CHARIM

Caribbean Handbook on Risk Information Management

Preliminary Assessment Report

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Author:

Cees J. Van Westen Faculty ITC, University of Twente

WORLD BANK GROUP

GFDRR

ACP-EU Natural Disaster Risk Reduction Program

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1. Introduction

The main objective of this consultancy is to build capacity of government clients in the Caribbean region, and specifically in the countries of Belize, Dominica, St. Lucia, St. Vincent and the Grenadines and Grenada, to generate landslide and flood hazards and risks information and apply this in disaster risk reduction use cases focusing on planning and infrastructure (i.e. health, education, transport and government buildings) through the development of a handbook and, hazard maps, use cases, and data management strategy.

The following sub-objectives are defined:

1. To make an inventory of the needs of each target country in terms of their capacity for spatial data collection, analysis and management, (landslide and flood) hazard and risk assessment, and integrate this information in spatial development planning and risk reduction planning;
2. To make an inventory of the tools available worldwide in terms of technical training manuals linked with practical applications and in terms of methodologies applied for flood and landslide hazard and risk assessment at different scales, as well as open source modelling tools for these hazard types;
3. To develop a theoretical framework for landslide and flood hazards and risks assessments, based on the review of existing quantitative and qualitative assessment methods and their appropriate use;
4. To develop nine national hazard mapping studies in the five target countries. One in Belize related to floods and two on each island for landslides and floods;
5. To develop a handbook to support the generation and application of landslide and flood hazard and risk information;
6. To develop a number of use cases of the application of hazard and risk information to inform projects and program of planning and infrastructure sectors. The methodology provides the overall framework for the use cases. The TOR states that there should be 10 generalized use cases for each of two sectors: the ministries of works & transport and the ministries of physical planning, resulting in at most 20 use cases.
7. To make the handbook, data and methodology available through a pdf document and through a web-based platform, consisting of web-based databases, and a Decision Support system set-up for risk reduction planning;
8. To provide training courses based on the materials and the handbook, that is made available to the entire region through a web-based platform and distance education course in collaboration with the University of the West Indies;

To contribute to knowledge exchange between the target countries as well as to the regional and international expert community.

Objective	Methodology	Expected outputs
1. Inventory existing situation in target countries	Literature review, interviews with stakeholders,	Preliminary Assessment Report (due 2 months after contract signing)
2. Inventorise available handbooks and tools for similar situations	Detailed literature review, interviews and contacts with international organizations and experts	
3. To develop a theoretical framework for landslide and flood hazards and risks assessments	Based on literature review and expertise develop the workflow for flood and landslide hazard & risk assessment	Preliminary Assessment Report, set-up and structure of the Handbook.

In order to achieve objectives 1, 2, and 3 a detailed literature study will be carried out, as well as interviews with local representatives of the target countries, contacts with International Organizations that have been involved in previous studies (e.g. World Bank, OAS, IDB, CDB, UNDP, CDEMA etc.) and international experts that have carried out work in the target countries related to landslide and flood hazard and risk assessment (e.g. J. De Graff, M.G. Anderson, C.T. Rogers, P.E. Quinn, E. Castellanos etc.)

The outcome will be a preliminary assessment report, which contains

(a) a summary of the current situation in terms of data available, hazard and risk mapping initiatives, and organizations involved in the target countries;

(b) Literature review of similar guidelines and lessons learnt that are relevant for the handbook

(c) A proposal for the handbook design process to follow, and

(d) A proposed table of content of the handbook, including brief summaries for each chapter and section

This preliminary assessment report addresses the above topics. This report is subdivided into three sections:

- **Section 1: Literature review** of handbooks, manuals, guidelines and textbooks on landslide and flood hazard and risk assessment, the use of risk information in planning and the use of Spatial information for disaster risk management.
- **Section 2: A proposal for the structure** of the Caribbean Handbook for Risk Information Management, consisting of three volumes:
    - Handbook
    - Use cases on the application of risk information in planning
    - Data management;
- **Section 3: Analysis of available data** and hazard and risk assessment studies for the 5 target countries

This preliminary assessment report reflects the situation in the project from July 2014. Since then ideas and plans have further developed, however, to avoid that this document requires continuous updating, it reflects the status at that time.

2. Examples of training materials and handbooks

This chapter presents a number of examples of handbooks, training materials and manuals based on a literature review of similar guidelines and lessons learnt that are relevant for the development of the handbook. We have made an extensive literature review and have limited this review to the most representative examples that we could find on the internet. The literature review was carried out using Google search terms, using only English search terms, therefore manuals in other languages are not included. We have also specifically searched for handbooks and manuals that refer to the Caribbean region. The review might not be exhaustive, but gives a reasonable overview of materials that are freely available. We have divided the materials in a number of categories:

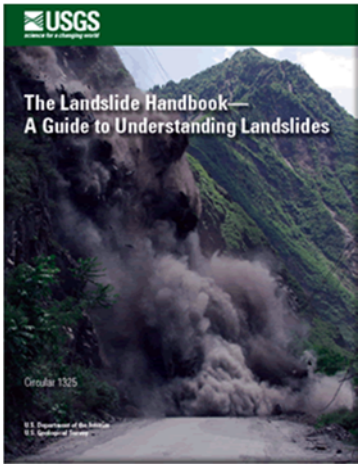
- Landslide hazard and risk assessment
- Flood hazard and risk assessment
- Use of risk information in planning
- Use of spatial information for risk management

For each manual/book we have made a short description, often based directly on the summary provided by the authors, and have made a short evaluation in a table. In the final part of this chapter we summarize the materials and draw conclusions.

2.1 Landslide hazard and risk assessment

2.1.1 The Landslide Handbook – A Guide to Understanding Landslides. L. M. Highland, United States Geological Survey, and P. Bobrowsky, Geological Survey of Canada

Source: http://pubs.usgs.gov/circ/1325/

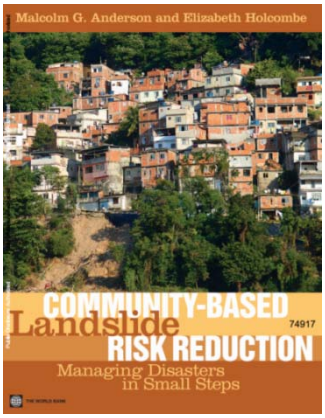


This handbook is intended to be a resource for people affected by landslides to acquire further knowledge, especially about the conditions that are unique to their neighbourhoods and communities. Considerable literature and research are available concerning landslides, but unfortunately little of it is synthesized and integrated to address the geographically unique geologic and climatic conditions around the globe. This handbook aims to help homeowners, community and emergency managers, and decision makers to take the positive step of encouraging awareness of available options and recourse in regard to landslide hazard. The handbook provides a list of references that can be used for further knowledge about landslides. The handbook is intended for use by managers and decision makers in communities so that the information will be disseminated by such officials to other members of those communities.

Document	Type of Document	Target group	Level	Exercises	Remarks	Quality and usefulness
The Landslide Handbook	Handbook: overview	Wide: homeowners, community & emergency managers Decision makers	Basic overview	No	This is a general handbook covering many of the aspects related to landslide mapping, susceptibility, hazard and risk and risk reduction measures.	Very useful overview manual. Fits very well in the type of product that we are making

2.1.2 Community-Based Landslide Risk Reduction: Managing Disasters in Small Steps. M.G. Anderson and E. Holcombe

Source: https://openknowledge.worldbank.org/handle/10986/12239



This book has two main aims: to demonstrate to international development agencies, governments, policy makers, project managers, practitioners, and community residents that landslide hazard can often be reduced in vulnerable urban communities in the developing world, and to provide practical guidance for those in charge of delivering Management of Slope Stability in Communities (MoSSaiC) on the ground. The purpose of the book is to take readers into the most vulnerable communities in order to understand and address rainfall-triggered landslide hazards in these areas. Community residents are not just seen as those at risk, but as the people with the best practical knowledge of the slopes in their neighbourhood. As used here, 'community based' means engaging and working with communities to find and deliver solutions to landslide risk together. This approach leads governments to develop new practices and policies for tackling landslide risk. This book standardizes those elements of MoSSaiC that have led to its successful implementation in the Eastern Caribbean, and that are essential to the overall objectives (such as community engagement, mapping localized slope features, and broad drainage design principles). The book's nine chapters provide guidance to project managers and practitioners on the entire end-to-end process of community-based landslide risk reduction. While certain chapters are more directly relevant to one audience than another, it is helpful for all audiences to read the 'getting started' section of each chapter and be alerted to the nine project milestones

Document	Type of Document	Target group	Level	Exercises	Remarks
Community-Based Landslide Risk Reduction	Manual, showing step by step procedure	international development agencies, governments, policy makers, project managers, practitioners, and community residents that landslide hazard	This book is at the level of practitioners	No	Very useful manual that contains also a lot of examples from the Caribbean islands. It will be very useful to investigate the integration with our handbook. We are currently in discussion with the authors

2.1.3 Recommendations for the quantitative assessment of landslide risk. J. Corominas et al.

Source: http://link.springer.com/article/10.1007%2Fs10064-013-0538-8#page-1


Recommendations for the quantitative analysis of landslide risk

This guideline presents recommended methodologies for the quantitative assessment of the landslide hazard, vulnerability and risk at different scales (site specific, local, regional and national), as well as for the verification and validation of the results. The methodologies described focus on the evaluation of the probability of occurrence of different landslide types with certain characteristics. Methods to determine the spatial distribution of landslide intensity, the characterisation of the elements at risk, the assessment of the

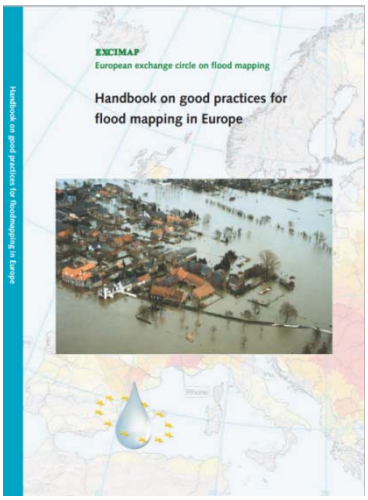
potential degree of damage and the quantification of the vulnerability of the elements at risk, and the quantitative risk assessment (QRA) are also described. The guidelines are intended to be used by scientists and practising engineers, geologists and other landslide experts.

Document	Type of Document	Target group	Level	Exercises	Remarks
Recommendations for the quantitative assessment of landslide risk	Guideline document	Researchers and engineers involved in landslide risk assessment	Advanced. Containing many references	No	This is a well-structured guideline document that contains all steps required in landslide risk assessment.

2.2 Flood hazard and risk assessment

2.2.1 Handbook on good practices for flood mapping in Europe. EXCIMAP

Source:
http://ec.europa.eu/environment/water/flood_risk/flood_atlas/pdf/handbook_goodpractice.pdf



This handbook shows a non-exhaustive picture of the current, existing and accessible good practices for flood mapping in Europe in the year 2006. It is based on experiences and knowledge available at that time in the countries represented in EXCIMAP. This handbook should serve as a technical instrument for practitioners, showing general aspects and features of flood maps and provide examples from all over Europe. The main users of this handbook are Member State's authorities in charge of flood mapping, at any level of competence, according to subsidiarity levels, and any stage of the process, from production to dissemination and use; Authorities of non-EU countries, with which the EU develop cooperation in the area of natural risk management policies, may also be interested; To inform oneself on risk exposure is becoming a must, in order to develop one's strategies and actions in avoiding, reducing or limiting vulnerability to flooding. Private sector, in particular risk management experts and advisors, insurance and real estate business sectors, utility networks and critical infrastructure operators, individual industrial and commercial concerns.

Document	Type of Document	Target group	Level	Exercises	Remarks
Handbook on good practices for flood mapping in Europe	Handbook	Private sector, in particular risk management experts and advisors, insurance and real estate business sectors, utility networks and critical infrastructure operators	General level	No	Good state of the art document showing flood risk assessment practices in Europe.

2.2.2 Cities and Flooding: A Guide to Integrated Urban Flood Risk Management for the 21st Century

Source: https://www.gfdrr.org/node/1068

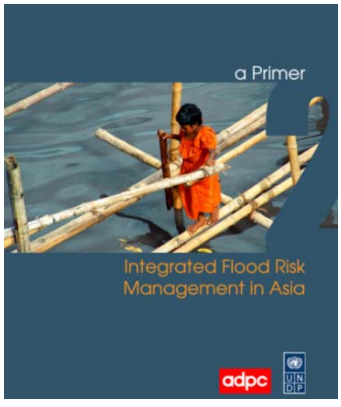
This handbook provides comprehensive, forward-looking operational guidance on how to manage the risk of floods in a rapidly transforming urban environment and changeable climate. The Guide serves as a primer for decision and policy makers, technical specialists, central, regional and local government officials, and concerned stakeholders in the community sector, civil society and non-governmental organizations, and the private sector. The Guide starts with A Summary for Policy Makers which outlines and describes the key areas which policy makers need to be knowledgeable about to create policy directions and an integrated strategic approach for urban flood risk management. The core of the Guide consists of seven chapters, organized as follows: Understanding Flood Hazard; Understanding Flood Impacts; Integrated Flood Risk Management: Structural Measures. Integrated Flood Risk Management: Non-Structural Measures; Evaluating Alternative Flood Risk Management Options: Tools for Decision Makers; Implementing Integrated Flood Risk Management; Conclusion: Promoting Integrated Urban Flood Risk Management.

Document	Type of Document	Target group	Level	Exercises	Remarks
Cities and Flooding	Handbook	Decision and policy makers, technical specialists, central, regional and local government officials, and concerned stakeholders in the community sector, civil society and non-governmental organizations, and the private sector	This handbook is at a basic level. Does not contain details, but treats the matter in a comprehensive manner.	No	This is a very comprehensive handbook that contains many components which are also useful for our handbook. Perhaps it is too large for our purpose. Contains useful chapters on flood hazard and flood risk assessment. However, it is not focused specifically on the flooding problems in the target countries. Very useful.

2.2.3 ADPC Integrated Flood Risk Management in Asia.

Source:

http://www.adpc.net/maininforesource/udrm/floodprimer.pdf



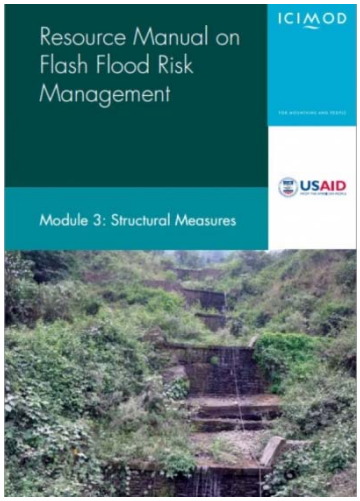
This document is a 'how-to' reference manual for all stakeholders engaged in development at all levels, who in their daily work need to understand basic concepts, terminologies, methodologies and available tools to address their risks. It provides examples from various parts of the world to demonstrate the use of tools and successful methodologies. It is hoped that the Primer will support stakeholders in assessing their risks, planning for actions, and forming collaborative partnerships, to reduce risks and ultimately save human lives.

Document	Type of Document	Target group	Level	Exercises	Remarks
ADPC Integrated Flood Risk Management in Asia	Primer	Decision and policy makers, technical specialists, central, regional and local government officials, and concerned stakeholders in the community sector, civil society and non-governmental organizations, and the private sector	This primer is at a basic level. Does not contain details, but treats the matter in a comprehensive manner.	No	This primer is rather similar to the cities and flooding handbook, but is exclusively focused on Asia. It is less focused on flood hazard, has a component on flood risk but deals mainly with flood risk management issues. It is also a very useful source for the handbook. The design is quite nice.

2.2.4 Resource Manual on Flash flood risk management

Source:

http://www.icimod.org/publications/index.php/search/publication/822



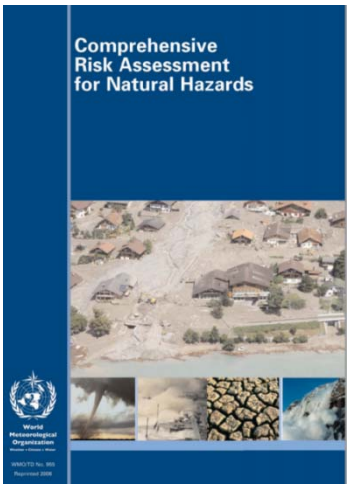
This manual was designed to help build the capacity of trainers in the field of flash flood risk management. It is largely based on ICIMOD's Resource Manual on Flash Flood Risk Management, to support the training of planners and practitioners in managing flash flood risk, in 2008 ICIMOD published two modules of a resource manual which focused on community-based management and non-structural measures. This publication, the third module of the series, deals with structural measures. It presents bioengineering techniques, physical measures for slope stabilization and erosion control, and physical measures for river training. The measures described are simple yet effective; they can be implemented using local and low-cost materials with a minimum of external materials and technical support and a low environmental impact. The publication also presents the concept of integrated flood management as a component of integrated water resource management. It emphasizes that structural measures are most effective and sustainable when implemented together with appropriate non-structural measures. The manual is aimed at junior to mid-level professionals with a civil engineering background working on flash flood risk management at the district level...

Document	Type of Document	Target group	Level	Exercises	Remarks
Resource manual on flash flood risk management	Resource manual	Both technical people and decision makers.	It is a bit mixed. Some of the materials are rather simple, and others much more advanced.	Yes. contains a number of worked out case studies	This manual focuses on bioengineering techniques, physical measures for slope stabilization and erosion control, and physical measures for river training. Useful resource materials. But too much in detail for our handbook.

2.3 Multi-hazard risk assessment

2.3.1 Comprehensive Risk Assessment for Natural Hazards. WMO.

Source: http://www.planat.ch/fileadmin/PLANAT/planat_pdf/alle_2012/2006-2010/Melching__Pilon_2006_-_Comprehensive_Risk_Assessment_for_Natural.pdf



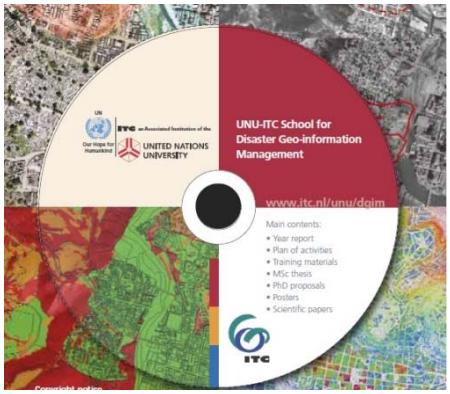
The primary aim of this handbook is on identifying and presenting the various existing technologies used to assess the risks for natural disasters of different origins and to encourage their application, as appropriate, to particular circumstances around the world. A very important aspect of this report is the promotion of comprehensive or joint assessment of risk from a variety of possible natural activities that could occur in a region. At the same time, it does identify gaps where there is a need for enhanced research and development. By presenting the technologies within one volume, it is possible to compare them, for the specialists from one discipline to learn from the practices of the other disciplines, and for the specialists to explore possibilities for joint or combined assessments in some regions.

Document	Type of Document	Target group	Level	Exercises	Remarks
Comprehensive Risk Assessment for Natural Hazards	Textbook	Technical staff and scientists.	Technical level document focusing on tools and techniques for hazard assessment	No	The book deals with a series of hazards, including flooding and landslides. It also has a good glossary. It deals more with hazards than with risk.

2.3.2 Multi-hazard risk assessment. C.J. van Westen et al. ITC, The Netherlands

Source:

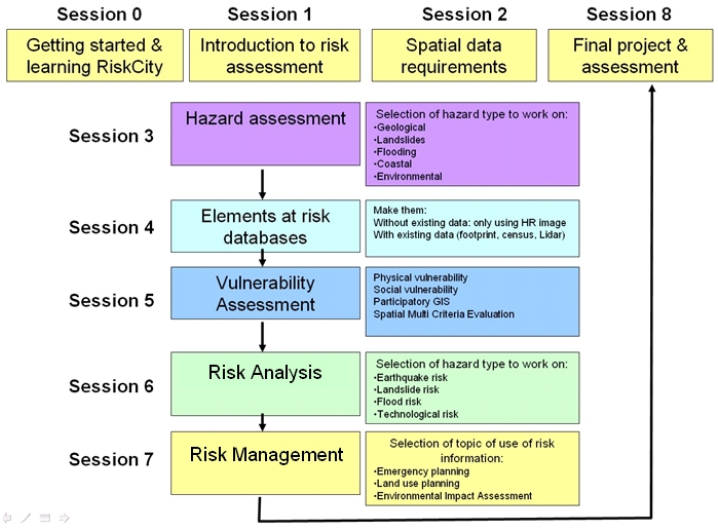
http://www.ecapra.org/training-multi-hazard-risk-assessment



The course explains how to conduct a risk assessment using spatial information on hazards, elements at risk and vulnerability with the aid of GIS and remote sensing, and how this information can be used in risk management, with a focus on urban areas. This course is designed for all those who have to carry out risk assessment and require knowledge and skills in using a GIS to handle the necessary the procedures, such as professionals working in governmental and non-governmental organizations, planners, engineers, architects, geographers, environmental specialists and university teachers. Some basic background in GIS is desirable, although not strictly necessary as the course follows a step-by-step approach that enables participants to rapidly acquire the basic skills in handling GIS software. The course will guide participants through the entire process of risk

assessment, on the basis of a case study of a city exposed to multiple hazards. At the end of this course, you will be able to: understand the concepts of hazard assessment, elements-at-risk mapping, vulnerability assessment and risk assessment; formulate the spatial data requirements for risk assessment; use GIS to generate an elements-at-risk database; apply various methods for vulnerability assessment; generate risk maps using qualitative and quantitative methods; understand how risk assessment is used in risk reduction and disaster preparedness.

