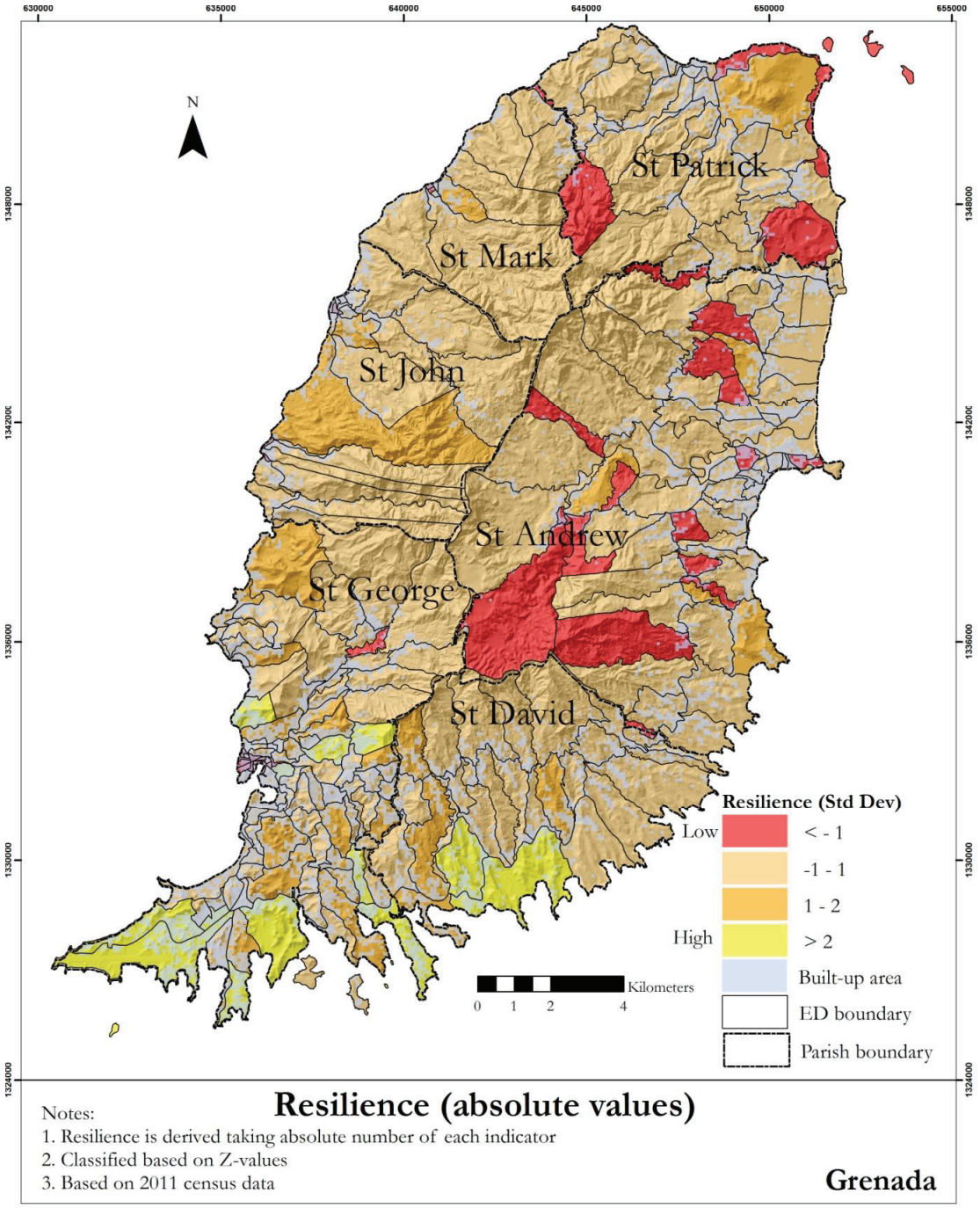
ANNEXURE 4: RESILIENCE MAP BASED ON PERCENT



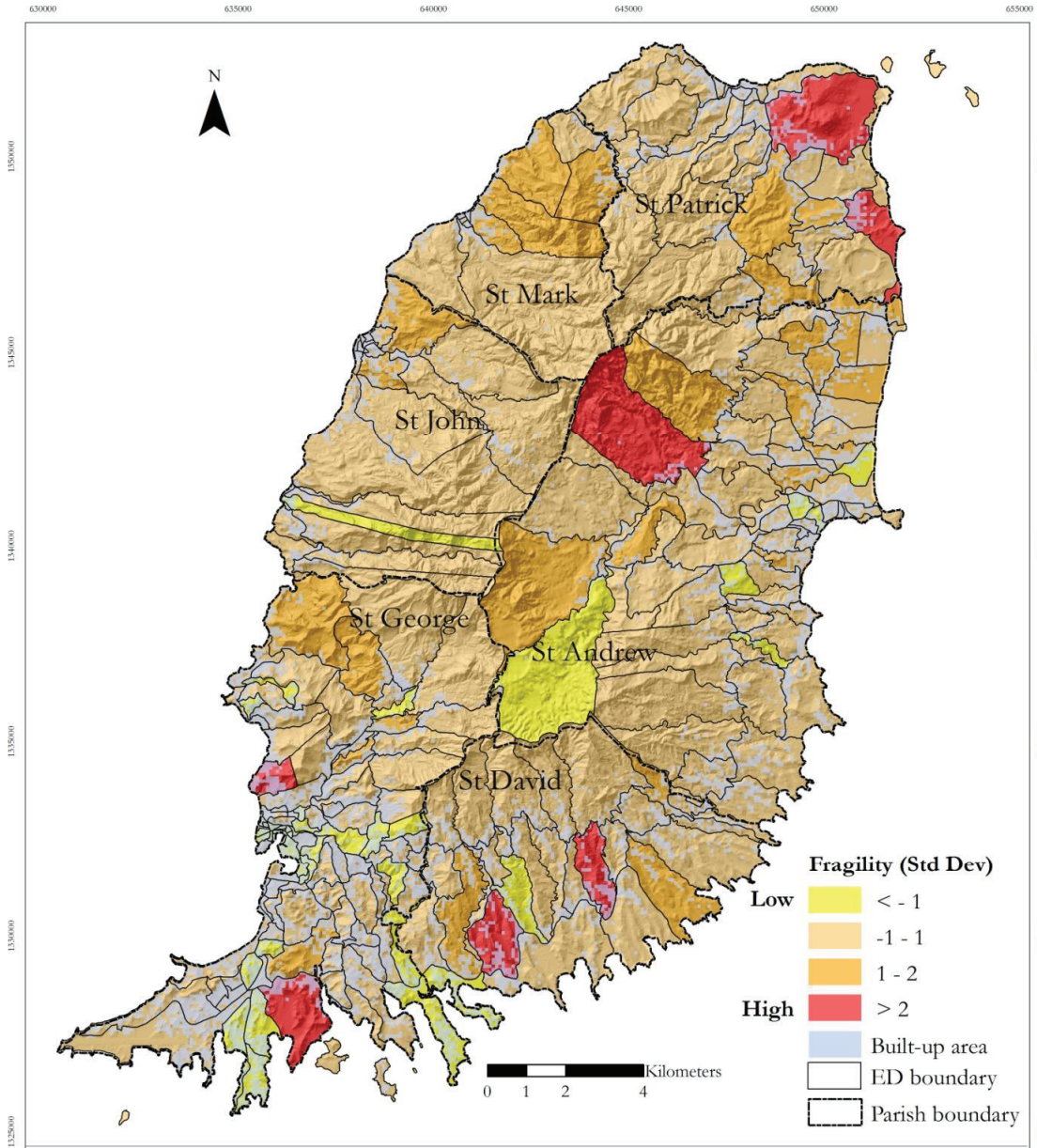
ANNEXURE 5: FRAGILITY MAP BASED ON ABSOLUTE VALUES