The course is composed of a number of sessions. Below is a summary of the sessions and detailed content.



Session 1: Introduction to risk assessment

- Theory: Introduction to disaster risk management and risk assessment.
- Exercise: Generation of a hazard profile using disaster databases; Introduction to ILWIS, and introduction to the RiskCity dataset. Learn the various hazard problems by evaluating high resolution images

Session 2: Obtaining spatial data for risk assessment

- Theory: Presentation of data requirements for the various types of hazards. Sources of spatial data.
- Exercises: Defining spatial data requirements for risk assessment; Internet search for information on risk assessment; acquiring free and low cost data; generating three dimensional image data using Google Earth; stereo image interpretation

Session 3: Hazard Assessment

- Theory: Hazard types; Main concepts of hazard assessment; Frequency magnitude – relationships
- Exercises: Frequency assessment; Selection of hazard assessment example (flooding, landslides, earthquakes, technological hazards, volcanic hazards etc.)

Session 4: Elements at risk assessment

- Theory: Types of elements at risk; classification of buildings, infrastructure, lifelines, critical facilities; population information; collection of elements at risk information.
- Exercise: Generating an elements at risk database from scratch; Generating an elements at risk database using available data (building footprint map, census data and LiDAR)

Session 5: Vulnerability assessment

- Theory: Types of vulnerability; social vulnerability; physical vulnerability; methods for vulnerability assessment; participatory GIS; Spatial Multi Criteria Evaluation
- Exercises: Defining vulnerability curves; Spatial Multi-criteria evaluation for vulnerability assessment

Session 6: Risk assessment

- Theory: Loss estimation models; HAZUS; qualitative risk assessment; QRA; basics of flood risk, seismic risk, landslide and technological risk assessment;
- Exercises: Creating risk curves; Selection of risk assessment method: flooding, earthquakes, landslides, technological.

Session 7: Risk management

- Theory: Risk evaluation; risk governance; risk communication; cost benefit analysis; Using risk information for emergency planning; spatial planning, and Environmental Impact Assessment
- Exercises: Multi-hazard risk assessment for buildings; assessing economic losses; Cost benefit analysis

Session 8: Final project and examination

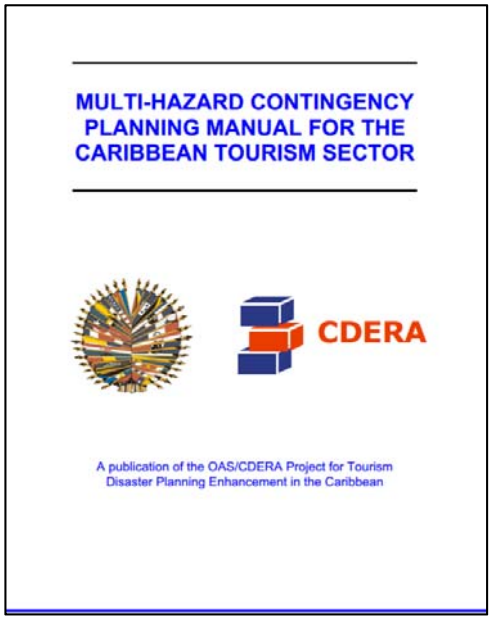
- Discussion: How to do such a study in your area?
- Final project: Selection of project topic related to risk assessment and its use in risk management

Document	Type of Document	Target group	Level	Exercises	Remarks
Multi-hazard risk assessment	Training package, containing a textbook and exercise book	Technical staff dealing with the use of spatial information for multi-hazard risk assessment	This is at a somewhat more advanced level, although the textbook is easy to follow	Yes, the textbook has many exercises, and the package has also a series of GIS exercises with datasets.	This is a distance education course that illustrates the theory with GIS exercises that cover most aspects relevant for the handbook. It uses a virtual example, called RiskCity. Very useful for the design of the handbook.

2.3.3 Multi-Hazard Contingency Planning Manual For The Caribbean Tourism Sector

Source:

http://www.onecaribbean.org/content/files/OASDisasterManual2009final.pdf



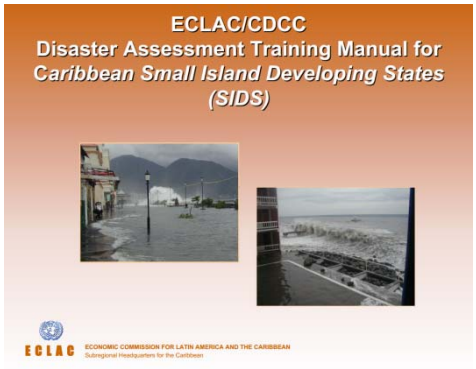
The tourism industry is a vital economic force in the Caribbean, and its continued health is an important factor in generating jobs, revenue and infrastructure development throughout the region. To maintain its long-term viability, the tourism sector must be prepared to endure and recover from a wide range of hazards and emergencies. Two of the most significant threats to the industry are hurricanes and terrorist incidents, which can both cause significant physical and structural damage, lead to human injuries and loss of life, and impact the attractiveness of a destination to potential visitors. This Multi-Hazard Contingency Planning Manual is designed to help the industry to be better prepared for dealing with such critical incidents. This document is part of the Organization of American States (OAS)/Caribbean Disaster Emergency Response Agency (CDERA) Project for Tourism Disaster Planning Enhancement in the Caribbean, a joint initiative of the OAS, CDERA, the Caribbean Hotel Association (CHA), the Caribbean Tourism Organization (CTO) and other stakeholders.

Document	Type of Document	Target group	Level	Exercises	Remarks
Multi-Hazard Contingency Planning Manual For The Caribbean Tourism Sector	Manual, with a lot of practical information	both government agencies responsible for tourism and for individual tourism establishments in the Caribbean region	Manual to develop contingency plans	No	We included the manual because it relates to the target region and deals with multi-hazards, although focusing on tourism, hurricanes and terrorism.

2.3.4 Disaster Assessment Training Manual for Caribbean Small Island Developing States (SIDS)

Source:

http://www.eclac.cl/cgi-bin/getProd.asp?xml=/publicaciones/xml/8/14978/P14978.xml&xsl=/publicaciones/ficha-i.xsl&base=/publicaciones/top_publicaciones-i.xsl#



This handbook Introduces and explains the ECLAC method of disaster assessment training, and disaster preparation and reduction. It identifies the issues of disaster vulnerability facing SIDS, including cyclical meteorological phenomena like hurricanes and storms, as well as geophysical phenomena like earthquakes and volcanic activity. Furthermore, it provides examples of disaster occurrence, their frequencies and consequences; discusses land use and vulnerability; and reviews planning approaches and practices, and coastal tourism policies.

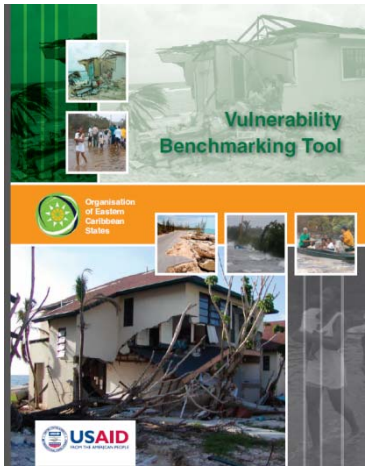
Document	Type of Document	Target group	Level	Exercises	Remarks
Disaster Assessment Training Manual for Caribbean Small Island Developing States	Training manual	Government officials and technical personnel involved in disaster risk assessment	Basic	There are some selected exercises in Annex 2	This is basically more a set of PowerPoint slides than a complete manual. It is quite general. One needs to download each of the parts individually. It focuses on assessing damage from disasters

2.3.5 Vulnerability Benchmarking Tool

Source:

http://www.oecs.org/publications/doc_download/80-vulnerability-benchmarking-tool-booklet

Organization of Eastern Caribbean States



The Caribbean is particularly vulnerable to natural hazards such as hurricanes, earthquakes, volcanoes, flooding. In order to achieve sustained growth, the public and private sectors in the region must formulate and implement meaningful actions to measurably reduce the economic and social impacts of disasters at the national and regional level. In many cases positive steps have already been initiated, these however, lack the political support and will to follow through with the implementation of necessary but possibly unpopular measures such as proactive land use zoning and the implementation of full disclosure laws. In some cases, national policies and plans exist, but lack resources for implementation. In other cases, national policies and plans are not in place, and there are no overarching frameworks to

address disaster preparedness and mitigation. Generally, the technical analysis regarding the region's risks and the appropriate solutions has already been undertaken. However, a specific action agenda that is directed to achieving a measurable reduction in the region's risk profile for natural disasters has largely been missing. The United States Agency for International Development (USAID) through its Caribbean Open Trade Support program in collaboration with the Organisation of Eastern Caribbean States (OECS) Secretariat has developed the Vulnerability Benchmarking Tool (BTool) to assist the OECS countries to proactively plan and implement actions to reduce vulnerability to natural disasters and create greater economic resilience when they do occur. This publication explains the BTool, how it was developed, how it can be used to conduct a national assessment and includes a copy of the actual tool. This publication was developed by Rd. Jacob Opadeyi and Dr. Balfour Spence of The University of the West Indies for the Organisation of Eastern Caribbean States with funding from the United States Agency for International Development's Caribbean Open Trade Support (COTS) Program.

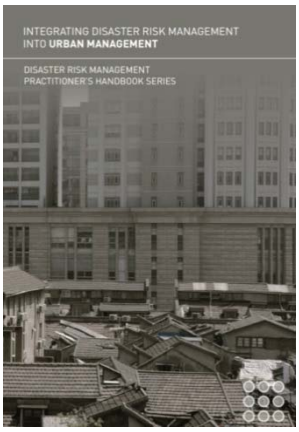
Document	**Type of Document**	**Target group**	**Level**	**Exercises**	**Remarks**
the Vulnerability Benchmarking Tool (BTool)	Guide	To assist the OECS countries to proactively plan and implement actions to reduce vulnerability to natural disasters and create greater economic resilience when they do occur.	Basic explanation, with a lot of questionnaires	No	The book is more about hazard susceptibility than on vulnerability. It aims at comparing vulnerability levels for the different Caribbean countries. It is a useful background document for the handbook

2.4 Integrating Disaster Risk Management in Planning

2.4.1 Integrating Disaster Risk Management into Urban Management. Disaster Risk Management Practitioner's Handbook Series. ADPC. 2013.

Source:

http://www.adpc.net/2012/download/DRM-Handbook/ADPC%20DRM%20Practitioners%20Handbook%20-%20Urban%20Management.pdf



This handbook was developed by the Asian Disaster Preparedness Center, Bangkok (ADPC), with funding from the Asian Development Bank (ADB). The Disaster Risk Management Practitioner's Handbook Series portrays what the disaster risk management (DRM) practitioner can contribute to a selection of government-led processes in order to strengthen disaster resilience and foster sustainable, inclusive development across Asia and the Pacific.
The handbooks aim to provide advice to the DRM practitioner on both strategic and practical options for operational implementation of DRM within a selection of development processes and tools.

Document	Type of Document	Target group	Level	Exercises	Remarks
Integrating Disaster Risk Management into Urban Management	Handbook	Disaster Risk Management Practitioner, government officials, municipal units of DRM	Basic level, but containing many small examples	No	The handbooks aim to provide advice to the DRM practitioner on both strategic and practical options for operational implementation of DRM within a selection of development processes and tools

2.4.2 Eco -DRR Manual UNEP

Source: http://www.unep.org/disastersandconflicts/portals/155/dnc/docs/drr_training/Eco-DRR%20InstructorManualApril2013.pdf

n October 2011, at the third network meeting of the Center for Natural Resources and Development (CNRD), CNRD and the Partnership for Environment and Disaster Risk Reduction (PEDRR) decided to develop a joint Master's module entitled, "Disasters, Environment and Risk Reduction (Eco-DRR)" for introduction at CNRD partner universities and beyond. The close inter-linkages between sound environmental management, climate change impacts and disaster responses require a more systematic and comprehensive approach to disaster risk management, which in the past has mainly been reactive rather than preventive, engineering focused rather than based on planning and use of natural landscape features to prevent disaster risks. This is what we refer to as the "Eco-DRR" approach wherein disaster risk management incorporates ecosystem management

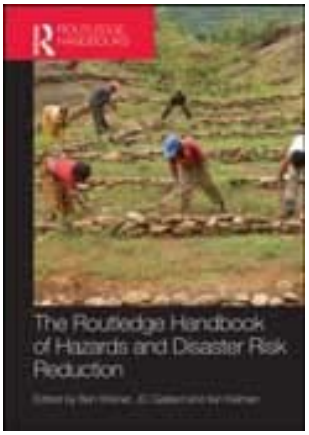
tools, which constitute the core of this module and introduces a more innovative and systems approach to sustainable disaster risk management.

Document	Type of Document	Target group	Level	Exercises	Remarks
Eco -DRR Manual UNEP	Course manual	Master students	Basic	Yes	This is the instructors manual of a masters course on disasters, environment and risk reduction. It contains some useful components for the handbook.

2.4.3 Handbook of hazards and disaster risk reduction. Wisner, Gailard, Kelman

Source:

http://www.routledge.com/books/details/9780415590655/

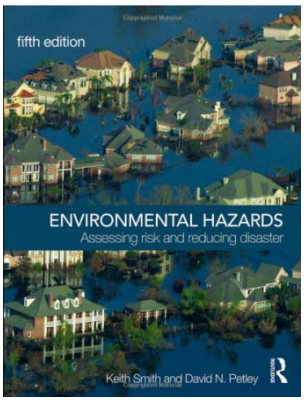


This handbook provides a comprehensive statement and reference point for hazard and disaster research, policy making, and practice in an international and multi-disciplinary context. It offers critical reviews and appraisals of current state of the art and future development of conceptual, theoretical and practical approaches as well as empirical knowledge and available tools. Organised into five inter-related sections, this handbook contains sixty-five contributions from leading scholars. It includes five sections, which: (i) situates hazards and disasters in their broad political, cultural, economic, and environmental context; (ii) contains treatments of potentially damaging natural events/phenomena organized by major earth system; (iii) critically reviews progress in responding to disasters including warning, relief and recovery; (iv) addresses mitigation of potential loss and prevention of disasters under two sub-headings: governance, advocacy and self-help, and communication and participation; and (v) ends with a concluding chapter by the editors.

Document	Type of Document	Target group	Level	Exercises	Remarks
Handbook of hazards and disaster risk reduction	Textbook	Scientists	Advanced	No	This is a comprehensive textbook covering many aspects relevant for the handbook, and is a good background reading document

2.4.4 Environmental Hazards: Assessing Risk and Reducing Disaster. Smith and Petley

Source: http://www.allbookez.com/environmental-hazards-keith-smith/



The expanded fifth edition of Environmental Hazards provides a balanced overview of all the major rapid-onset events that threaten people and what they value in the twenty-first century. It integrates cutting-edge material from the physical and social sciences to demonstrate how natural and human systems interact to place communities of all sizes, and at all stages of economic development, at risk. It also shows how the existing losses to life and property can be

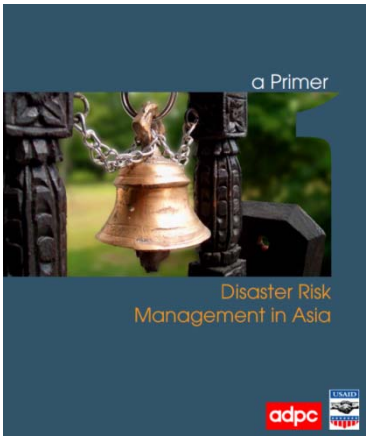
reduced. Part I of this established textbook defines basic concepts of hazard, risk, vulnerability and disaster. Critical attention is given to the evolution of theory, to the scale of disaster impact and to the various strategies that have been developed to minimise the impact of damaging events. Part II employs a consistent chapter structure to explain how individual hazards, such as earthquakes, severe storms, floods and droughts, plus biophysical and technological processes, create distinctive patterns of loss throughout the world. The ways in which different societies make a positive response to these threats are placed in the context of ongoing global change.

Document	Type of Document	Target group	Level	Exercises	Remarks
Environmental Hazards: Assessing Risk and Reducing Disaster	Textbook	(under) graduate students	advanced	No, but contains good example	Very useful textbook on hazard and risk assessment. One of the best textbooks available on this topic. Good background material for the Handbook development

2.4.5 ADPC. Disaster Risk Management in Asia. A Primer

Source:

http://www.adpc.net/v2007/ikm/ONLINE%20DOCUMENTS/downloads/DRMPrimerV1.pdf

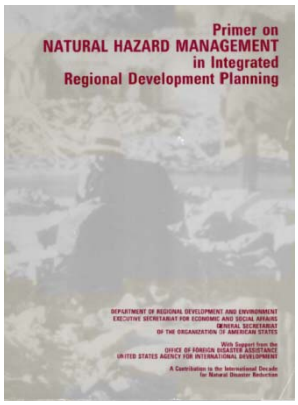


The Primer for Disaster Risk Management in Asia is a 'how-to' reference manual for all stakeholders engaged in development at all levels, who in their daily work need to understand basic concepts, terminologies, methodologies and available tools to address their risks. It provides examples from various parts of the world to demonstrate the use of tools and successful methodologies. It is hoped that the Primer will support stakeholders in assessing their risks, planning for actions, and forming collaborative partnerships, to reduce risks and ultimately save human lives. This Primer is based on consultations with and inputs from a number of local, national, regional and international experts, and stakeholders. It is published by the Asian Disaster Preparedness Center, Bangkok, Thailand. The Primer is a series of publications - the first volume provides an overview of disaster risk management, while the subsequent volumes are to be hazard specific.

Document	Type of Document	Target group	Level	Exercises	Remarks
ADPC Disaster Risk Management in Asia	Primer	Decision and policy makers, technical specialists, central, regional and local government officials, and concerned stakeholders in the community sector, civil society and non-governmental organizations, and the private sector	This primer is at a basic level. Does not contain details, but treats the matter in a comprehensive manner.	No	This primer is rather similar to the other ones from ADPC, and is exclusively focused on Asia. It is also a bit too general for our purpose. It is also a very useful source for the handbook. The design is quite nice.

2.4.6 OAS: Primer on Natural Hazard Management in integrated Regional Development Planning.

http://pdf.usaid.gov/pdf_docs/Pnabj801.pdf

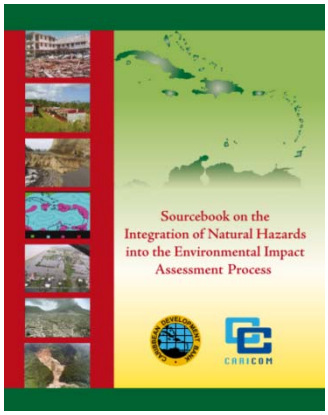


This Primer has been prepared as reference document for practitioners in the field, to guide integrated development planning teams in Latin America and the Caribbean in the use of natural hazard information during the different stages of the planning process. The information presented is specifically oriented toward regional planning studies, whether the area in question is a few hundred or a few hundred thousand square kilometres, and complements other planning information that is typically gathered and analysed during the course of the study. The methods have been selected for their utility in the regional planning process. The Primer is divided into three parts, each covering a specific subject area and complementary to the others. Each part, with the chapters contained therein, is meant to provide the planning team sufficient guidance in that subject area for it to proceed with the task at hand. There is extensive cross referencing between chapters. Since the book is intended for reference, each chapter is complete within itself (even though this results in some redundancy), with its own detailed table of contents, a short summary, a statement of its objective, and complete references.

Document	Type of Document	Target group	Level	Exercises	Remarks
OAS: Primer on Natural Hazard Management in integrated Regional Development Planning	Primer	Decision and policy makers, technical specialists, central, regional and local government officials, and concerned stakeholders in the community sector, civil society and non-governmental organizations, and the private sector	Basic level but very comprehensive	No	Although this is already a bit old, this is one of the best background documents that also is very relevant with respect to the Caribbean setting. It focuses however more on regional analysis.

2.4.7 CARICOM: Sourcebook on the Integration of Natural Hazards into the Environmental Impact Assessment (EIA) Process

http://www.caribank.org/uploads/2012/03/Source-Book5.pdf



The Sourcebook on the Integration of Natural Hazards into the Environmental Impact Assessment (EIA) Process (NHIA-EIA Sourcebook) has been developed as a collaborative effort between the Caribbean Development Bank (CDB), through its Disaster Mitigation Facility for the Caribbean (DMFC) and the Caribbean Community (CARICOM) Adapting to Climate Change in the Caribbean (ACCC) Project. The Sourcebook on the Integration of Natural Hazards into the EIA Process is intended to be a compilation of current and appropriate mechanisms for assessing, within EIA, the potential interaction between a proposed project and natural

hazards. The combined process is referred to as Natural Hazard Impact Assessment–Environmental Impact Assessment (NHIA-EIA). The Sourcebook presents a generic approach to the NHIA-EIA process, which can be adapted to existing EIA processes at the national and regional levels. Appendices with appropriate checklists, references and examples are provided for each step in the NHIA-EIA process. The target audience for the Sourcebook includes EIA practitioners and reviewers at the national and regional levels in the Caribbean. The Sourcebook is not a guide to the full EIA process. Rather, it focuses exclusively on the interventions into the EIA process that are necessary to ensure that natural hazard risk considerations are appropriately addressed.

Document	Type of Document	Target group	Level	Exercises	Remarks
CARICOM: Sourcebook on the Integration of Natural Hazards into the Environmental Impact Assessment (EIA) Process	Handbook	includes EIA practitioners and reviewers at the national and regional levels in the Caribbean	Very useful step by step guide	No	Very useful handbook on the use of risk information in Environmental Impact Assessment, with examples from the Caribbean. Good background document for the handbook development.

2.4.8 EU – Flood Risk Directive 2007/60/EC on the assessment and management of flood risks

Source: http://ec.europa.eu/environment/water/flood_risk/

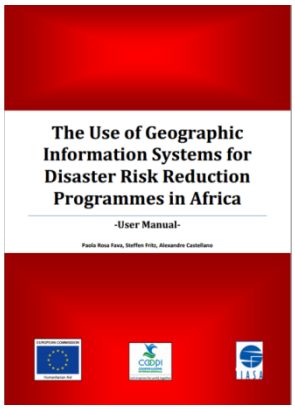
Directive 2007/60/EC on the assessment and management of flood risks entered into force on 26 November 2007. This Directive now requires Member States to assess if all water courses and coast lines are at risk from flooding, to map the flood extent and assets and humans at risk in these areas and to take adequate and coordinated measures to reduce this flood risk. With this Directive also reinforces the rights of the public to access this information and to have a say in the planning process. Between 1998 and 2009, Europe suffered over 213 major damaging floods, including the catastrophic floods along the Danube and Elbe rivers in summer 2002. Severe floods in 2005 further reinforced the need for concerted action. Between 1998 and 2009, floods in Europe have caused some 1126 deaths, the displacement of about half a million people and at least €52 billion in insured economic losses. (Source: EEA). Catastrophic floods endanger lives and cause human tragedy as well as heavy economic losses. Floods are natural phenomena but through the right measures we can reduce their likelihood and limit their impacts. In addition to economic and social damage, floods can have severe environmental consequences, for example when installations holding large quantities of toxic chemicals are inundated or wetland areas destroyed. The coming decades are likely to see a higher flood risk in Europe and greater economic damage. Member States shall furthermore coordinate their flood risk management practices in shared river basins, including with third counties, and shall in solidarity not undertake measures that would increase the flood risk in neighbouring countries. Member States shall in take into consideration long term developments, including climate change, as well as sustainable land use practices in the flood risk management cycle addressed in this Directive.

Document	Type of Document	Target group	Level	Exercises	Remarks
EU – Flood Risk Directive	Guideline document	Governments from the EU member states, flood hazard specialists, planners etc.	Policy document	No	The Directive requires Member States to first carry out a preliminary assessment by 2011 to identify the river basins and associated coastal areas at risk of flooding. For such zones they would then need to draw up flood risk maps by 2013 and establish flood risk management plans focused on prevention, protection and preparedness by 2015. The Directive applies to inland waters as well as all coastal waters across the whole territory of the EU.

2.5 Use of spatial information in Disaster Risk Management

2.5.1 The Use of Geographic Information Systems for Disaster Risk Reduction Programmes in Africa.

Source: http://www.coopi.org/repository/pagine/gis.manual_22.09.2010.pdf



The manual aims to provide support to Aid Agencies working in Disaster Risk Reduction contests. The development of this manual is part of one of the activities of a Disaster Risk Reduction project in Malawi, funded by DIPECHO and implemented by COOPERAZIONE INTERNAZIONALE (COOPI), an Italian Non-Governmental Organization. The purpose of this manual is to provide useful information, practical solutions and advices in the implementation of Geographic Information System and other remote sensing instruments (RS), such as satellite images and Global Positioning System (GPS), with reference to specific web sites, on line sources, books, tutorials and other documents. Specific focus is given to the use of GIS in Disaster Risk Reduction activities. GIS has been considered a fundamental tool in order to act promptly in case of floods, earthquakes or other natural disasters by enabling to use available spatial information. This information can be gathered through the combination of traditional knowledge at ground level and remote sensing techniques. This could be particularly useful in projects run by governments, NGOs and other International Organizations.

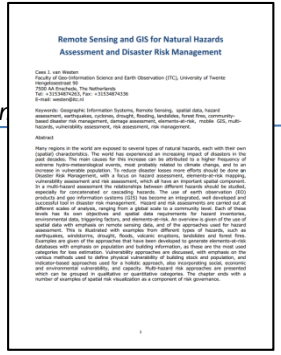
Document	Type of Document	Target group	Level	Exercises	Remarks
Use of Geographic Information Systems for Disaster Risk Reduction	Manual	Technical staff involved in Disaster risk Management	Basic	No	This guide gives an overview of GIS in DRM for non-experts.

2.5.2 Remote Sensing and GIS for Natural Hazards Assessment and DRM

Source:

ftp://ftp.itc.nl/pub/westen/Multi_hazard_risk_course/Powerpoints/Background%20paper%20Spatial%20data%20for%20hazard%20and%20risk%20assessment.pdf

An overview is given of the use of spatial data with emphasis on remote sensing data, and of the approaches used for hazard assessment. This is illustrated with examples from different types of hazards, such as earthquakes, windstorms, drought, floods, volcanic eruptions, landslides and forest fires. Examples are given of the approaches that have been developed to generate elements-at-risk


Remote Sensing and GIS for Natural Hazards Assessment and Disaster Risk Management

databases with emphasis on population and building information, as these are the most used categories for loss estimation. Vulnerability approaches are discussed, with emphasis on the various methods used to define physical vulnerability of building stock and population, and indicator-based approaches used for a holistic approach, also incorporating social, economic and environmental vulnerability, and capacity. Multi-hazard risk approaches are presented which can be grouped in qualitative or quantitative categories. The chapter ends with a number of examples of spatial risk visualization as a component of risk governance

Document	Type of Document	Target group	Level	Exercises	Remarks
Remote Sensing and GIS for Natural Hazards Assessment and DRM	Overview paper	Scientists and practitioners in disaster risk management	Overview	No	Overview paper on the application of GIs and Remote Sensing in disaster risk Management

2.5.3 Some other useful resources

Below some other useful resources are mentioned, for which there was no time to review them in detail. :

- http://www.gripweb.org/gripweb/sites/default/files/methodologies_tools/guidelines%20for%20disaster%20risk%20management_black.pdf: This document, serving as a practical tool and resource, is designed to guide the country office on how to design projects or programmes for national risk assessment (NRA). The guide is intended for the following audience: Local decision makers (central and local government); managers and implementers of risk assessment projects. The guidelines sketch out the various components of a risk assessment project.
- **http://www.onecaribbean.org/resources/disaster-management/**
- http://webra.cas.sc.edu/hvri/docs/handbook.pdf
- http://www.eclac.org/publicaciones/xml/4/52674/Handbookfordisasterassessment.pdf
- http://www.eclac.cl/publicaciones/xml/2/41482/ResumINGFinal.pdf_frances.pdf
- http://traininglearningcircle.aidmi.org/DRR_training_resources.html
- http://go.worldbank.org/VW5ZBJBHA0 \ : A framework for carrying out urban risk assessment, seeking to strengthen coherence and consensus on how cities can plan for natural disasters and climate change.
- http://www.disasterassessment.org : A portal to exchange DRR assessment tools and case studies. Search under “Comprehensive Disaster Risk Assessment;” more under “Techniques Used in Disaster Risk Assessment.”

2.6 Summary and conclusions

Our review of a number of examples of handbooks, manuals, textbooks and training manuals on the landslide and flood hazard and risk assessment, use of risk information in planning and the application of spatial information for Disaster Risk Management, has of course its limitations with respect to the available time. The overview is of course far from complete but gives, in our opinion, a good idea of what is generally available. A summary is given in table 2.1.

Document	Type of Document	Target group	Level	Exercises	Remarks
Landslide hazard and risk assessment					
The Landslide Handbook	Handbook: overview	Wide: homeowners, community & emergency managers Decision makers	Basic overview	No	This is a general handbook covering many of the aspects related to landslide mapping, susceptibility, hazard and risk and risk reduction measures.
Community-Based Landslide Risk Reduction	Manual, showing step by step procedure	international development agencies, governments, policy makers, project managers, practitioners, and community residents that landslide hazard	This book is at the level of practitioners	No	Very useful manual that contains also a lot of examples from the Caribbean islands. It will be very useful to investigate the integration with our handbook. We are currently in discussion with the authors
Recommendations for the quantitative assessment of landslide risk	Guideline document	Researchers and engineers involved in landslide risk assessment	Advanced. Containing many references	No	This is a well-structured guideline document that contains all steps required in landslide risk assessment.
Flood hazard and risk assessment					
Handbook on good practices for flood mapping in Europe	Handbook	Private sector, in particular risk management experts and advisors, insurance and real estate business sectors, utility networks and critical infrastructure operators	General level	No	Good state of the art document showing flood risk assessment practices in Europe.
Cities and Flooding	Handbook	Decision and policy makers, technical specialists, central, regional and local government officials,	This handbook is at a basic level. Does not contain details, but treats the matter in a comprehensive manner.	No	This is a very comprehensive handbook that contains many components which are also useful for our handbook. Perhaps it is too large for our purpose. Contains useful chapters on flood hazard and flood risk assessment. However, it is not focused specifically on the flooding problems in the target countries. Very useful.
ADPC Integrated Flood Risk Management in Asia	Primer	Decision and policy makers, technical specialists, central, regional and local government officials, and concerned stakeholders in the community sector, civil society and non-governmental organizations, and the private sector	This primer is at a basic level. Does not contain details, but treats the matter in a comprehensive manner.	No	This primer is rather similar to the cities and flooding handbook, but is exclusively focused on Asia. It is less focused on flood hazard, has a component on flood risk but deals mainly with flood risk management issues. It is also a very useful source for the handbook. The design is quite nice.
Resource manual on flash flood risk management	Resource manual	Both technical people and decision makers.	It is a bit mixed. Some of the materials are rather simple, and others much more advanced.	Yes. contains a number of worked out case studies	This manual focuses on bioengineering techniques, physical measures for slope stabilization and erosion control, and physical measures for river training. Useful resource materials. But too much in detail for our handbook.
Multi hazard risk assessment					
Comprehensive Risk Assessment for Natural Hazards	Textbook	Technical staff and scientists.	Technical level document focusing on tools and techniques for hazard assessment	No	The book deals with a series of hazards, including flooding and landslides. It also has a good glossary. It deals more with hazards than with risk.
Multi-hazard risk assessment	Training package, containing a textbook and exercise book	Technical staff dealing with the use of spatial information for multi-hazard risk assessment	This is at a somewhat more advanced level, although the textbook is easy to follow	Yes, the textbook has many exercises, and the package has also a series of GIS exercises with	This is a distance education course that illustrates the theory with GIS exercises that cover most aspects relevant for the handbook. It uses a virtual example, called RiskCity. Very useful for the design of the handbook.

				datasets.	
Multi-Hazard Contingency Planning Manual For The Caribbean Tourism Sector	Manual, with a lot of practical information	both government agencies responsible for tourism and for individual tourism establishments in the Caribbean region	Manual to develop contingency plans	No	We included the manual because it relates to the target region and deals with multi-hazards, although focusing on tourism, hurricanes and terrorism.
Integrating Disaster Risk Management in Planning					
Integrating Disaster Risk Management into Urban Management	Handbook	Disaster Risk Management Practitioner, government officials, municipal units of DRM	Basic level, but containing many small examples	No	The handbooks aim to provide advice to the DRM practitioner on both strategic and practical options for operational implementation of DRM within a selection of development processes and tools
Eco -DRR Manual UNEP	Course manual	Master students	Basic	Yes	This is the instructors manual of a masters course on disasters, environment and risk reduction. It contains some useful components for the handbook.
Handbook of hazards and disaster risk reduction	Textbook	Scientists	Advanced	No	This is a comprehensive textbook covering many aspects relevant for the handbook, and is a good background reading document
Environmental Hazards: Assessing Risk and Reducing Disaster	Textbook	(under) graduate students	advanced	No, but contains good example	Very useful textbook on hazard and risk assessment. One of the best textbooks available on this topic. Good background material for the Handbook development
ADPC Disaster Risk Management in Asia	Primer	Decision and policy makers, technical specialists, central, regional and local government officials, and concerned stakeholders in the community sector	This primer is at a basic level. Does not contain details, but treats the matter in a comprehensive manner.	No	This primer is rather similar to the other ones from ADPC, and is exclusively focused on Asia. It is also a bit too general for our purpose. It is also a very useful source for the handbook. The design is quite nice.
OAS: Primer on Natural Hazard Management in integrated Regional Development Planning	Primer	Decision and policy makers, technical specialists, central, regional and local government officials, and concerned stakeholders in the community sector	Basic level but very comprehensive	No	Although this is already a bit old, this is one of the best background documents that also are very relevant with respect to the Caribbean setting. It focuses however more on regional analysis.
CARICOM: Sourcebook on the Integration of Natural Hazards in EIA	Handbook	includes EIA practitioners and reviewers at the national and regional levels in the Caribbean	Very useful step by step guide	No	Very useful handbook on the use of risk information in EIA with examples from the Caribbean. Good background document for the handbook development.
EU – Flood Risk Directive	Guideline document	Governments from the EU member states, flood hazard specialists, planners etc.	Policy document	No	The Directive applies to inland waters as well as all coastal waters across the whole territory of the EU.
Use of spatial information in Disaster Risk Management					
Use of Geographic Information Systems for Disaster Risk Reduction	Manual	Technical staff involved in Disaster risk Management	Basic	No	This guide gives an overview of GIS in DRM for non-experts.
Remote Sensing and GIS for Natural Hazards Assessment and DRM	Overview paper	Scientists and practitioners in disaster risk management	Overview	No	Overview paper on the application of GIs and Remote Sensing in disaster risk Management

From this overview we can conclude that there are many useful manuals, handbooks and primers available, but that they generally are quite at a general level, and lack links to practical exercises. They often also do not link to the level of the practitioners in the five target countries dealing with problems they are faced with in their work. The specific link between a theory part, a part where the theory is illustrated with use cases, and a data management part, has not been encountered. The closest to what we are aiming to do is the multi-hazard risk assessment training package developed by ITC. However it is apparent that a lot of information is already available in various formats targeting different types of users and it demonstrates that not all knowledge, methods and approaches need to be extensively incorporated in the Handbook. The handbook should make reference to these sources wherever it is required, whether the user needs a broader overview, or if the user requires more in-depth (technical) information. Good examples and reference texts are out

there and there is no need to replicate them in this handbook. The next chapter gives the overall outline of the structure of the handbook.

3. Proposed structure of the handbook

3.1 Introduction

The development of a handbook for the assessment of landslide and flood hazards and risks is one of the main deliverables in this project. This book will comprise three components:

1) **A methodology book**, which focuses on the methods for generating landslide and flood hazard and risk information for different scales and taking into account different situations of data availability.
2) **A use case book**, which illustrates the steps required to use the hazard and risk information in so-called use cases for planning of infrastructure, planning of risk reduction measures, emergency preparedness and emergency response.
3) **A data management book**, which indicates the aspects related to use collection, management and sharing of spatial data related to landslide and flood hazard and risk and planning. This book will detail the types and quality of data needed for activities at different scales and methods for data creation and sharing

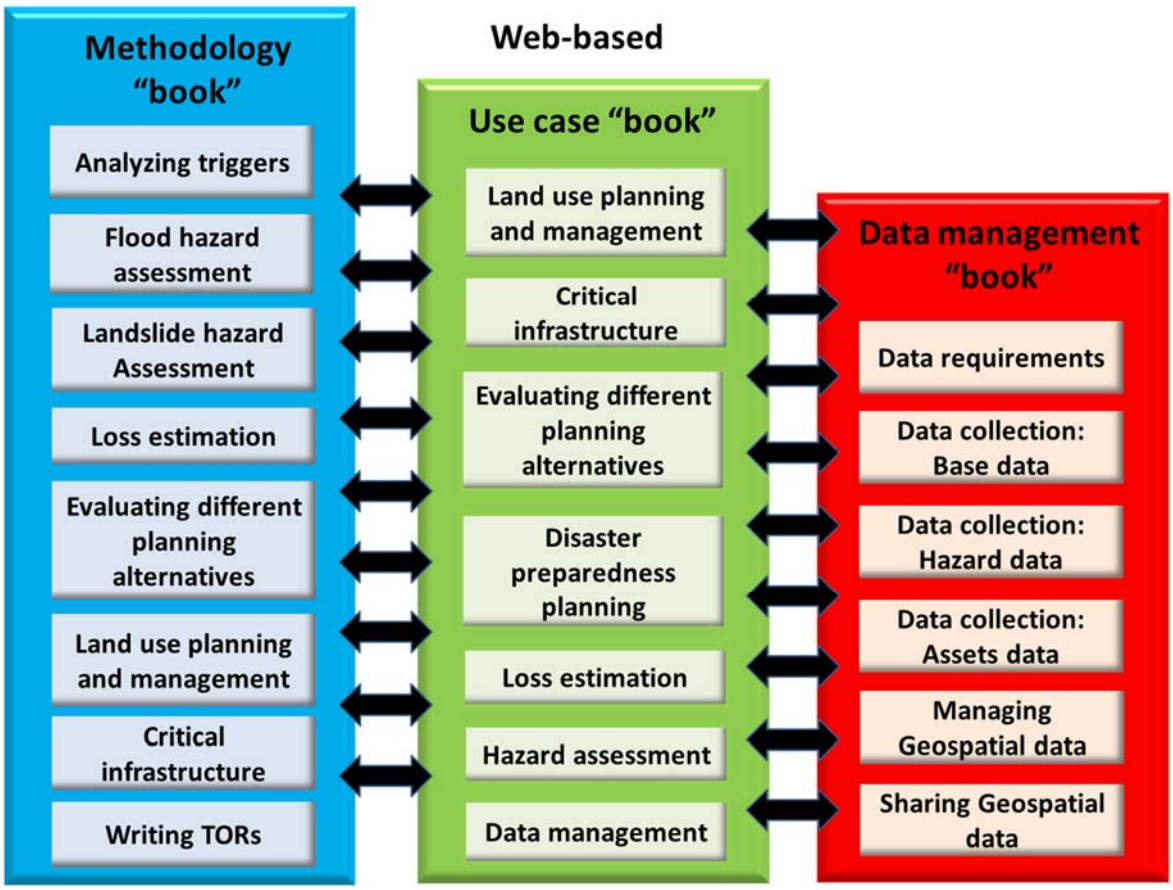


Figure 3.1: Simplified structure of the handbook, consisting of three parts: 1 (green): the use case book forming the entry point for the users and consist of examples; 2 (blue): the methodology book contains explanations on methods; 3 (red): the data management book with technical information on the spatial data types, data collection and web-based databases. The system will be web-based and will have many links between the three components.

In practice these will be three individual parts which can also be joined together as the overall handbook. The handbook will be designed to provide technical guidance to government officials about the generation and use of information regarding landslide and flood hazard as well as risk assessment. Emphasis will be given on its use for planning and critical infrastructure (health, education, transport and government buildings). Although the handbook will be developed targeting the specific needs of the five beneficiary countries, the scope will be sufficient generic to extent its use to the wider region. In general, the handbook should be easy to use and support government institutions to easier identify which information required for their work. The handbook will consists of three separate components that will be strongly interlinked (See Figure 3.1, taken from the Description of Work).

3.2 Target audiences

The three components have a different focus and are directed to a different target audience. They are closely linked but are aiming at different aspects.