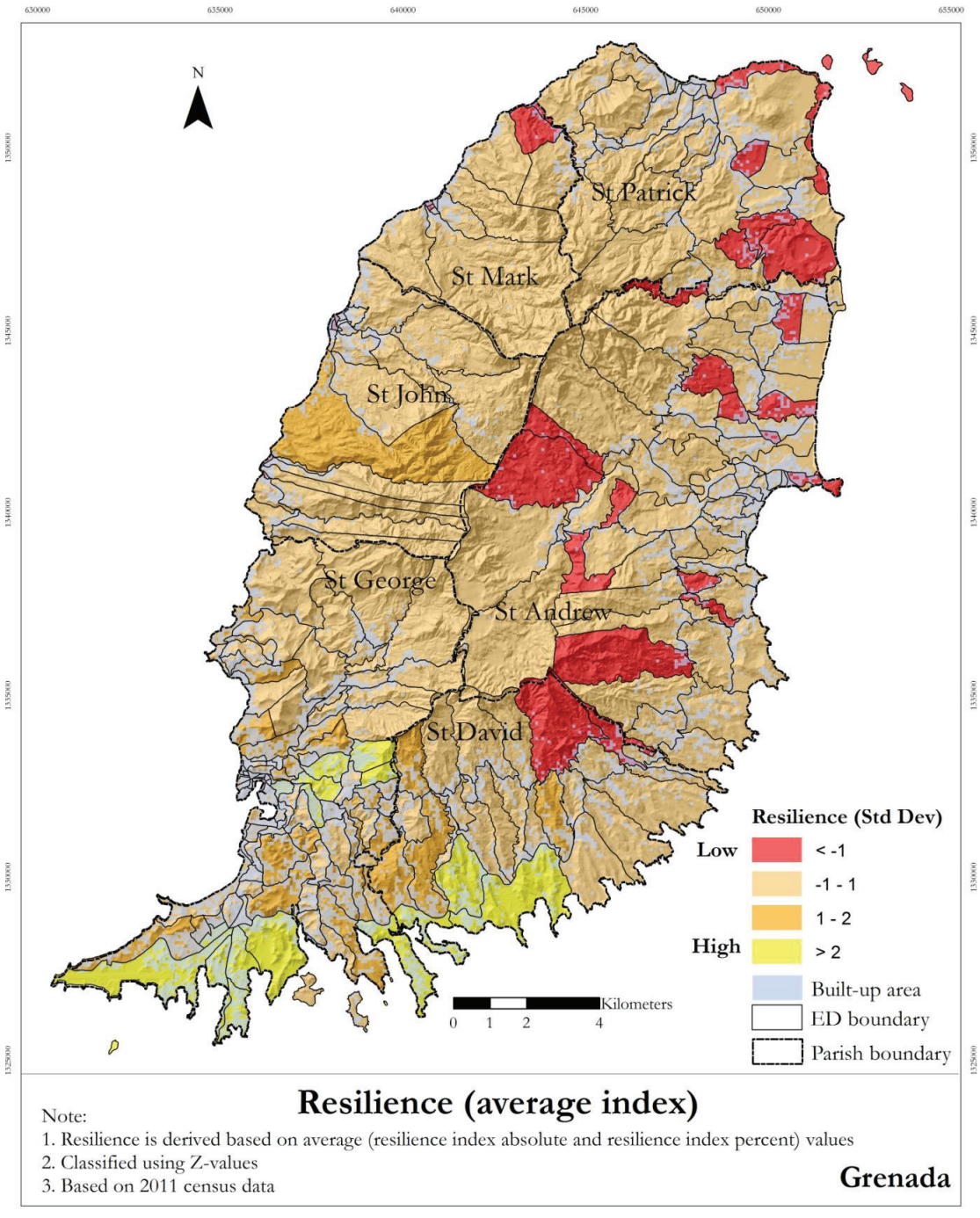
ANNEXURE 6: RESILIENCE MAP BASED ON ABSOLUTE VALUES



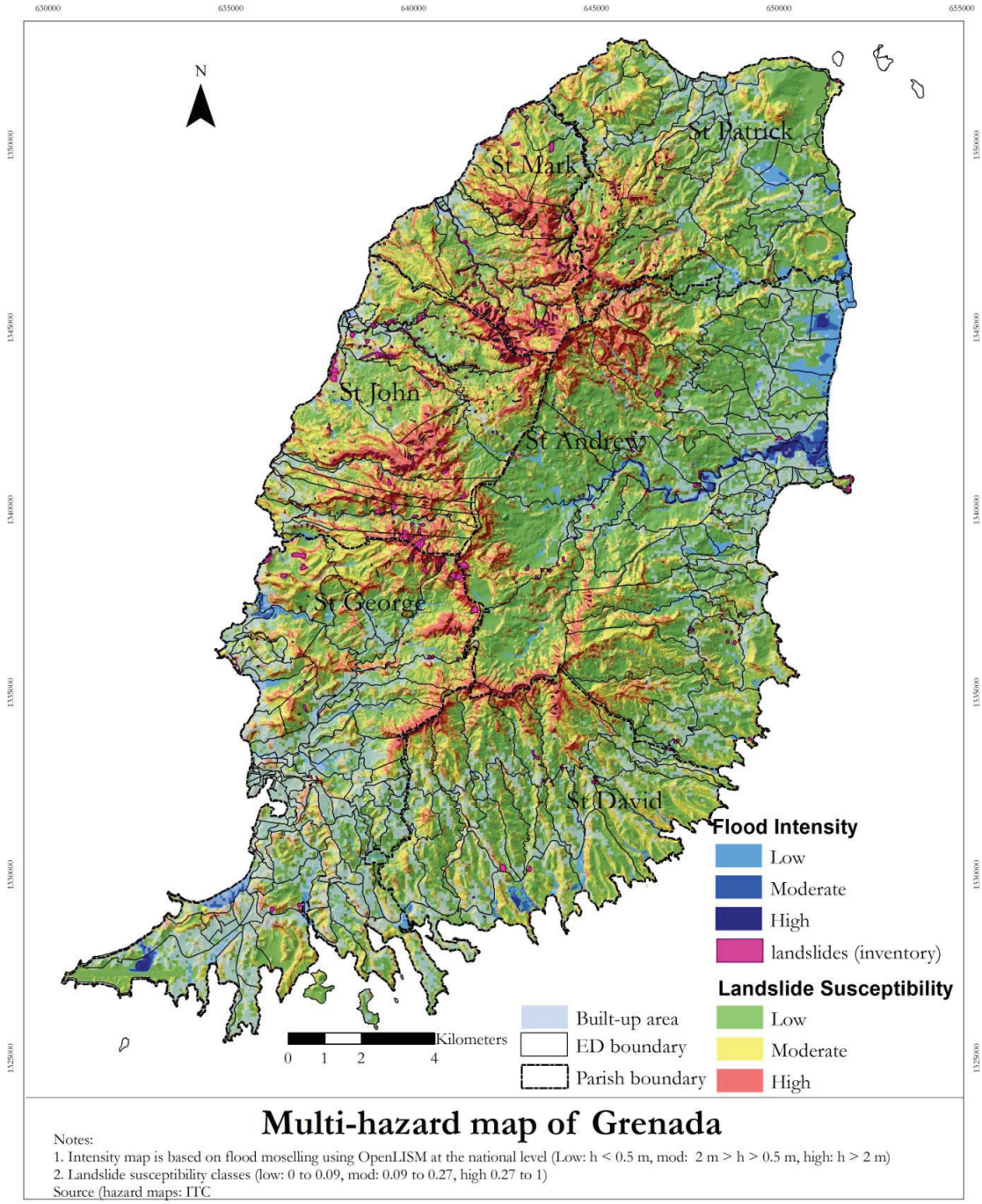
ANNEXURE 7: FRAGILITY MAP BASED ON AVERAGE FRAGILITY INDEX VALUES



ANNEXURE 8: RESILIENCE MAP BASED ON AVERAGE RESILIENCE INDEX VALUES



ANNEXURE 9: MULTI-HAZARD MAP



Multi-hazard map of Grenada

Notes:
1. Intensity map is based on flood moselling using OpenLISM at the national level (Low: h < 0.5 m, mod: 2 m > h > 0.5 m, high: h > 2 m)
2. Landslide susceptibility classes (low: 0 to 0.09, mod: 0.09 to 0.27, high 0.27 to 1)
Source (hazard maps: ITC