1) The methodology book is aimed to be used by technical staff from government organizations and private consultants;
2) The use case book is aimed to be used by representatives from government sectors, specifically from the Ministries of Physical Planning and Public Works;
3) The data management book is targeted to technical staff from government organizations and consultants that work on geo-spatial data management & GIS;

The three parts are not exclusively written for the three target groups listed above. The target group of one component might also be interested in the contents of another part. We also foresee that other target groups might be interested in this handbook, although they are not the main target audience:

- Representatives from other government sectors (apart from the direct target groups of Physical Planning and Public Works) such as health, transportation, housing, tourism, agriculture that have to take into account risk information in their planning work;
- Representatives of the National Disaster Management Organisations;
- Representatives from non-governmental organizations dealing with risk reduction;
- Representatives from communities, although they would be better served by the handbook Community-Based Landslide Risk Reduction;
- University students, specifically focusing on the University of the West Indies. We are also foreseeing that the handbook can be used in a course environment;
- Other World Bank consultants. We are specifically thinking of the country representatives for the World Bank related to the setting-up and maintenance of the GeoNode portals;
- Other World Bank departments dealing with the target countries, and representatives from other Caribbean and international organizations working in the field of Natural Disaster Risk Management, Planning , Early Warning etc. such as CDEMA, CARICOM, CDB, UNDP, DFID, CMH, Caribbean Conservation Association (CCA), CARIBANK, Inter-American Development Bank (IDB), Caribbean Planning for Adaptation to Global Climate Change Project (CPACC), etc. Many of these organizations have been directly or indirectly involved in projects dealing with natural hazards and risk in the target countries and they would also benefit for the

handbook and the data sharing and management component, as currently there seems to be a lot of redundancy in the work carried out, and a lot of the resulting data gets lost along the way.

During the workshops in the five target countries we were able to meet representatives from most of the user group indicated above, and discuss with them their requirements in terms of contents for the three volumes.

3.3 Focus of the handbook

The use case book contains a number of case studies for the use of landslide hazard and risk information in the work done by the Ministries of Physical Planning and the Ministries of Public Works in small countries in the Caribbean region. The use cases are related to general examples that illustrate the methodological process needed to conduct a range of activities that are common in the region, rather than detailed efforts to produce specific recommendations for action in specific applications. The use cases have been identified by a collaborative process with participating government ministries, World Bank staff, UT-ITC, and other regional technical experts, during the workshops in the five target countries. The use cases should indicate what are the requirements in terms of basic information depending on the scale of the work and the objectives of the use case.

The target audience for the use case book are technical staff from government sectors, specifically from the Ministries of Physical Planning and Public Works. The description of the use cases should be at a level that they understand:

- The data requirements with specific focus on hazard and risk data;
- The steps needed in the analysis;
- The expected outcomes and the characteristics of these outcomes;
- Each use case starts with a flow chart outlining the above components, which are then described in more detail and illustrated with maps and other data from a specific example.
- Each use case will be limited to about 5 pages or less;

Some of the use case are also GIS exercises, dealing with actual data, and are therefore more extensive than the others, which only use maps/graphs etc. as illustrations. There are also generic use cases, for which no particular suitable example was found in the 5 target countries.

The use case book should contain many links to the methodology book that covers the various methodological aspects related to hazard and risk assessment, loss estimation, planning, critical infrastructure, and the analysis of different planning alternatives.

The Use Case book is expected to have about 200 pages. The table below gives an overview of the chapters, use cases, which ones will actually be with GIS data (others use illustrations in the form of photo's, maps, graphs, tables).

The table of contents gives the main chapter name, use case topic (with proposed number of pages), the possible use case sites, remarks, with data (meaning whether the use case is actual a GIS exercise, or a description with illustration in the form of maps, graphs etc., or a generic one without a specific location), and the proposed authors for the writing of the use cases

3.4 Table of contents for the Use Case Book

Main Chapter	Use case topic	Possible use case sites	Remarks	With data	Proposed authors
1 Introduction (10 pages)	1.1 Objectives of this book (2 pages)	Learn by doing, based on practical examples, and referring to methodological and data aspects in the two other books.			
	1.2 Characteristics of the target countries (3 pages)	Small areas, low population, limited developments, single small organizations responsible for DRR,			
	1.3 How to use this book (3 pages)	Flowchart structure and link between use case book, methodology book and data management book. How to select the right use case? Some use cases are descriptions only, other have also data and exercise materials. Link to the chapter in the methodology book dealing with requirements for TORS. Each of the use cases should end with stating these requirements.			Dinand Alkema & Cees van Westen, Wim Feringa
	1.4 Page with overview of use cases (2 pages)	PDF with links to the different use case chapters, and from the use case many links to the relevant sections in the methodology and data management books.			
2 Land use planning and management (30 pages)	2.1 National land use plan (5 pages) (link to MB and DMB)	Dominica (they are developing a national land use plan)	How results of national scale hazard assessment can be used in developing a national land use plan	No	Richard Sliuzas
	2.2 Local land use planning (5 pages) (link to MB and DMB)	Castries, Saint Lucia	How hazard and risk information can play a role in local development plans This links to the super use case for Castries	Yes	Richard Sliuzas
	2.3 Incorporating landslide and floods in existing building codes (5 pages) (link to MB and DMB)	All countries, the OECS building code doesn't include it yet	Which building characteristics are required that relate to flooding and landslides	No	Navid Nawar
	2.4 Evaluation of relocation options	Saint Vincent	Include hazard information	No	Richard

	for settlements (5 pages) (link to MB and DMB)		together with other factors for relocation planning		Sliuzas
	2.5 Use of hazard and risk information for building control (5 pages) (link to MB and DMB)	Dominica, country wide	What minimum hazard/risk information is needed for including in restrictive zoning maps	No	Charisse Griffith
	2.6 Land subdivision process (5 pages) (link to MB and DMB)	Belize, Cayo District	How hazard and risk information is used in land subdivision	No	Jeanna Hyde, Mark Brussel
3 Critical infrastructure (Health, Education, transportation, water & sanitation) (50 pages)	**3.1 Planning safe infrastructure (2 pages)**				
	3.1.1 Roads (3 pages) (link to MB and DMB)	Planning a new road from Rodney Bay to Dennery, Saint Lucia	How hazard information is used together with other data for planning optimal route that avoids high hazard zones for landslides and floods and ensures adequate design.	No	Richard Sliuzas, Mark Brussel
	3.1.2 Water & sanitation (3 pages) (link to MB and DMB)	Planning a new landfill site in Grenada.	Existing landfill site is not in appropriate location, and seems to be quite full. Which hazard information should be used in combination with other data?	No	Richard Sliuzas, Mark Brussel
	3.1.3 Transportation sector: bridge construction (3 pages) (link to MB and DMB)	Grenada	Indicating the necessary studies and parameters for bridge construction. Analysis of the transportation network including critical facilities in order to be able to determine the criticality of a specific bridge. Also: new construction of bridges after major event. Temporary cheap bridges versus expensive “permanent” ones.	No	Victor Jetten, Navid Nawar

			Which return periods / maximum discharge?		
	3.2 Relocation planning for existing infrastructure in dangerous locations (2 pages)				
	3.2.1 Health sector (3 pages) (link to MB and DMB)	St. George national hospital Grenada, or hospital in Saint Vincent	Move it or not? Cost-benefit analysis. Network analysis. Multi-Criteria evaluation of potential sites.	No	Richard Sliuzas, Mark Brussel,
	3.2.2 Educational sector (3 pages) (link to MB and DMB)	Canaries school Saint Lucia	Should the school be relocated or not? What decides this?	No	Richard Sliuzas, Mark Brussel,
	3.2.3 Government sector (3 pages) (link to MB and DMB)	Court house are in Castries, Saint Lucia	Should the courthouse be relocated or not? What decides this?	No	Richard Sliuzas, Mark Brussel,
	3.3 Retrofitting of critical infrastructure in dangerous locations (2 pages)				
	3.3.1 Educational sector (3 pages) (link to MB and DMB)	Bexon School Saint Lucia	Analysing different options for retrofitting buildings, versus other measures	No	Navid Nawar
	3.3.2 Transportation sector in flat terrain (3 pages) (link to MB and DMB)	Ladyville are , Belize: design of culverts in low lying areas	Hydrological information requirements for designing culvert sizes for alluvial floods	No	Mark Brussel & Mark Trigg
	3.3.3 Transportation sector, hilly terrain (3 pages) (link to MB and DMB)	St. Urbain, SW area in Saint Lucia. Culvert failure	Hydrological information requirements for designing culvert sizes against flash flood, including logs and debris	No	Victor Jetten & Mark Brussel
	3.4 Design of mitigation measures to protect critical infrastructure in dangerous locations (2 pages)				
	3.4.1 Transportation sector: rock fall protection(3 pages) (link to MB and DMB)	Dominica, Stowe area	Which geotechnical information is needed to analyse the different options.	No	Robert Hack
	3.4.2 Transportation sector: landslide	Belmont landslide , Saint	Which geotechnical	No	Robert

	protection (3 pages) (link to MB and DMB)	Vincent	information is needed to analyse the different options.		Hack
	3.4.3 Water and sanitation: water intakes (3 pages) (link to MB and DMB)	Water intake obstructions, Dec. 2013. Saint Lucia and Saint Vincent	Which information is needed to protect water intakes;	No	
	3.4.4 Health sector: flood protection (3 pages) (link to MB and DMB)	Saint Vincent (the Milton Cato Memorial Hospital)	Which flood protection measures can be applied to protect the hospital and the surrounding area against flooding? Which hazard information is needed?	No	Mark Brussel
	3.4.4 Tourism and transportation sector: flood protection of international airport. (3 pages) (link to MB and DMB)	Hewanorra International airport , Saint Lucia	Improve flood protection after the airport was flooded in 2013 due to problems in diverting a stream around the airport	No	Victor Jetten
4 Evaluating different planning alternatives (20 pages)	4.1 Comprehensive evaluation of different risk reduction alternatives using a GIS based approach (10 pages) (link to MB and DMB)	Generic use case for floods and landslides in a coastal area with steep slopes	Analyse risk for multi-hazards in the current situation (flash floods, debris flows, landslides). Propose different combinations of planning options (Engineering approach, ecological approach, relocation approach). Analyse risk reduction after implementation. Estimate the investment costs and maintenance costs. Carry out a cost-benefit analysis. Make a final evaluation based on a	yes	Cees van Westen

			number of criteria, depending on the stakeholder views		
	4.1 Comprehensive evaluation of different risk reduction alternatives using a web-based tool. (10 pages) (link to MB and DMB)	Generic use case for floods and landslides in a coastal area with steep slopes	Same activities as above, but now the entire analysis is done using a web-based Spatial Decision Support System (RiskChanges). http://changes.itc.utwente.nl/CHANGES-SDSS/	yes	Cees van Westen
5 Disaster preparedness planning (10 pages)	5.1 Design of a local Early Warning system for flooding (5 pages) (link to MB and DMB)	Saint Lucia Grenada, based on the JICA study	Data requirements for setting up a local early warning system. Technical requirements, institutional requirements, what works and what not?	no	Dinand Alkema, Victor Jetten
	5.2 Shelter planning (5 pages) (link to MB and DMB)	Dominica	Method for analysing the optimal location of shelters, and technical characteristics of shelters. Are they multi-hazard shelters?	No	Navid Nawar, Ellen-Wien Augustijn
6 Loss estimation (20 pages)	6.1 National multi-hazard exposure and risk assessment (5 pages) (link to MB and DMB)	Saint Vincent / Saint Lucia or Grenada	Using national scale hazard results, combine with national land use map and building footprint & roads. Calculate exposure.	yes	Cees van Westen
	6.2 Loss estimation for river flooding in low lying areas (5 pages) (link to MB and DMB)	Belize	Steps required for loss estimation of floods, with flood intensity maps of different return periods.	yes	Dinand Alkema and Mark Trigg

	6.3 Loss estimation for flash flooding in island countries (5 pages) (link to MB and DMB)	Saint Vincent, Vermont area (for example. There are many examples possible)	Flood intensity maps, building footprints, population. Quantitative risk	yes	Victor Jetten and Dinand Alkema
	6.4 Loss estimation for landslides along roads (5 pages) (link to MB and DMB)	Saint Lucia, also using existing study (UK consultant)	Failure probability, network analysis	yes	Cees van Westen, Ellen Wien Augustijn
7 Hazard assessment (25 pages)	7.1 Analysing rainfall triggers (5 pages) (link to MB and DMB)	All islands	Spatial variability, magnitude-frequency analysis.	yes	Dinand Alkema
	7.2 Generating a national scale landslide hazard map using multi-temporal landslide inventories (5 pages) (link to MB and DMB)	Saint Lucia	Use of statistical method and Spatial Multi-Criteria Evaluation for initiation susceptibility. Using run-out modelling with FLOW-R	yes	Cees van Westen
	7.3 Generating a landslide hazard map along the road network (5 pages) (link to MB and DMB)	Saint Lucia	Segmenting the road, landslide density, road cuts and fills, road drainage, soil types, statistical analysis	yes	Cees van Westen
	7.4 Generating a national flood hazard map for river flooding (5 pages) (link to MB and DMB)	Belize	Parameterization of LISFLOOD model, rainfall characterization, hydrological modelling, hydraulic modelling	yes	Mark Trigg
	7.5 Generating a national flood hazard map for island countries (5 pages) (link to MB and DMB)	One of the four islands	Parameterization of the OPENLISEM model. Rainfall characterization. Running the model for different	yes	Victor Jetten

			return periods.		
8 Data management (50 pages)	8.1 Homogenization of base data (5 pages) (link to MB and DMB)	Grenada	About cartographic projections, Data quality of thematic data, metadata. Data standards	yes	Tarick Hosein & Manzul
	8.2 Generation of Digital Elevation Models (5 pages) (link to MB and DMB)	Grenada, whole country Belize	Sources of DEMs, data quality, DEM derivatives. What are the requirements for different applications	yes	Tarick Hosein & Manzul Hazarika , Colm Jordan
	8.3 Use of satellite data (5 pages) (link to MB and DMB)	Saint Vincent, example	Sources of data, characteristics , image classification, multi-temporal images , land cover	yes	Tarick Hosein & Wietske Bijker Manzul Hazarika
	8.4 Generation of land use maps (5 pages) (link to MB and DMB)	Dominica St Lucia,	Image classification, image interpretation, field checking	yes	Tarick Hosein & Wietske Bijker Colm Jordan
	8.5 Generation of building and road maps (5 pages) (link to MB and DMB)	Saint Lucia	Mapping building footprints from satellite images, and collecting relevant attributes through field sampling	yes	Tarick Hosein & Wietske Bijker
	8.6 Generation of population maps	Belize	Dasymetric mapping, based	yes	Tarick

	(5 pages) (link to MB and DMB)		on building footprints and population data		Hosein , Manzul Hazarika
	8.7 Landslide inventory mapping (5 pages) (link to MB and DMB)	Saint Lucia	Stereo-image interpretation using DEM and satellite image	yes	Cees van Westen, Tom Dijkstra
	8.8 Building a historical hazard & loss database – within the existing (institutional) structures (5 pages) (link to MB and DMB)	Saint Lucia	Historical records, maintaining a database, community involvement	yes	Manzul Hazarika
	8.9 Data sharing (10 pages) (link to MB and DMB)	All countries, comparing of situation	GeoNode set-up, institutional agreements, metadata, user management.	No	Manzul Hazarika
200 pages					

3.5 Table of contents for the Methodology Book

This book provides an overview of existing methods, both quantitative and qualitative that can be applied for the assessment of landslide and flood hazards and risk. It will discuss the appropriateness of applying a certain method for a given problem in terms of data needs, scale (resolution), uncertainty, required expertise and the physiographic setting. It will describe in detail nine national hazard mapping studies. The handbook will also link to internet resources that provide data and meta data, analyses tools and their manuals, and results of other studies and scientific papers. This will be a theoretical handbook with links to specific examples from the target countries, and the data available for these. There will also be links to hazard assessment exercises using the case studies and Open Source software.

Chapter Total: < 200 pages	Section	Description	First responsible
1 Introduction (5 pages)	1.1 Objectives of this book (3 pages)	Given the users from the ministries in the target countries that are not experts on the topic enough background information to understand the concepts and be able to address issues with consultants.	Dinand Alkema and Cees van Westen, Wim Feringa
	1.2 How to use this book (2 pages)	This is actually a set of individual section to which the use case book refers to. It is summarizing the methods used and gives links to more extensive documentation.	
2 Analysing triggers (15 pages)	2.1 Analysis of rainfall distribution (8 pages)	Analysing the spatial distribution of rainfall based on rain gauge data and rainfall data.	Dinand Alkema
	2.1 Magnitude-frequency analysis (7 pages)	Magnitude-frequency analysis, spatial variability, IDF curves	
3 Flood hazard assessment (25 pages)	3.1 Introduction (4 pages)	Types of flooding, data requirements, scales of hazard assessment, broad sub-division in methods that could be applied.	Dinand Alkema
	3.2 Run-off analysis: hydrological modelling (7 pages)	Factors involved , parameterization of models, types of models to be used under a given condition and data constraints	Victor Jetten, Dinand Alkema
	3.3 Flash flood modelling (7 pages)	Methods that can be applied for the four islands. What detail of output can be expected given the input data?	Victor Jetten

	3.4 Alluvial flood modelling (7 pages)	Methods that can be applied for Belize. What detail of output can be expected given the input data?	Mark Trigg
	3.6 Human influence onflood hazards (3 pages)	Human influence on hazards plays a crucial role in the occurrence of hazardous events, like flooding. This section will highlight these human influences related to flooding (e.g. lack of maintenance of drainage systems aggravates urban flooding etc)	Victor Jetten and Mark Trigg.
4 Landslide hazard assessment (30 pages)	4.1 Introduction (4 pages)	Landslide types, data requirements, scale, broad subdivision of approaches.	Cees van Westen
	4.2 Landslide susceptibility assessment (5 pages)	Methods for susceptibility assessment based on the availability of data, multi-criteria evaluation, statistical analysis;	Cees van Westen
	4.3 Landslide run out assessment (3 pages)	Empirical modelling tools, more detailed analysis if data is available.	Cees van Westen
	3.4 Landslide hazard assessment (3 pages)	Using spatial and temporal probability estimation to convert susceptibility maps into hazard maps	Cees van Westen
	3.5 Landslide hazard assessment along the road network (5 pages)	Characterization of road segments, mapping cut slopes, weathering, and classification methods.	Cees van Westen Robert Hack
	3.6 Site specific slope stability analysis (10 pages)	Geotechnical data, weathering, characteristics of volcanic materials,	Robert Hack
	3.7 Human influence onflood hazards (3 pages)	Human influence on hazards plays a crucial role in the occurrence of hazardous events, like landslides. This section will highlight these human influences related to landslides (e.g. lack of drainage systems aggravates landslides etc)	Cees van Westen and Robert Hack..
5 Loss estimation (25 pages)	5.1 Introduction (3 pages)	Different approaches: qualitative / quantitative	
	5.2 Characterization of assets (5 pages)	Attributes required for analysing risk: occupancy types, value estimation, population estimation for different types of assets (e.g. buildings, roads)	Cees van Westen

	5.3 Vulnerability (5 pages)	Different approaches, but concentrating mainly on physical vulnerability characterisation	Cees van Westen
	5.4 Qualitative methods at national scale (5 pages)	Exposure analysis, spatial multi-criteria evaluation using indicators.	Cees van Westen
	5.5 Quantitative methods (7 pages)	Integrating intensity, spatial probability, vulnerability, values, generation of risk curves, calculating annualized risk, F-N curve	Cees van Westen
6 Decision making tools for risk reduction (20 pages)	6.1 Introduction (3 pages)	What are risk reduction alternatives? Land use planning, land management, building control, building codes, design of structural measures Objectives, stakeholders, risk governance, public participation	Cees van Westen
	6.2 Evaluation of risk (3 pages)	Risk perception, risk acceptability, risk evaluation thresholds for individual or societal risk	Cees van Westen
	6.3 Cost-benefit analysis (5 pages)	Methods for estimating costs of planning alternatives, project lifetime, investment, maintenance, avoided losses, IRR, NPV, effects of changes.	Cees van Westen, Emile Dopheide
	6.4 Cost-effective analysis (3 pages)	Simplified methods for comparing alternatives for which no monetary benefits can be calculated	Cees van Westen, Emile Dopheide
	6.5 Multi-Criteria Evaluation (6 pages)	Comparing different alternatives with other indicators than only cost-benefit ones, stakeholder involvement, perception, SMCE	Cees van Westen, Luc Boerboom
7 Land management and land use planning (25 pages)	7.1 Introduction (2 pages)	How planning and land management can contribute to risk reduction. Overview of tools	
	7.2 Overview of legislation and procedures in target countries (10 pages)	Summary of the existing legislations and procedures used in the target countries; are they effective; is hazard/risk information used; what should be adopted in terms of regulations to incorporate hazard/risk information. Who is responsible?	Charisse Griffith-Charles, Jeanna Hyde
	7.3 Building control and hazard information (6 pages)	Which planning tools are useful for risk reduction, and how hazard and risk information is used; Building permits, building codes; restricted areas. Which procedures are followed for building control and how hazard and risk information can play a role in this?	Navid Nawar Charisse Griffith-Charles
	7.4 National land use planning (6 pages)	Broad subdivision of the territory and main uses, public and private land subdivision; future developments	Richard Sliuzas Charisse Griffith-

			Charles
	7.5 Local use planning (6 pages)	Local land use plans as a basis for future development; legal basis, incorporation of hazards into planning	Richard Sliuzas
8 Critical infrastructure (35 pages)	8.1 Introduction (5 pages)	Classification of critical infrastructure, with major focus on: education, health, transportation, water & sanitation.	Richard Sliuzas Mark Brussel
	8.2 Planning new critical infrastructure (6 pages)	Planning new roads, hospitals, schools. Information requirements and procedures.	Richard Sliuzas Mark Brussel
	8.3 Relocation planning for existing infrastructure in dangerous locations (6 pages)	Summarize the requirements for relocating critical infrastructure (health, education, transportation, water & sanitation).	Richard Sliuzas Mark Brussel
	8.4 Retrofitting of existing infrastructure (6 pages)	Summarize the requirements for retrofitting critical infrastructure (health, education, transportation, water & sanitation) for floods and landslides, taking into account other hazards as well that occur in the target countries (windstorms, earthquakes).	Navid Nawar
	8.3 Design of mitigation measures to protect critical infrastructure against flooding (6 pages)	Summarizing the criteria that are used in the target region or the design of culverts, bridges, flood walls, embankments etc. taking into account the available manpower and resources in the target countries. What is practically applicable? Which information is needed for the proper design?	Mark Brussel Navid Nawar
	8.4 Design of mitigation measures to protect critical infrastructure against landslides (6 pages)	Summarizing the criteria that are used in the target region for the design of slope stabilization measures, drainage, retaining walls, terracing etc., taking into account the available manpower and resources in the target countries. What is practically applicable? Which information is needed for the proper design?	Robert Hack
9 Risk information for disaster preparedness planning (15 pages)	9.1 Introduction (5 pages)	Which hazard and risk information is required in order to plan the required response to emergencies?	Dinand Alkema
	9.2 Design of early warning systems (5 pages)	What are the possibilities for early warning of flooding and landslides? What are the data requirements? What is the feasibility in the target countries?	Mark Trigg,
	9.3 Disaster response planning	Which scenarios are possible? How to analyse the possible	t.b.d.

	(5 pages)	consequences? Shelter planning. Information requirements.	
10 Writing technical requirements for Terms of Reference for projects (10 pages)	10.1 Introduction (2 pages)	Importance of knowledge of Terms of Reference for implementing projects in the target countries.	Melanie Kappes Dinand Alkema
	10.2 Composition of a TOR (4 pages)	Generally how Terms of References are composed, determining realistic objectives, planning of resources required, versus output obtained. Getting outside expertise for TOR development and evaluation.	Melanie Kappes Dinand Alkema
	10.3 Hazard and risk information requirements (4 pages)	How to formulate the hazard and risk information requirements for a TOR, and how this comes back in the use cases. What (geospatial) products should be delivered, and in which form. Who is responsible	Melanie Kappes Dinand Alkema
Literature list and links to websites			

3.8 Table of contents for the Data Management Book

This book addresses the various issues related to the (geospatial) data. It will list the data requirements of the hazard and risk assessment methodologies discussed in part 1 at different scales, and the data required for decision making (e.g. cost-benefit analysis, multi criteria evaluation). Another component of this management book relates to design of the data flow, including data management, metadata standards, updating policies, data sharing, quality assurance and output generation. It will also provide a library of free and open-source internet resources, (geo-spatial) data warehouses, archives of historical landslide and flood events and relevant hydro-meteorological information. This will be technical manual, describing the data structure, and metadata and the system architecture. Incorporates data developed under objective 4 on national scale hazards. Incorporates data developed under objective 6 on local scale hazards, elements at risk, and use cases.

Chapter Total: < 200 pages	Section	Description	First responsible
1 Introduction (5 pages)	1.1 Objectives of this book (3 pages)	Given the users from the ministries in the target countries that are not experts on spatial data and data management to understand the concepts and be able to address issues with consultants.	Manzul Hazarika, Dinand Alkema Cees van Westen Wim Feringa
	1.2 How to use this book (2 pages)	This is actually a set of individual section to which the use case book refers to. It is summarizing the methods used and gives links to more extensive documentation.	
2 Data requirements (15 pages)	2.1 Introduction (3 pages)	Explain the relationship between scales, size of the area, type of analysis and required input data. Focus on hydro-meteorological hazards.	Victor Jetten, Cees van Westen
	2.2 Flood hazard assessment at national scale (2 pages)	List the data requirements in a table for flood hazard assessment at national scale in general. Link to further sections where data types are discussed in detail	Victor Jetten, Mark Trigg and colleagues
	2.3 Flood hazard assessment at local scale (2 pages)	List the data requirements in a table for flood hazard assessment at local scale in general. Link to further sections where data types are discussed in detail	Victor Jetten, Mark Trigg and colleagues
	2.4 Landslide hazard assessment at the national scale (2 pages)	List the data requirements in a table for landslide hazard assessment at national scale in general. Link to further sections where data types are discussed in detail	Cees van Westen, Tom Dijkstra
	2.5 Landslide hazard assessment at	List the data requirements in a table for landslide hazard	Cees van

	the national scale (2 pages)	assessment at national scale in general. Link to further sections where data types are discussed in detail	Westen, Tom Dijkstra
	2.6 Risk assessment at the national scale (2 pages)	List the data requirements in a table for risk assessment at the local scale. Link to further sections where data types are discussed in detail	Cees van Westen
	2.7 Risk assessment at the local scale (2 pages)	List the data requirements in a table for risk assessment at national scale in general. Link to further sections where data types are discussed in detail	Cees van Westen
3 Data collection: Base data	Introduction (2 pages)	Which base data sets should be available for the target countries…	Tarick Hosein, Jeanna Hyde
	Digital Elevation Models (2 pages)	Different sources for Digital Data relevant for the target countries, with explanation of their characteristics, accuracy levels, and applications related to hazard and risk assessment.	Tarick Hosein, Colm Jordan,
	Satellite data (2 pages)	Different sources of satellite data relevant for the target countries and their characteristics, and applications related to hazard and risk assessment. Main focus on optical data.	Tarick Hosein, Jeanna Hyde, Wietske Bijker
	Land cover maps (2 pages)	Methods to generate land cover maps. Required legends and application for hazard and risk assessment. Attributes required for hazard and risk assessment.	Tarick Hosein, Jeanna Hyde, Wietske Bijker
	Geological maps (2 pages)	Methods for collecting geological maps. Requirements for hazard and risk analysis. Scale related information. Limitations in data poor environments.	Robert Hack
	Soil maps (2 pages)	Methods for collecting soil maps. Requirements for hazard and risk analysis. Relevant attributes: soil types, soil depth, geotechnical and hydrological parameters. Approaches in data poor environments.	Victor Jetten
4 Data collection: Hazard related data (2 pages)	4.1 HydroMet data (2 pages)	What are the main characteristics of the hydromet data in the region? What are the standards internationally? Recommendations for central storage. Involvement of CIMH as a regional hub for hydromet data. Working with derivatives like IDF curves, instead of raw data.	Dinand Alkema, Mark Trigg
	4.2 Disaster Loss databases (2 pages)	Which approaches are available? CRED, DESINVENTAR, GAR, etc. Which data bases are available for the Eastern Caribbean	Manzul Hazarika, Cees

		countries?	van Westen
	4.3 Hazard event databases (2 pages)	Methods used for generating historical event databases. Geospatial location, date information, participatory tools, who is responsible? Maintenance.	Cees van Westen
	4.4 Landslide inventory mapping (2 pages)	Methods used for landslide inventory mapping. Digital Stereo image interpretation, field mapping, archive data. Differences for mapping along roads and in natural terrain.	Cees van Westen, Tom Dijkstra
	4.5 Flood specific information (2 pages)	Mapping of past flood events, cross sections, flood control measures, surface roughness, Manning's coefficients etc.	Victor Jetten, Mark Trigg
5 Data collection : Assets data (2 pages)	5.1 Introduction (2 pages)	Classification of assets, and summary of methods for collecting them	
	5.2 Building footprint maps (2 pages)	Methods used for generating building footprint maps. Characterization of building footprint maps for hazard and risk assessment, field sampling methods. Attributes: occupancy type, structural type, number of floors, replacement value, number of people	Cees van Westen
	5.3 Population distribution maps (2 pages)	Methods used to collect population information at different scales (	
	5.4 Road maps (2 pages)	What information should be collected related to roads, including attribute information required to carry out hazard and risk studies (e.g. road types, cut slopes, bridges, culverts etc.) How these should be collected and stored.	Mark Brussel
	5.5 Water and sanitation data (2 pages)	What information should be collected for the water and sanitation sector (water intakes, water tanks, pipes, sewage system, waste water treatment, landfills etc.).	Mark Brussel
	5.6 Critical infrastructure in health and educational sectors. (2 pages)	What information should be collected for the critical health and educational infrastructures (e.g. hospitals and schools), accessibility, population distribution etc.	Richard Sliuzas
6 Managing Geospatial data (2 pages)	6.1 Introduction (2 pages)	Link to INSPIRE framework for geospatial data	Tarick Hosein, Manzul Hazarika
	6.2 Data projections (2 pages)	Explanation of map projections, datums, etc. and problems involved in the target countries and possible solutions	Tarick Hosein

	6.3 Data homogenization (2 pages)	Which aspects are needed to create homogeneous spatial data sets, in terms of coordinate systems, etc.	Tarick Hosein
	6.4 Accuracy and precision (2 pages)	Spatial, Temporal , thematic, lineage etc.	Tarick Hosein, Manzul Hazarika
	6.5 Metadata requirements (2 pages)	Explanation of metadata standards, and items that need to be covered.	Tarick Hosein, Manzul Hazarika
	6.6 Data formats (2 pages)	Explanation of data formats for geospatial data for vector, raster and attribute data	Tarick Hosein, Manzul Hazarika
	6.7 Data analysis tools (2 pages)	Overview of software tools for geospatial data analysis, with advantages and disadvantages. Comparing ArcGIS with Open source tools like Q-GIS and ILWIS. Software tools used in the project for hazard assessment: OpenLISEM, LISFLOOD, ILWIS, FLOW-R.	Tarick Hosein, Manzul Hazarika, Mark Trigg, Victor Jetten, Cees van Westen
7 Sharing geospatial data (2 pages)	7.1 Introduction (2 pages)	Why data should be shared within a country, region. Spatial data Infrastructures	Manzul Hazarika
	7.2 Framework for institutional collaboration (5 pages)	Explain the different aspects related to the roles that the different organizations working with/producing geodata are playing, and their willingness to share data, and definition for which purposes. Who produces/ updates specific data sets.	Manzul Hazarika, Tarick Hosein
	7.3 Open data policies / data ownership (2 pages)	Benefits of open data policy and OpenDRI versus selling data to each other as ministries. Clear definition of data ownership and access rights for specific types of data.	Manzul Hazarika
	7.4 Data standards (3 pages)	Explanation to international agreed standard for data. INSPIRE, OGC etc.	Manzul Hazarika
	7.5 Technical tool: GeoNode (10 pages)	Explanation of the technical tool. What is required, how does it work. Which ones are established in the target countries?	Manzul Hazarika
	7.6 Other tools for specific applications (3 pages)	GeoNode is less suitable for certain types of data, e.g. hydromet data, or data which is updated very frequently. Explanation of other options.	Manzul Hazarika
8 Risk changes SDSS (21 pages)	8.1 Introduction (3 pages)	Explanation of the RiskChanges SDSS: changes.itc.utwente.nl/CHANGES-SDSS/	Cees van Westen
	8.2 Upload data sets	Module for creating a study area, uploading hazard and assets	Cees van

	(3 pages)	data, vulnerability databases etc.	Westen
	8.3 Calculate losses and risk (3 pages)	Methods for calculating losses for multi-hazards and different elements at risk. Risk analysis for specific administrative units	Cees van Westen
	8.4 Define planning alternatives (3 pages)	Defining possible planning alternatives, and determined what effect they have on hazards, elements at risk and vulnerability	Cees van Westen
	8.5 Cost-benefit analysis (3 pages)	Estimate costs for the planning alternatives, and calculating cost -benefit	Cees van Westen
	8.6 Decision making (3 pages)	Incorporate other indicators in the decision making process using multi criteria evaluation	Cees van Westen
	8.7 Analysing future scenarios (3 pages)	Use the tool for analysing the changes in risk under future scenarios of land use change, population change and climate change.	Cees van Westen
9 Data (or Risk) visualization	Data visualization	Maps intend to communicate information and before GIS those maps were created by cartographers while now everyone can do this in a GIS - however, in order to be useful the right visualization is crucial.	Wim Feringa, Cees van Westen
Literature list and links to websites			

3.9 Structure of the Handbook

We propose to make the handbook in the form of a series of web-pages that are interlinked. Users should be able to create PDF files from the sections in which they are interested. The web-based platform allows also better to link to other websites, movies etc. and allows for the inclusion of animations.

The use cases are foreseen to follow the same structure which is shown in a very simplified manner in the figure on the right. The use case will follow a flow chart structure. The flow chart can be expanded by the user when clicking on it.

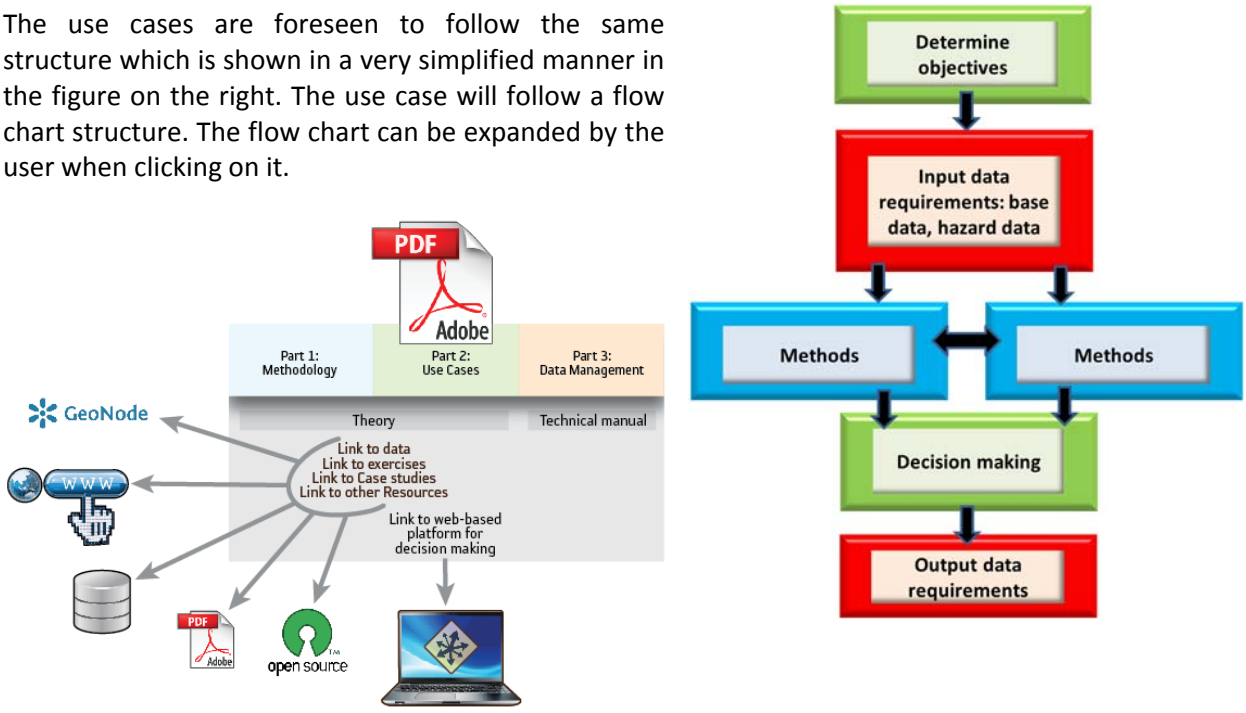


Figure 3.2: Technical design of the handbook

4. Analysis of available data for the 5 target countries

4.1 Introduction

The Caribbean region is highly impacted by natural hazards. Its location within the path of the Atlantic hurricanes exposes the small island states and countries in the Caribbean to extreme wind conditions and torrential rains. This, in combination with steep terrain makes them extremely susceptible for landslides, floods and storm surges. Their location along the edges of tectonic plates adds tectonic hazards to their threats as well, including earthquakes and tsunamis for the whole region as well as active volcanism on some islands. On a longer time scale, sea level rise is expected to make the hazard situation worse for the coastal areas.

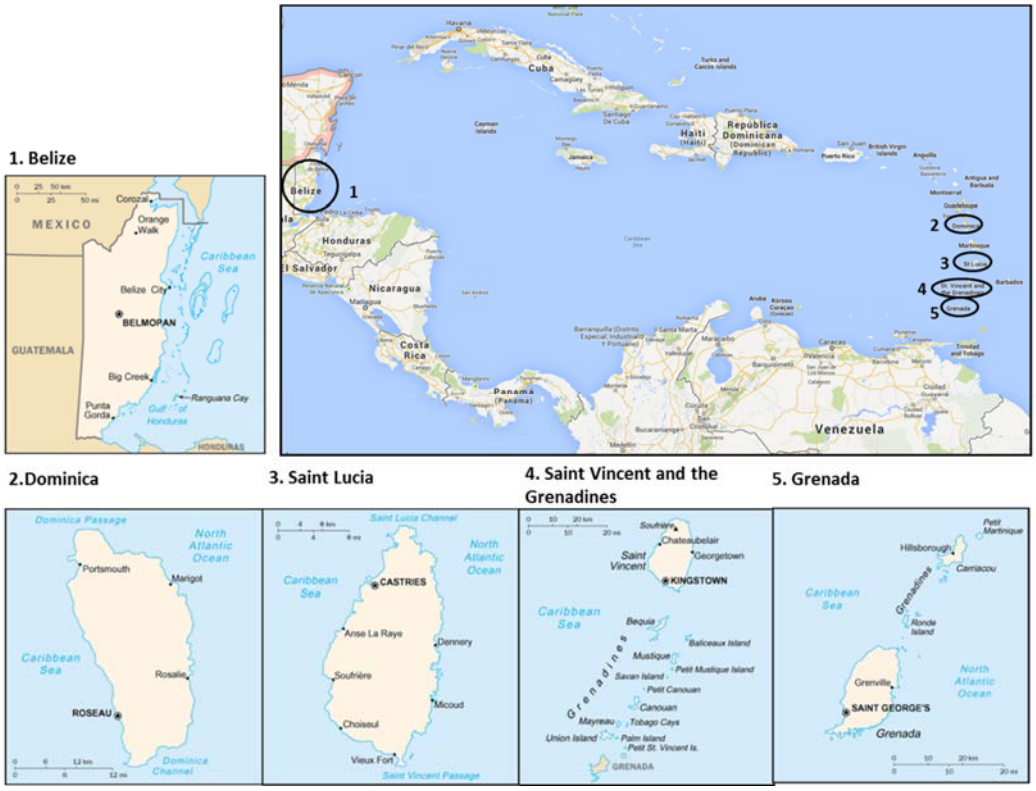


Figure 4.1: Location of the 5 countries involved in this project. There is a large difference between Belize and the island states in the Eastern Caribbean in terms of topography, physiographic setting and natural hazards.

The small island states and countries in the Caribbean – especially those of volcanic origin with rugged and steep terrain – have limited suitable surface area for development and agricultural production. Most of the population lives along the coast and most economic activities are concentrated. These areas are affected by floods (flash floods, drainage floods and coastal floods) and disrupt the socio-economic systems. Vital infrastructure that traverses the mountainous areas can be severely damaged by landslides, thereby isolating parts of the islands and disrupting the distribution of goods (and relief). Because of their size there is very little robustness in the system to deal with these impacts. As a consequence these events have a severe impact on the relatively small economy of these countries.

The national governments have limited human and financial resources to cope with these hazards and generally lack the expertise for hazard and risk assessment in their territory. This is aggravated by the lack of geospatial data that is needed to carry out these analyses. As a consequence new development activities are often carried out with limited considerations to these hazards. It also

hampers the authorities in developing pro-active hazard mitigation plans, such as early warning systems, preparedness planning and risk-reduction strategies.
Table 4.1 gives a summary of a number of relevant aspects related to natural hazards and disaster risk management in the 5 countries involved in this study.

Table 4.1: General information for the 5 countries involved in this project, related to disasters and Disaster Management (Source: CDEMA website). Also the available hazard maps that could be assessed through internet search for the 5 countries is indicated.

	Belize	**Dominica**	**Saint Lucia**	**St. Vincent and the Grenadines**	**Grenada**
Area	22,806 km^2	754 km^2	606 km^2	389 km^2 (Saint Vincent 344 km^2) with 32 islands and cays	344 km^2
Coastline	386 km	148 km	158 km	84 km	121 km
Terrain	Flat, swampy coastal plain; low mountains in south. Max. elevation 1,160 m	Rugged mountains of volcanic origin, Max. elevation: 1,447 m	Volcanic and mountainous with some broad, fertile valleys. Max. elevation: 950 m	Volcanic, mountainous. Max. elevation: 1,234 m	Volcanic in origin with central mountains. Max elevation: 840 m
Natural hazards	Frequent, devastating hurricanes (June to November) and coastal flooding (especially in south),	Flash floods are a constant threat; destructive hurricanes can be expected during the late summer months, 10 active volcanoes	Hurricanes and volcanic activity, debris flows, flashfloods	Hurricanes; Soufriere volcano on the island of Saint Vincent is a constant threat. Flashfloods and landslides	Lies on edge of hurricane belt; hurricane season lasts from June to November. Flashfloods and landslides.
Population	334,297 (2013)	71,293 (2011)	174,000 (2010).	104,574 (2009)	110,000 (-)

Table 4.2 gives a description of the hazards within each of the 5 countries. From the summary given in the table it is clear that the types of hazard differ considerably in terms of the associated geological hazards, as several of the countries also have active volcanoes and/or are exposed to higher levels of earthquake hazards. Within the landslide hazard assessment the hazard triggered by earthquake therefore might also be relevant to analyse for some of the countries, apart from the rainfall trigger which is apparent for all the countries, except for Belize, that has no significant exposure to landslides. In terms of flood hazards it is important to study both rainfall related flooding and coastal related flooding associated to storm surges.

Table 4.2: Hazard characteristics for the 5 countries involved in this project (Source: GFDRR Country profiles).

	Hazard characteristics
Belize	Hurricanes and tropical storms are the principal hazards affecting Belize, causing severe losses from wind damage and flooding due to storm surge and heavy rainfall. Recently, hurricanes Keith (2000), and Iris (2001) caused some of the worst damage ever, reaching 45% (US$280 million) and 25% of GDP, respectively. Belize city was heavily affected in 1931 and 1961, leading to the formation of Belmopan. The country has low levels of seismic and tsunami risk.
Dominica	Dominica experiences some of the highest annual rainfall amounts in the region which are heavily influenced by orographic effects. Since 1950, Dominica has been exposed to 13 named tropical storm systems passing within 40 km of the island. Since 1979, the island has been impacted by 15 tropical systems including 11 hurricanes. Dominica is considered the most geologically active island in the Caribbean. Dominica has eight volcanoes. Earthquake activity originates from two sources, tectonic activity associated with plate movement and magma displacement associated with volcanic activity. The severe topography of the island favors landslide potential and flooding from the island's many streams; this is a significant recurrent event.
Saint Lucia	Saint Lucia experiences landslides, particularly in the aftermath of heavy rains. Saint Lucia's mountainous topography coupled with its volcanic geology produces a significant opportunity for landslides. Much of the island's housing is distributed along steep slopes and poorly engineered and constructed housing is particularly at risk. Additionally, the island periodically experiences earthquakes of generally lower magnitudes. The island is classified as seismic zone 2 on a 4-class scale, indicating low to moderate earthquake risk. Also storm surge and

	flash floods are among the other risks regularly faced by the island.
St. Vincent and the Grenadines	Landslides, particularly on the larger islands, are a significant hazard and the risk is increased during the seasonal rains. Coastal flooding is a major concern particularly relating to storm surge and high wave action. The Grenadines are more susceptible to drought. The active volcano La Soufriere, located on the north end of St. Vincent is another risk factor, posing threats from shallow earthquake and eruption events. Since 1900, St. Vincent has been hit by 8 named storms, the strongest being Hurricane Allen (Category 4), which passed between St. Lucia and St. Vincent in 1980. Prior to that, Hurricane Hazel, a Category 1 storm passed some 38 km south of St. Vincent in 1954. These Islands were also severely affected by Hurricane Lenny in 1999, a Category 4 storm. The 1939 eruption of the volcano Kick-'em-Jenny located some 100 km reports S of Grenada, generated a 2-meter high tsunami.
Grenada	Historically, Grenada was considered relatively safe from hurricanes owing to its location in the southernmost region of the hurricane belt, with 3 hurricanes since the beginning of the 20th century. However, the country was heavily affected by Hurricane Ivan in 2004 and Hurricane Emily in 2005. There are two active volcanoes in Grenada, Mount St. Catherine in the center of the island and the submarine volcano Kick-'em-Jenny located 8 km north of the island, which has led to tsunami in the past. Flood risk in Grenada is largely associated with storm surge in low lying coastal areas. Flash flooding from mountain streams coupled with storm surge events are the primary causes of flood events and effects are generally limited to communities located in the coastal margins along stream passages. Landslides are a common event in Grenada, with much of the impact experienced along the roadway network.

This part of the assessment report addresses these issues and makes a detailed inventory of the available data for the 5 countries (Grenada, Saint Vincent and the Grenadines, Satin Lucia, Dominica and Belize). Also an inventory is made of previous work on hazard assessment that could be found from the literature, through extensive internet searches. We are first presenting the method used, then the satellite data which was obtained from a European project, and then the data situation is reviewed country by country.

4.2 Data compilation procedure

Since the start of the project we have been actively searching for available data for the five countries. Staff from GFDRR provided the majority of the data through ftp. Furthermore we have investigated the available data from GeoNode portals of the various countries:

- Dominica http://www.dominode.net/
- Belize http://geoserver.bnsdi.gov.bz
- St. Lucia http://sling.gosl.gov.lc
- St. Vincent http://geonode.gov.vc/
- Grenada not open - intranet version only

Out of the five, only the sites of Dominica and Saint Lucia were actually operational. The other ones were not accessible during the several weeks we made the inventory.

We have also collected data from a number of internet sites, specifically for the country of Belize (http://biological-diversity.info/GIS.htm).

4.2.1 Acquiring very high resolution satellite images

Furthermore we have obtained a series of high resolution satellite images within an EU Copernicus project INCREO (http://www.increo-fp7.eu/), which allowed project partners to order very high resolution satellite data for free. We have obtained a number of satellite images for the four island countries. The results are shown in Table 4.3. Unfortunately Belize was not included in this

component. We have also downloaded high resolution satellite imagery from Google Earth, specifically for Dominica where we initially didn't have enough coverage of the entire island.

For Dominica, Saint Lucia, Saint Vincent and Grenada we now have very high resolution satellite images, both in panchromatic (with a resolution of 0.5 meters) and multi-spectral (4 bands with a spatial resolution of 2 meters). These images are adequate to carry out the following tasks:

- Detailed landslide inventory mapping, making use of digital stereo-image interpretation. Digital stereo images are made using the ILWIS GIS, from the high resolution satellite images in combination with a Digital Elevation Model. We are also using the existing landslide inventory maps for this. Table 4.3 gives a summary of this.
- Land use / land cover mapping.
- Building footprint mapping

Table 4.3: Available satellite images for the five countries

Country	Satellite	Date	Type	Columns, Rows
Dominica	Downloaded from google Earth	Various covering the island, but all with very high resolution	Colour image	35120, 63354
	Digital Globe	13 02 2014	Cloud cover 3.6 % pixel size 2 meters	6983, 30999
	Pleiades	2014 03 08	0.5 meter panchromatic 2 meter multispectral. Covers North west part of the island	43814, 80743
	Pleiades	2014 01 17	0.5 meter panchromatic 2 meter multispectral. Covers middle part of the island	7009, 18049
	Pleiades	2014 03 08	0.5 meter panchromatic 2 meter multispectral. Covers Northwest part of the island	10921, 20183
	Pleiades	2014 01 17	0.5 meter panchromatic 2 meter multispectral. Covers east part of the island	47246, 101040
Saint Lucia	Pleiades	2014 02 25	0.5 meter panchromatic 2 meter multispectral. Covers whole island, except extreme west coast	10676, 23943
	Pleiades	2012 11 20	0.5 meter panchromatic 2 meter multispectral. Covers south part of the island	41149, 42418
Saint Vincent	Pleiades	2014 02 23	0.5 meter panchromatic 2 meter multispectral. Covers whole island	12507, 16250
Grenada	Digital Globe	2010	1 meter, only of SE part	16384, 15700
	Ikonos	2004	1 meter, Only of the SE part. Entire island except SE corner	8269, 5797
	Pleiades	2013 08 06 About 5 % clouds	0.5 meter panchromatic 2 meter multispectral. Entire island except SE corner	45354, 65909
	Pleiades	2013 11 17	0.5 meter panchromatic 2 meter multispectral. SE corner of the island	49947, 48707
Belize	No images are available			

4.2.2 ESA Earth Observation Information Products/Services for World Bank Projects.

Multilateral Development Banks (MDB), e.g. World Bank, European Investment Bank, etc., provide financial support and professional advice to mainly public (but also some private) sector organisations for development activities on local to regional scale.

These activities are generally focused in developing countries and organized in dedicated projects financed by long-term loans or grants for infrastructure development in a wide range of fields leading to social and economic growth and benefits. Regular assessments of the environmental and social impacts of the activities undertaken in connection with the loans are a necessary condition for receiving and maintaining the financing.

Given this, Earth Observation (EO) products / services are potentially useful tools in providing a wide range of environmental information (past and present) to support the monitoring and management of MDB projects. The particular advantages of EO in this context are:

- Access to information that is non-intrusive, objective and consistent around the globe,
- Access to historical information that can be compared to the current status (through the usage of mission archives),
- Access to an information technology for which there is long-term continuity (i.e. decades), for the future, especially with the prospect of the joint European Union (EU) and European Space Agency (ESA) initiative of the Global Monitoring for Environment and Security (GMES).

ESA and the World Bank (WB) have been collaborating under the umbrella of the "Earth Observation for Development" initiative - branded eoworld - since 2008.

The form of this collaboration has been to develop, produce and deliver limited-scale examples of EO-based information products that respond specifically to the geo-information requirements of on-going World Bank projects. ESA provides the financial and technical capacity to procure the information products on an open competitive basis from the leading European and Canadian EO service providers (companies).

Within this cooperation a pilot study for the five Caribbean countries has been defined between the European Space Agency (ESA) and the World Bank. The following activities have been defined:

- **Service 1: Land use/land cover mapping** will be delivered over AOI-A (Saint Lucia, 615 km^2), AOI-B (Grenada, 364 km^2) and St Vincent & Grenadines.
- **Service 2: Hazard mapping to support landslide risk assessment** will be delivered over AOI-A (**Saint Lucia, 615 km^2**) and B (**Grenada, 364 km^2**) as per the Statement of Work. WB & ITC suggested covering all three AOIs but the SoW requires covering AOI-A & B. Following the request from WB & ITC to have products with a better scale than 1:20 00, 50% of AOI-A (Saint Lucia) will be performed at a scale of 1:10 000. The subdivision will be agreed with the WB TTL and users (and ITC) during the SRR. Note that moving from 1:20 000 to 1:10 000 is multiplying by almost four the burden on data analysis, so the request from WB & ITC has been taken on board but there are cost implications (on ESA). It is understood that AOI-A is the one with the most pressing landslide risk hazard/exposure/vulnerability higher than AOI-C or B). The service will include:

  - Landslide inventory mapping over the Area of Interest; shall seek to capture as far as possible: information on landslides: this includes the location and, where known, the date of occurrence and types of observable landslides
  - Generation of a Digital Elevation Model (DEM) generated using EO data (such as SPOT or ASTER, etc.) or other EO or non-EO data to be proposed by the bidder
  - Ground truth in St Lucia and Grenada: collecting in-situ measurement to support the landslide hazard mapping over the AOI...
- **Service 3: Generation of a Detailed Digital Elevation Model.** The DEM over Belize may be upgraded to Elevation30 (10m Z) instead of the Aster GDEM. The precise DEM will be based on Pleiades triplet data (or stereo data). The location of the precise DEM footprint needs to be provided by WB asap (Action 1 on WB).

The pilot has three phases; service review; service production (incl. map delivery and site visit to present/explain results); user feedback (stakeholder and users). WB project users are in the loop in addition to ITC to make sure that the space technologies we are going to demonstrate is fit for their purpose.

The Contractor of ESA (This service will be carried out by the British Geological survey) has been in close contact with ITC, and during the planned fieldwork period in September-October, joint fieldwork will be carried out. The consortium lead by ITC and BGS will also work closely together in developing the final products, in order to avoid duplication of efforts and increase the quality of the end products.

4.2.3 Data repository

All data that has been compiled for the five target countries have been made available on an ftp site on the ITC server. This ftp site has separate directories for each country, and subdirectories for data (GIS data in ARCGIS format), text (with reports on the country) and images (with high resolution satellite images). There is also a General directory with project information, and with the examples of handbooks, manuals and guidelines, used in this report. Also this report itself can be found on the ftp site.

Later we intend to transfer the compiled data and the results to the GeoNode portals of the respective countries.

In the following sections an overview will be given of the results of the compilation of data for each of the countries, and of the hazard and risk assessment projects that we were able to fund through internet search using Google. For each country we describe the existing hazard studies, the data that has been compiled, and the main missing types of data. A complete overview of the individual data layers is given in the Annexes of this report, which are copies of an Excel file that can also be found on the ftp site.

The chapter ends with a section where we describe the main type of work that will be required in order to generate the national scale flood and landslide hazard maps.

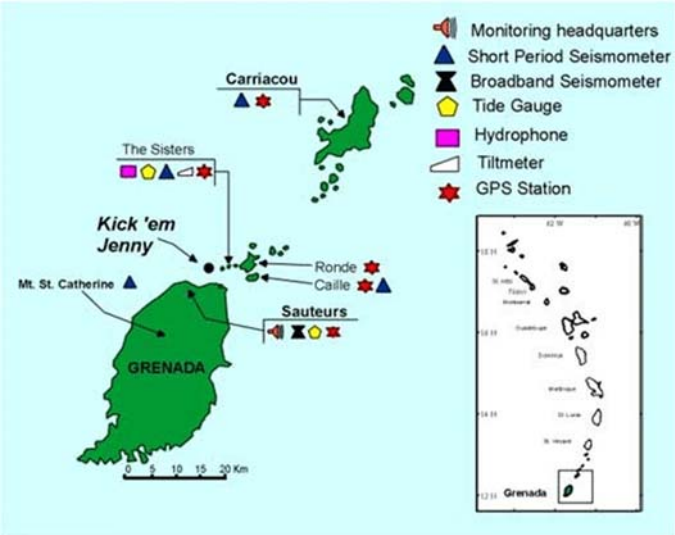
4.3 Grenada

Grenada has, in comparison with the other islands, the lowest availability of digital maps (as can be observed from the accompanying Excel sheet of data inventory. Grenada doesn't have an OpenGeo portal that can be accessed. We were told that there is an intranet version only, so we cannot evaluate the availability of the data there. We came across several initiatives on the use of GIs data for Grenada, such as the Grenada Land information System.

A comprehensive Environmental Profile was produced in 1991, by the Caribbean Conservation Association funded by US-AID, which contains a good overview of topography, geology, natural hazards, demography, economy and natural resources. In Grenada flood hazard assessment studies have been carried out before for specific areas.

According to a study by CDERA in 2003 (Status of Hazard Maps Vulnerability Assessments and Digital Maps) hazard maps have been prepared at scale of 1:25000 to identify areas prone to natural hazards and recommend mitigation measures in a study for OAS in 1988. Towns of St. George's, Gouyave, Victoria, Sauteurs, Grenville, Tivoli, St. Paul, St. David Parish. The study was funded by OAS and Physical Planning Division, Ministry of Finance and Planning. The author is Vivian Bacarreza. This old report contains a number of maps that could be useful but have to be reconsidered.

Coastal hazard and risk assessment of Grenada has been carried out under the Caribbean Planning for Adaptation to Global Climate Change Project (CPACC) where future impact was analysed for three scenarios related to sea level rise and storm surge frequency. A detailed study on the analysis of storm surge analysis was carried out by Smith Warner International Ltd for the countries of Saint Vincent and the Grenadines and Grenada. Coastal erosion hazard maps have been generated in a project by CEAC Solutions Co. Ltd. in 2006 for the Caribbean Disaster Emergency Response Agency.



Grenada is threatened by the presence of a submarine volcano; Kick 'em Jenny, located 9km North of Grenada, at 12º 10.8' N, 61º 22.8' W. It is said to be the only 'live' submarine volcano in the Eastern Caribbean, having erupted about 12 times since 1939, when it began to be observed. As the vent of the volcano approaches the surface of the sea, the threat of tsunamis also increases. http://www.uwiseismic.com

Landslide Hazard Maps for St. Lucia and Grenada were prepared in 2006 for The Caribbean Development Bank (CDB) and the Caribbean Disaster Emergency Response Agency (CDERA) by a team headed by Jeffrey Euwema (Council for Information and Planning Alternatives, Inc. Puerto Rico) with several consultants from the US. Landslides were mapped using field reconnaissance. Field reconnaissance conducted on both islands was limited because the Project Team was restricted in identifying and evaluating landslide events by the existing road network. Only forty (40) landslide points were recorded for St. Lucia and two hundred and forty five (245) for Grenada. The landslide

susceptibility assessment was carried out using an analysis of the conditioning factors (elevation, slope geology and soils) and did not included man-made factors, even though the study was carried out only along the roads. The susceptibility method followed weighted approach using GIS. The landslide inventory map and the result maps for Grenada are not available.

In a study carried out by UNEP and the Caribbean Environmental Health Institute (CEHI) in 2006 on Geographical Information System-Assisted Water Availability Analysis for Grenada, a compendium was made of GIS data from the Land Use Division of the Ministry of Agriculture, Lands, Forestry and Fisheries, Grenada. The study aimed to assist planners in water sector development initiatives through identification of areas over Grenada that will require investment in water augmentation measures (based on water availability) such as rainwater harvesting. The study compiled data on topography, watersheds and rainfall stations which were used in analysing average rainfall and water deficit, and raw water supply (runoff) estimates for National Water and Sewerage Authority (NAWASA) catchment areas in Grenada.

An island-wide flood hazard assessment study was carried in 2006 by consultants (Vincent Cooper and Jacob Opadeyi) for the Caribbean Development Bank. The map (1:25.000 scale) was based on a ranking method (so not on a proper hydrologic and hydraulic analysis) and defines three hazard zones, high, medium, low, on the basis of the danger posed to an average human being as a result of floodwater depths. Also a detailed flood hazard map for the St. John River Floodplain was made with flood depth for return periods of 2 year, 5 year, 10 year and 25 year. The report concludes that “The reliability of the maps, the detailed and the island-wide flood hazard maps, has both been adversely affected by the inadequacies of the rainfall database for flood studies. Lengths of records were too short to confidently perform the rainfall analysis for extreme daily rainfall and too few gauges existed for adequately covering the island. Consideration should be given to the establishment of some permanent rainfall stations which combined can provide coverage of the spatial rainfall over the entire island. There are relatively inexpensive, low maintenance continuous rainfall recorders that could be acquired for this network”.

The Grenada Land information System (GLIS) was developed by the Land Use Division. It is computer based Land Informa8on System. The main clients are Government Ministries & Agencies, Farmers, Extension, Officers, Utility Companies, Engineers, Agricultural Planners, Environmentalists, Students, NGO’s, Consultants (Local, Regional and International organizations, General Public. We were not able to access the website of the GLIS, so we cannot evaluate which data is online. In a presentation they outlined the following problems: Maintaining the database system and data; inputting data and upda8ng the database; outdated database management software.

The following main types of data are available for Grenada:

- **Digital Elevation Data**. We have a raster DEM with 10 meter pixel size and a set of LIDAR points covering part of the areas.
- **Land cover data** is available in the form of a general raster maps from a USDA project (30 meter pixel size) and in the form of a number of thematic layers (built-up area, vegetation, agriculture, wetlands, swamps, lakes). They should still be integrated into a combined land cover map.
- **Elements-at-risk data** is available in the form of building footprints maps for the entire country. However, they do not have any attributes. Road information is also quite complete.

The most problematic points with respect to available data in Grenada are:

- **Incomplete lidar data**. We currently have a Digital Elevation Model with a pixel size of 10 meters, for which it is not clear how it was generated. Apart from that we have also a set of point files with Lidar data points, for the coastal area of Grenada, for half of the island of Carriacou and for the island of Petite Martinique. So it is not clear yet how we can integrate these data sets. There are no contour lines available.
- **Geological map**. We do not have a geological map for Grenada, other than a very general one covering the entire Eastern Caribbean area (made by USGS). Also a very course geological map is available from a study by Weaver, 1989, and from a FAO study. A geology map was developed in 1981 as part of a reconnaissance study of the geothermal resources conducted by Geothermica Italana. The geology base maps (1:25,000) were digitized by the Ministry of Agriculture in 1994.
- **Soil map**. Also a soil map is not available for Grenada. There is an old report from 1959 on the soils in Grenada (Vernon, K., et 01. 1959, Soil and land use surveys No.9, Grenada. Reg. Res. Cent., Imp. Coli. Trop. Agri., Trinidad, WI) which we haven't been able to obtain.
- **Discharge data**. There is not discharge data for any station in Grenada available now. There has been a study in Grenada on Geographical Information System-Assisted Water Availability Analysis for Grenada (UNEP and Caribbean Health Institute) that has collected a substantial amount of data on rainfall and runoff for Grenada, however they also conclude that continuous stream flow data do not exist on any of the rivers making it difficult to check the results from the hydrologic study
- **Geotechnical data**. Thus far we do not have any geotechnical data for Grenada.
- **Rainfall data**: we have obtained rainfall data for some stations in Grenada, but these are not continuous and further data should be collected on rainfall. There are about 50 rainfall stations spread out over the island, and the data is available with Land Use Division, Ministry of Agriculture, Lands, Forestry and Fisheries, St. George's, Grenada
- **Landslide inventory and hazard map**. We have not found any landslide inventory maps for Grenada, either in paper or digital form. However, we did find a report "Development of Landslide Hazard Maps for St. Lucia and Grenada" by CDB and CDERA in 2006. However, we couldn't find any of the related maps.
- **Flood hazard map**. Thus far we haven't been able to find any results from previous flood hazard assessment projects for Grenada. A flood hazard study was carried out in 2006 in Grenada by Vincent Cooper and Jacob Opadeyi. They generated a country wide flood map and a detailed flood hazard assessment for St. John River Floodplain.
- **Socio-economic data** is missing, as well as **population data**.

4.4 Saint Vincent and the Grenadines

The GeoNode for Saint Vincent and the Grenadines (available at http://geonode.gov.vc/) is not available. Message: "The server is temporarily unable to service your request due to maintenance downtime or capacity problems. Please try again later". Nevertheless, we obtained quite a lot of data for Saint Vincent.

A comprehensive Environmental Profile was produced in 1991, by the Caribbean Conservation Association funded by US-AID, which contains a good overview of topography, geology, natural hazards, demography, economy and natural resources.

Boruff and Cutter (2010) produced a study on The Environmental Vulnerability of Caribbean Island Nations, in which Saint Vincent is one of the study areas. They carried out an extensive literature study on hazard occurrences in Saint Vincent (See table with results for 1901-2000). The data from their study is available in digital form, and forms the most comprehensive dataset on hazards for Saint Vincent. Unfortunately the original data is not available and in many cases it is unclear how the authors came to their (rather simple) classification of hazard and vulnerability.

	SAINT VINCENT	
HAZARD	Number of Events	Return Period[a]
Drought	Occasional[b]	
Earthquake	7	14.14
Flood	4	24.75
Fire	Annual	< 1.0
Landslide	Frequent	
Tropical system	7	14.14
Tsunami	1	99
Volcanic eruption	3	33

Landslide inventory maps have been generated by Jerry deGraff from the USDA in 1987. These maps are available in scanned form. He also produced a landslide susceptibility map by analysing the relation between landslides and geology, slope and land cover.

Rainfall Intensity –Duration-Frequency curves based on three rain gauges have been derived for Saint Vincent by a study by H.R. Wallingford. Sub-daily rainfall data are only available at the ET Joshua rainfall gauge for 6 hour accumulations. Frequency analyses were performed on these data sets to establish the 6 hour rainfall accumulations associated with the 2, 5, 10, 25 and 50 year return periods. The same organization produced national-scale flood maps for different return periods for the island of Saint Vincent. Extreme flood flows were estimated at approximately 50 m intervals along each stream in each catchment. Owing to the unavailability of flow data, the extreme flood flow was estimated using data from the World Catalogue of Observed Maximum Floods, using simple relations between Q and area. Cross-sections were derived from the DTM dataset along each drainage path at about 50 m intervals. The extreme flood water levels were then estimated using the freely available Conveyance Estimation System (CES), www.river-conveyance.net. The CES was used to produce water level versus flow rating curves at approximately 50 m intervals along each drainage path. These rating curves were then used to estimate extreme flood levels at the determined cross-section location. The extreme flood levels were used in combination with the DTM to identify the specific height of the flood at each cross section location. These benchmarks were then connected up from the first to the last cross-section of each drainage path section identified. Unfortunately the results from this study are not available.

A detailed study on the analysis of storm surge analysis was carried out by Smith Warner International Ltd for the countries of Saint Vincent and the Grenadines and Grenada.

There have been five major eruptions of the Soufrière volcano recorded since European settlement, the most recent being in 1979. The volcano is active and poses a serious threat to the inhabitants of the island. As a result, the island is affected by volcanic and seismic activity. Tsunami risk is generally associated with the potential effects of an eruption of the volcano Kick-'em-Jenny located some 100 km to the south off the coast of Grenada. The 1939 eruption reports indicate that a 2-meter tsunami was generated. We didn't find detailed reports to analyse this hazard for Saint Vincent.

The data which is currently available can be summarized as follows:

- **Digital Elevation Data**. This is available in the form of a raster DEM covering Saint Vincent and the Grenadines, as well as Grenada. The DEM has a cell size of 5 meters. The higher parts of Saint Vincent do not have data. There are also Lidar data for Saint Vincent. The LIDAR data points in the form of text files, and raster files (which are not correct). It wasn't possible yet to analyse the completeness of the data due to the wrong format of the data, and reformatting would take a lot of time.
- **Land cover data** is available in the form of a polygon map with 11 land use classes. Separate information is available for drainage, water bodies, coastlines, etc.
- **Hazard data** is available in the form of landslide footprints (which are not described in detail). Most of the hazard data is coming from one report by Boruff and Cutter. They have probably used existing data, which have been modified. It would be good also to have access to these original data.

The most problematic points with respect to available data in Saint Vincent and the Grenadines are:

- **Geological map**. We do not have a geological map for Saint Vincent, other than a very general one covering the entire Eastern Caribbean area (made by USGS). Also a very course geological map is available from a study by Robertson 2003.
- **Soil map**. Also a soil map is not available for Grenada. There seems to be a soil map available from the FAO GIs site (http://data.fao.org/map?entryId=dfbb04d0-88fd-11da-a88f-000d939bc5d8&tab=metadata) but we haven't been able to download it. Also there is a general soil map in a USAID study from 1990
- **Discharge data**. There is not discharge data for any station in Saint Vincent available now.
- **Geotechnical data**. Thus far we do not have any geotechnical data for Saint Vincent.
- **Rainfall data**: we have not obtained rainfall data for Saint Vincent, but in a study "The challenges of developing rainfall intensity – duration – frequency curves and national flood hazard maps for the Caribbean" by D M Lumbroso, S Boyce, , H Bast and N Walmsley, several rainfall stations were used for generating rainfall intensity-duration/frequency curves for eastern Caribbean islands.
- **Flood hazard assessment.** Previous studies on flood hazard assessment have been carried out in Saint Vincent and the Grenadines, by H R Wallingford (UK). In 2006 DLN Consultants carried out an island wide flood risk assessment study of St Vincent,
- We haven't been able to obtain their final report and maps.
- **Socio-economic data** is missing, as well as **population data**.

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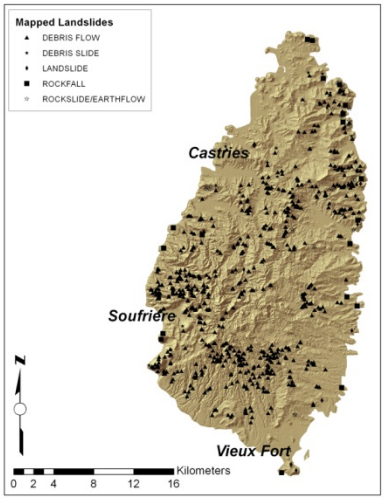
4.5 Saint Lucia

Data for Saint Lucia were obtained from the World Bank. The GeoNode platform for Saint Lucia (http://sling.gosl.gov.lc is accessible and is well maintained. We have been able to download the relevant data sets.

A comprehensive Environmental Profile was produced in 1991, by the Caribbean Conservation Association funded by US-AID, which contains a good overview of topography, geology, natural hazards, demography, economy and natural resources.

Landslide inventory maps have been generated by Jerry deGraff from the USDA in 1987. These maps are available in scanned form. Landslide Hazard Maps for St. Lucia and Grenada were prepared in 2006 for The Caribbean Development Bank (CDB) and the Caribbean Disaster Emergency Response Agency (CDERA) by a team headed by Jeffrey Euwema (Council for Information and Planning Alternatives, Inc. Puerto Rico) with several consultants from the US. Landslides were mapped using field reconnaissance. Field reconnaissance conducted on both islands was limited because the Project Team was restricted in identifying and evaluating landslide events by the existing road network. Only forty (40) landslide points were recorded for St. Lucia and two hundred and forty five (245) for Grenada. The landslide susceptibility assessment was carried out using an analysis of the conditioning factors, and a weighted approach using GIs. The landslide inventory map and the result maps for Grenada are not available.



Cassandra Rogers carried out a Landslide hazard study for watershed management and development planning in St. Lucia, West Indies in 1997.

In a more recent study P.E. Quinn (BGC Engineering Inc., Victoria, BC) prepared a landslide inventory for Saint Lucia, and used this for generating a landslide susceptibility map (See: http://petequinnramblings.wordpress.com/2012/04/02/landslide-susceptibility-and-risk-in-saint-lucia-draft-paper/). The work uses the weights of evidence method, a bivariate statistical approach that compares landslide absence/presence with several other layers of geospatial data in a geographic information system (GIS) to obtain a predictive model for relative spatial frequency of future landslides.

After Hurricane Thomas in 2010 the Economic Commission for Latin America and the Caribbean (ECLAC) carried out a study on the macro socio-economic and environmental assessment of the damage and losses caused by Hurricane Tomas, which contains a lot of detailed information on the landslides and floods caused by this Hurricane. This study also proposed a number of follow-up projects that are very useful in the scope of the current project.

An island-wide flood hazard assessment study was carried in 2006 by consultants (Vincent Cooper and Jacob Opadeyi) for the Caribbean Development Bank. The map (1:25.000 scale) was based on a ranking method (so not on a proper hydrologic and hydraulic analysis) through a combination of the land cover and soil hydrologic characteristics are quantified using the empirical curve number

approach of the Natural Resources Conservation Service (NRCS, formerly Soil Conservation Service)that rank runoff potential of lands on a scale of 1 to 100, lands with 100 having the highest runoff potential and defines three hazard zones, high, medium, low, on the basis of the danger posed to an average human being as a result of floodwater depths.

Also a detailed flood hazard map for the Castries area was made using FLOW-2D resulting in flood depth maps (scale 1:2500) for return periods of 2 year, 5 year, 10 year and 25 year.

A detailed study on volcanic hazards for Saint Lucia was carried out by Lindsay et al in the Volcanic Hazard Atlas of the Lesser Antilles in 2002. A drought hazard assessment study is available through (http://www.drmonline.net/drmlibrary/droughtsaintlucia/susceptibility/index.htm)

Currently the following main features for the data for Saint Lucia can be mentioned:

- **Digital Elevation Data** for Saint Lucia is very good. This is a raster map with 50 meter cell size. Apart from that we have detailed contour lines in the form of vector (line shapefile), with 2.5 meter contour interval.
- Watersheds, streams, shorelines etc. are available in digit6al form.
- **Rainfall data** is available in the form of Excel files with hourly rainfall data for 24 stations with varying periods. Maximum period is 2003 to 2014.
- **Land use / land cover** maps are available in the form of raster maps at 1:50000 scale. Vegetation information is available in the form of vector files.
- A **Geological map** and a **digital soil map** are available as vector (polygon shapefile), soil types and other characteristics of the soil. Quite detailed map with many attributes.
- **Landslide inventory maps** are available as vector (Polygon shapefiles), with locations for the 2010 situation (made through satellite image interpretations) and as point maps with type information.
- A **debris flow susceptibility map** is available as vector file, but this map has a rather low quality as most of the area is in the “no class” zone.
- **Flood maps** are available for one study area in the Northwest of the country in the form of several Vectors (Polygon shapefile) with flood intensity maps for different return periods.
- **Also coastal hazard, volcanic hazard and wind storm hazard** maps are available for the country.
- **Elements-at-risk maps** are available for the entire country. Building footprints are available for the entire country. However, they do not have information on occupancy types or structural types. Road information is also very detailed. There is also information available on airports, bridges and tunnels, churches, beaches, health facilities, pharmacies, hotels, police stations and schools.
- **Remedial measures** are available in the form of retaining walls, culverts, and dams.

The most problematic points with respect to available data in Saint Lucia are:

- **Discharge data**. There is not discharge data for any station in Saint Lucia available now. Government of St. Vincent & the Grenadines
- **Geotechnical data**. Thus far we do not have any geotechnical data for Saint Lucia
- **Socio-economic data** is missing, as well as **population data**.

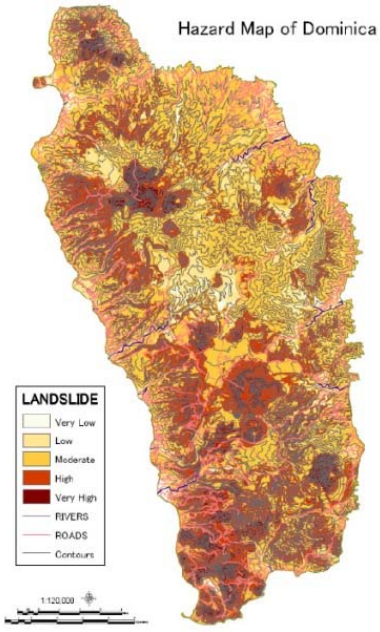
4.6 Dominica

Data for Dominica were obtained from the World Bank. The GeoNode platform for Saint Lucia (http://www.dominode.net/)is accessible and is well maintained. We have been able to download the relevant data sets

According the GFDRR country report "Dominica is considered the most geologically active island in the Caribbean. It lies close to the eastern margin of the Caribbean plate and is the only island with more than one volcano. Dominica has eight volcanoes. Earthquake activity originates from two sources, tectonic activity associated with plate movement and magma displacement associated with volcanic activity. The severe topography of the island favours landslide potential and flooding from the island's many streams; this is a significant recurrent event. Dominica is considered by the scientific community to be at significant risk from volcanic eruption within the next 100 years".

A comprehensive Environmental Profile was produced in 1991, by the Caribbean Conservation Association (CCA) funded by US-AID, which contains a good overview of topography, geology, natural hazards, demography, economy and natural resources.

Landslide inventory maps have been generated by Jerry deGraff from the USDA in 1987. These maps are available in scanned form. He also revisited the island in 1990 and made an analysis of the reliability of his 1987 landslide susceptibility map based on a number 0f 150 new landslides that occurred between 1987 and 1990.



There is also a report from 2006 from CIPA for USAID and Caribbean Open Trade Support (COTS) programme on landslide and multi-hazard risk assessment for Dominica. The digital maps available are probably from this project. They relate to landslide, earthquake, volcano, inland flooding, Coastal flooding, and Windstorm. They are also combined in a composite hazard map. The landslide inventory was based on the previous one from DeGraff but with additional aerial photo interpretation (of selected areas) and field verification. The landslide susceptibility assessment followed an expert-based weighting approach. The susceptibility map doesn't give information on temporal and spatial probabilities. The methodology for the flood hazard map of Dominica was made through a combination of land cover and hydrologic characteristics of the watersheds on the island, using a method developed by the National Resources Conservation Service of the US, which ranks peak runoff potential on a scale of 1 to 100. The resulting map is quite general. A detailed study on volcanic hazards for Dominica was carried out by Lindsay et al in the Volcanic Hazard Atlas of the Lesser Antilles.

Volcanic hazard assessments (http://www.uwiseismic.com/Downloads/Dominica_VHA.pdf) and seismic hazard assessment (http://www.oas.org/CDMP/document/seismap/windward.htm ; http://uwiseismic.com/seishaz.aspx) have been carried out for Dominica.

Currently the following main features for the data for Dominica can be mentioned:

- **Digital Elevation data** is currently only available in the form of contour lines, as vector (line shapefile), with 10 meter contour interval. It was been generated from a raster DEM, and contains many errors, and blocky contours. Code consistency is OK. There is also data available for spot heights, and mountains
- **Hydrography data** is available in the form of rivers, waterfalls and lakes.
- **Rainfall data** is only available in the form of isohyets. We do not have rainfall data for specific stations yet.
- There is a general **soil map**, with soil types and other characteristics of the soil.
- A **landslide inventory map** is available as vector (Polygon shapefiles), with types (debris flow, rock fall) class (scarp, deposit), status (definite). Some attribute codes are not defined. The map contained 810 landslides.
- A **landslide susceptibility map** is available with 5 classes, which seems rather general.
- A **flood hazard map is** available also with 5 classes, which is also a bit general.
- **Other hazard maps** are available for volcanic hazard, windstorm hazard, storm surge hazard, earthquake hazard and there is also a combined hazard map.
- **Administrative units** are available as well.
- Elements-at-risk data is available as health centres, health facilities, schools, towns and settlements, police stations, shelters, beaches, bus stands, estates,

The most problematic points with respect to available data in Dominica are:

- **Original contour lines** are required instead of the current ones which have a lot of problems (blocky structure as they are converted from raster data).
- A **Geological map** is required for the island. We have a scanned version which is rather general, and more detailed vector data would be required.
- **Rainfall data** are still missing.
- **Building footprints** are only available for Roseau. Data for the rest of the country are missing.
- **Discharge data**. There is not discharge data for any station in Dominica available now.
- **Geotechnical data**. Thus far we do not have any geotechnical data for Dominica
- **Socio-economic data** are missing, as well as **population data**.

4.7 Belize

For Belize the data came from various sources. Initially the geoserver which was indicated in the communication between WB and ITC (http://geoserver.bnsdi.gov.bz) turned out to inaccessible, which hampered our efforts to get a general overview of the data that was already available. We did try to get data from elsewhere, and were able to download data from a website related to biodiversity in Belize (http://biological-diversity.info/GIS.htm). There is also a web-GIS on the plants in Belize (http://www.geos.ed.ac.uk/~belize/). Later on access to the geoserver was restored.

With respect to the available data the following can be concluded:

- In 1999 a report was published from Ross Wagenseil, consultant to the CDMP, "Investigations of the Belize River: Modelling Flow Overland to the Macal Tributary".
- In 2013 a report was made by María Carolina Rogelis for the World Bank on "Simplified flood susceptibility analysis of the Belize´s road network". She used a simplified procedure based on earlier work by King et al (1992) using a Spatial Multi-Criteria Evaluation approach.
- A National Multi-hazard risk study was carried out in 1999 by ARA Consulting Group, KPMG LLP (CANADA) for the Ministry of Economic Development. This report forms one of the deliverables under an InterAmerican Development Bank (IDB)-approved Technical Cooperation programme. The intention of this programme was to assist in the implementation of essential technical support activities for the National Emergency Management Organisation (NEMO).
- A number of maps have been generated by J. Meerman (who also is consultant for the World Bank in Belize). Currently we downloaded the paper version of flood risk map, Land degradation, agricultural soils, protected areas etc.
- We also downloaded a number of GIS maps related to roads, settlements, protected areas, ecosystems, land use, boundaries and districts
- A storm hazard study has been carried out (http://www.caribank.org/wp-content/uploads/2012/03/Methodology_StormHazMapping_STLBZEFinal.pdf)

The most problematic points with respect to available data in Belize are:

- **Higher quality Digital Elevation Data** are required in order to be able to use flood modelling tools as both the ASTER and SRTM DEMs have a fairly low quality. Hopefully the ESA project will deliver a higher quality DEM for the Belize River area. A KML file with the proposed AoI was delivered to WB (See figure).

- A **Soil type map** is required for the country. We have a scanned version which is rather general, and more detailed vector data would be required.
- **Rainfall data** are still missing. The locations of the river and rain gauges can be found on the following websites:

  http://hydromet.gov.bz/hydrology-stations-locations

  http://hydromet.gov.bz/climatology-stations-locations

- **Building footprints** are not available for Belize. If we want to use detailed flood hazard and risk assessment in certain areas this may be needed, but not for the national scale flood map.

- **Discharge data**. There is not discharge data for any station in Dominica available now.
- **Socio-economic data** are missing, as well as **population data**.

4.8 Conclusions and proposed follow up

4.8.1 Summary of data availability

After reviewing the available data and reports from the five case study areas the following conclusions can be drawn with respect to landslide and flood hazard work done in the 5 countries:

Table 4.4: Summary with respect to the work done before on landslide and flood hazard assessment in the five target countries. Colors indicate from good (green), to poor (red)

	Input data	Landslide inventory available	Landslide susceptibility carried out	Flood hazard assessment carried out
Dominica	DEM: Available but problematic (digital contour lines with 10 m contour interval) contains many errors, and blocky contours. Code consistency is OK. Satellite images available. Soil, geology & land use map available	1987 DeGraff 1990: DeGraff 2006 CIPA USAID/COTS: they made a digital landslide inventory for the island Available as Polygon shapefile, with types (debris flow, rock fall) class (scarp, deposit), The map contained 810 landslides	1987 DeGraff 1990: DeGraff 2006 CIPA USAID/COTS. Made a landslide susceptibility map as part of a multi-hazard assessment study	2006 CIPA USAID/COTS. Made an inland flood hazard map as part of a multi-hazard assessment study. Very general result. Digitally available.
Saint Lucia	Very good data. Digital contour lines with 2.5 meters contour interval. Geological map, soil map, land cover maps are available. Rainfall data is available.	1989: DeGraff 1997: Rogers 2006: CBD/CDERA 2011: Quinn MoSSaIc project by Anderson et Holcombe. available as polygon shapefiles, with locations for the 2010 situation (made through satellite image interpretations) and as point maps with type information	Saint Lucia is the best studies island for landslides. Several studies have been done before and digital landslide inventory and susceptibility maps are available. A debris flow susceptibility map is available as vector file, but this map has a rather low quality as most of the area is in the "no class" zone	2006 by consultants (Vincent Cooper and Jacob Opadeyi) both island wide map as well as detailed study for Castries. These maps are not digitally available.
Saint Vincent	DEM with 5 m cell size and Lidar points. Land cover data is OK. We don't have a soil map and geological map yet, and also no rainfall data, although these should be available in the country	1988: OAS study by Jerry DeGraff 2010: Boruff and Cutter probably re-used this data. Vector (point shapefiles), with 510 locations, and few descriptions of types (incomplete).	1988: OAS study by Jerry DeGraff. 2010: Boruff and Cutter probably reused this data. The available digital map is a low quality map with few units only which do not correlate well with landslide points.	2011: H.R. Wallingford study of rainfall Intensity-duration and frequency curves, and a nationals scale flood assessment. Digital results are not available.
Grenada	DEM with 5 m cell size and Lidar points. No Geology, soil, rainfall data. Poor quality land cover map,	1988: OAS study for selected towns 2006: CBD/CDERA study. A limited inventory (40 landslides) was produced in 2006, but is not digitally available.	1988: OAS study for selected towns 2006: CBD/CDERA study. A landslide susceptibility study was carried out in 2006 using a simple approach with 4 factor maps. The results are not digitally available.	1988: OAS study for selected towns 2006: An island-wide flood susceptibility assessment was carried out in 2006, using a simple weighting approach. The results are not digitally available.
Belize	Only general DEMs obtained from ASTER (30 meters), SRTM (90 meters) and GTOPO. Land use map available, no rainfall data.	Not relevant	Not relevant	Yes, some general work has been done, and also some flood modelling for a part (the Macal Tributary)

With respect to the availability of landslide and flood hazard maps indicated in Table 4.4, we can conclude that in the four islands some sort of landslide project has been carried out. It is striking to note that most of the hazard maps that could be consulted through the internet are often a decade old. In a study on "The status of hazard maps, vulnerability assessment and digital maps in the Caribbean" which was produced by the Faculty of Engineering of the UWI (Trinidad and Tobago) in 2003, it is indicated that out of the 5 countries only Belize and Grenada have flood hazard maps at scale 1:25.000 to 1:50.000. According to the same report, landslide hazard maps are available for Dominica, St. Lucia, and St. Vincent, generated by OAS in the end of 1980's. From our literature study it appears that in all of the 4 islands both a flood susceptibility assessment and a landslide susceptibility assessment has been carried out. In both cases there are hardly any real flood hazard maps that indicate flood intensity for different return periods. These have been generated for a few detailed areas only. Also the landslide maps are susceptibility maps, and do not contain information on temporal and spatial probabilities. This will also be quite difficult, as we were not able to find landslide inventories with data of occurrence information. This may also be the main limitation in our nationwide landslide susceptibility work.

Table 4.5 presents the current situation with respect to hazard and risk mapping and digital data (As summarized from the GFDRR country profiles, with additional internet searches). This table might change after the workshops in the countries in May/June.

Table 4.5: Status of hazard and risk mapping in the 5 countries involved in this project (Source: GFDRR Country reports and own observations, internet searches).

	Spatial data and hazard assessment activities
Belize	As part of this activity the La Red methodology and software for recording disaster events DesInventar is being implemented (See: http://online.desinventar.org/desinventar/#BLZ-DISASTER/) the database contains 129 records.
	Belize is participating in the Central American probabilistic Risk Assessment (CAPRA) platform. To date the CAPRA initiative remains modest in Belize, focused on addressing existing needs and capacities. No concrete results can be found on internet
	The GRIP Risk Assessment package is being supported in Belize by UNDP. The GRIP Risk Assessment Package allows national entities to improve their capacities for disaster risk reduction by facilitating access to improved risk information. No information could be found on the internet on results.
	The underlying foundation in IT, data and staff capacity is being established by the government of Belize.
	Thus far no nationwide flood hazard maps have been made for the country based on hydrological modelling. The source of the only flood map that we were able to find on the internet is not clear
	Hazard Mapping has been completed in several areas and GIS map datasets have been prepared. Past initiatives have produced several hazard maps including landslide risk, volcanic hazard assessment, multiple hazard map, storm hazard, wind, and wave, seismic, structural and human structural. Additionally digital base maps at a scale of 1:25,000 have been prepared and include roads, contours, beaches, rivers, rainfall, electric lines, schools settlements, ports, and quarries.16 Maps are maintained by the physical planning unit of the Ministry of Housing, Lands, Settlement and Water Resources.
	The GeoNode platform for Belize is http://geoserver.bnsdi.gov.bz
Dominica	ODM currently does not have a GIS mapping capability and lacks equipment, software and trained GIS professional staff. As a result, ODM is unable to use the hazard mapping tools developed.
	World Bank is implementing a Disaster Vulnerability Reduction Program (DVRP) in Dominica. Component 2 of the DRVP project in Dominica: Capacity Building and Data Development, Hazard Risk Management and Evaluation. Core data systems to be developed under this component include: • Creation of a high resolution digital topographic and bathymetric model for Dominica • Creation of a high resolution soils survey map with chemical and physical characteristics for each soil unit • Design and deployment of a robust hydromet network to provide high resolution hydrologic data for use in a wide range of activities to support, for example, engineering design, EA - EMF for Dominica's DVRP national land use and coastal zone planning, disaster management, roads construction practices and design, agricultural development and others • Community level risk mapping and training on climate adaptation measures

	The GeoNode platform for Dominica http://www.dominode.net/ is accessible and contains quite some data. The metadata is very limited.
Saint Lucia	Vulnerability assessments, hazard maps and risk assessments for critical facilities have been prepared for flooding due to storm/wind surge, high wind, and drought and debris flow. Supporting base maps have been prepared in a GIS format and include infrastructure and drainage, national topography, land use, rainfall, soils, geology, etc. These are of varying age, prepared in the 1980s and 1990s, and may not reflect current conditions.
	While maps have been developed, they have not been integrated in the decision support or policy-making process. Presently, NEMO does not support a GIS capability and there is currently no program supporting additional hazard mapping or updates to current hazard maps.
	World Bank is implementing a Disaster Vulnerability Reduction Program (DVRP) in Saint Lucia. Component 2 – Technical Assistance, Regional Collaboration Platforms for Hazard and Risk Evaluation, Geospatial Data Management, and Applications for Improved Decision- Making (US$5Million). This component would finance: A series of capacity-building, knowledge-building and technical assistance interventions at the national and regional levels to support disaster risk management and climate change adaptation. There are specific areas that have been identified and proposed as high priorities for intervention. At the national level, activities would include, inter alia: i) enhancement of national hydro-meteorological monitoring networks; ii) development of an integrated watershed management plan for flood mitigation; iii) technical assistance for the establishment of maintenance monitoring systems for bridges and public buildings that would integrate natural hazards and extreme events considerations; iv) establishment of geo-spatial data sharing and management platform and related training activities; and v) Climate change adaptation public education and awareness campaigns.
	The GeoNode platform for Saint Lucia http://sling.gosl.gov.lc is accessible and contains quite some data. The metadata is also available.
	There is no DesInventar disaster database. It is not clear if there is a national disaster database.
St. Vincent and the Grenadines	Progress in preparation of hazard maps is limited. Mapping and GIS capability is managed largely through the Ministry of Planning with some use in other ministries. NEMO supports limited GIS and mapping capacity. To date risk mapping in St. Vincent is limited. Volcanic risks have been mapped and some coastal vulnerability analysis has been completed. A limited number of base maps have been prepared in a GIS format and include roads, contours, rivers and coastline, and agricultural and urban land use. These are variously available through the Ministry of Planning and NEMO.
	World Bank is implementing a Disaster Vulnerability Reduction Program (DVRP) in Saint Vincent. Component 1 - Capacity Building for Hazard and Risk Evaluation and Applications for Improved Decision Making. The project will support improving national capacity to evaluate and integrate natural hazard and climate change risk reduction into the national development policy and decision making process. Improvements in risk analysis capacity will support future programmers for retrofitting existing infrastructure, disaster risk mitigation, and disaster preparedness planning. This improved capacity will allow St. Vincent and the Grenadines to prioritize investments and improve risk management across a portfolio among various sectors using different tools such as cost-benefit analysis, hazard and vulnerability modeling. Activities will include: • Identification and creation of required baseline data for hazard assessment and risk modeling; • Development of institutional systems for the collection, sharing and management of geospatial data among national agencies and with regional institutions; • Training and education in applications integrating geospatial data systems, hazard and risk assessment to support decision making within various sectors and mainstream the use of these tools as a standard practice in development planning; • Training in the use of risk modeling software for relevant sectors and institutions where applicable; • Support development of operational agencies with purchase of equipment, hardware and software required to implement risk analysis and monitoring activities; and • Training of contractors and strengthening of institutional structures for improved use of building codes.
	Component 2 - Prevention and Mitigation Investments: This component includes a broad set of civil works activities, such as drainage improvements, rehabilitation, reconstruction and retrofitting of bridges and roads, retrofitting of critical public buildings (including schools and emergency shelters), investments in satellite emergency centers, coastal and river defense mechanisms, etc. Civil works will be executed to include construction and rehabilitation of existing infrastructure in order to reduce their vulnerability to natural hazards and climate change. Works will focus on priority public infrastructure including transportation, education and public utility sectors and will include activities to rehabilitate or construct emergency shelters, re-enforce river defenses that protect key infrastructure and realignment, and rehabilitation of bridges. Included under works is the potential for the design, development and preparation of priority works construction projects such as a new hospital complex to assist the Government in engaging construction financing available from other donors in the region. Other infrastructure works include construction of satellite community warehouses and stockpiling of gabion baskets in order to ensure a reliable stock in case of river and coastal defense malfunction.
	The GeoNode platform for Saint Lucia http://geonode.gov.vc/ is not accessible
	There is no DesInventar disaster database. It is not clear if there is a national disaster database.

Grenada	Mapping and GIS capability is managed largely through the Ministry of Agriculture with some use in other ministries but progress in this area is limited. Various risk mapping exercises have been completed, including a school construction risk assessment, school landslide vulnerability assessment (http://www.oas.org/CDMP/document/schools/vulnasst/gre.htm), shelter vulnerability and a coastal multi-hazard analysis prepared for selected communities.
	No comprehensive multi-hazard map compilation has been prepared. Supporting the development of hazard maps, GIS resources in Grenada include national topographic maps, soils, infrastructure, rainfall and other base map elements required to support hazard mapping. NaDMA lacks basic GIS capacity. NaDMA is in possession of 4 junos but requires licensed GIS programs. All the hurricane shelters in the south of the island are mapped. The Agency needs more training in GIS-based mapping resources as they currently lack equipment and a staff GIS professional
	The GeoNode platform for Grenada is not open. It is not clear what has been achieved.
	There is no DesInventar disaster database. It is not clear if there is a national disaster database.
	World Bank is implementing a Disaster Vulnerability Reduction Program (DVRP). Component 2 (Disaster and Climate Risk Reduction) of the Disaster Vulnerability Reduction Project which would consist of new construction and rehabilitation of existing infrastructure in order to reduce their vulnerability to natural hazards and climate change. They are located in various areas of Grenada (Figure 1) and involve the following activities: 1. The construction of drains, roads, retaining structures, sewage system, land regularization and engineering and supervision consultancy for both La Sagesse and Beausejour Housing 2. Construction of retaining wall structure and installation of gabion baskets in six landslip locations at Constantine, St. George's and Gouyave, St. John's. 3. Consultancy services to undertake soil investigation mitigation measures for Landslip Sites in Bellevue/Jean Anglais, Brizan, Grand Anse Housing Scheme, Melville Street and Sendall Tunnel in St. Georges. 4. Consultancy services for the designs, surveys, civil works and construction supervision for flood mitigation in Morne Rouge, Dusty Highway and St. Johns River in St. Georges 5. Construction of the Hubble Bridge and Lance Bridge at Gouyave, St. Johns 6. Rehabilitation of Holy Cross R. C. School and St. Patrick's Anglican School, St. Patrick's. 7. Construction of a reservoir at observatory, St. Georges 8. Construction of a storage reservoir and generator house at Chemin, St. David's 9. Retrofitting Hills View Home for the aged, St. Patricks 10. Retrofitting Cadrona Home for the aged, St. Andrews

4.8.2 Reflecting on the problems with data in the five countries

In the terms of Reference the WB has identified multiple issues related to geospatial information in the region present a considerable challenge to detailed hazard and risk assessments. The following points have been outlined:

- Poor quality of geospatial data: countries such as Belize or St. Lucia lack detailed DEMs. In rugged terrains as in the volcanic islands or the floodplains of Belize, slight elevation differences restrict the type and quality of flood analyses that may be conducted. This problem may be solved through the additional DEM work carried out in the ESA/WB project mentioned earlier in this report.
- In terms of hazard and risk information, there is almost no risk information available, and the hazard information is often little detailed and with low precision due to missing or low quality input and lack of data availability for calibration. This is indeed a major problem, as the countries have at most susceptibility maps with qualitative classes, and lack appropriate quantifications of the hazards. This is turn is related to the lack of good disaster database combined with rainfall data.
- Incomplete data set and time series: Hydro-meteorological time series, which only exist for a few places, often display long measurement interruptions. Furthermore, they may not be digitized but handwritten in books; data has been traditionally collected manually and only exists in paper, particularly historical data. This is currently being addressed in the Disaster Vulnerability Reduction Projects in the various countries, but for our project this will be a major problem.
- Unavailable collected geospatial data: Although consultants may have collected basic data to carry out analyses for their studies, neither these data nor the results (e.g., hazard maps and

risk information) are available. In many cases, the data got lost over time and people are hardly aware of their existence anymore. The intent to recover such data is rarely successful since the donors having funded these activities often don't received the data or forgot to request, and the consultants are hesitant, if they still have the data, to share it without additional payments. We encountered this problem especially for the hazard maps related to flooding and landslides. We hope that during the visits to the countries we will be able to collect missing data. Overall the data availability is not so very bad, as compared to other countries where we have been working.

- Lack of data sharing: Even if data exists and is available, tracing and collecting these data from the different ministries becomes a large effort. Often no data-sharing policies are in place and the data has to be bought, or internal discussions on the possibility of sharing have to take place before the data can be handed over. Data inventories of past events, if they exist, are scattered and may not be easily reconciled. The problem of data sharing is to be discovered by us. We obtained a lot of data directly through the contacts with the World Bank.
- Lack of metadata: Once data has been received or found, still the lack of metadata may impede its adequate use since the author may be unknown and no information on the quality of the input data, purpose of the study and the methodology used may be available. This is specifically challenging in the framework of hazard and risk information when the reports pertaining to the geospatial files are missing or too limited in their explanation of the modelling process.

Through several operations, The World Bank is working alongside government agencies to address these issues and improve data availability and management. The creative use of remote sensing technologies to capture additional data to close existing data gaps is expected under this activity. The products generated through this project will become good practice examples of data management for the beneficiary countries.

4.8.3 Planned follow-up work

The World Bank is currently supporting the target countries in the framework of the Disaster Vulnerability Reduction Project in the four islands. Through this project it is foreseen that the geospatial data availability will increase substantially, the data sharing is facilitated through GeoNode platforms, infrastructure for geospatial data management is improved, and staff will be trained. Also funding is given to the establishment of rain gauges in several countries. The project will also fund a number of vulnerability reduction projects through resettlement, retrofitting of existing buildings, construction of mitigation works, etc. The Charim project will seek active links with the other initiatives that are being planned or implemented, and the workshop in September-October should be an important vehicle for this.

We are planning to also carry out fieldwork in the four islands, together with a number of **Master of Science students**. We have selected 8 MSc students from ITC that will be carrying their fieldwork in the period Mid-September to Mid-October. There may also be MSC students from UWI that could be involved in the research, in a later phase. Table 4.6 gives a list of topics for the 8 MSC students. We intend to accompany the MSc students with several staff members.

Table 4.6: list of MSc topics related to the aim of the project.

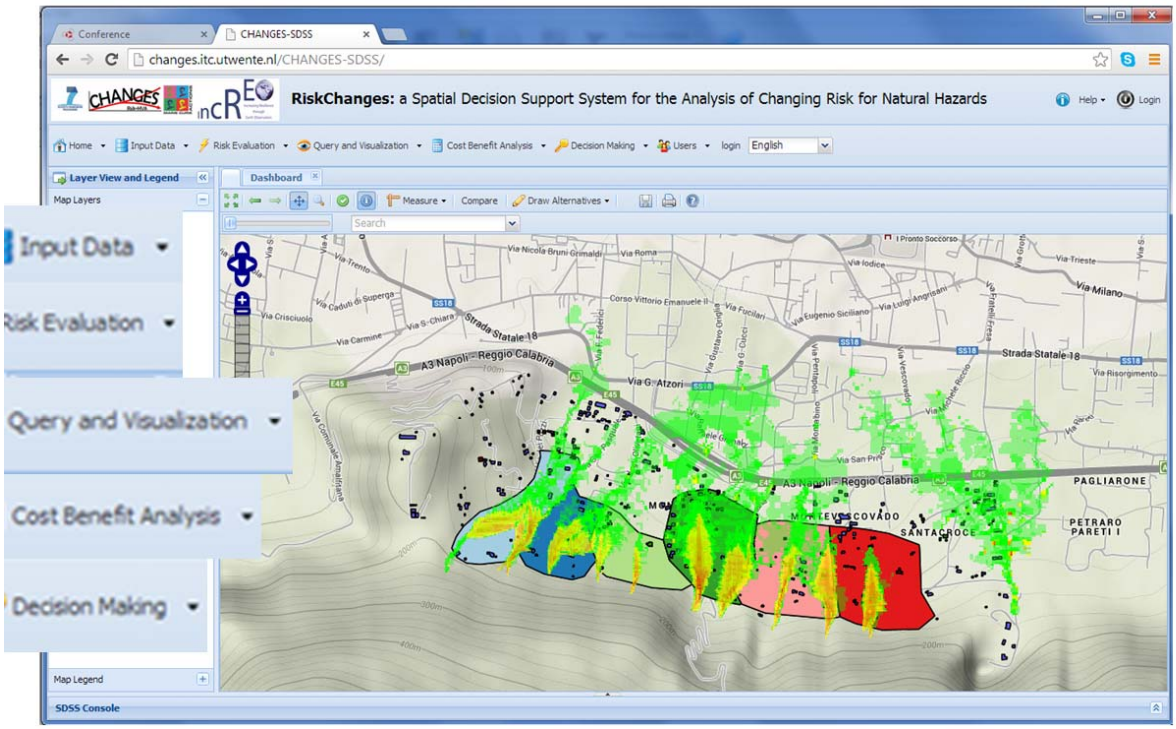
Student	MSc topic
Diana Patricia Lozano Zafra (Female. Colombia)	National scale landslide susceptibility and hazard maps for the Caribbean Island of Dominica and Saint Vincent, what can be done with incomplete data?
Andreas Christoffer Lundegaard (Male, Denmark)	Flood hazard assessment and transport network vulnerability on St. Vincent and Grenada
Jovani Yifru Bogale (Male, Ethiopia)	National Scale Landslide Hazard Assessment Along the Road Corridors of Dominica and St. Lucia
Chishala Mulenga (Male, Zambia)	Influence of weathering on geotechnical properties of road-cut slope mass and embankment fill in Saint Lucia and Saint Vincent
Anne Chinyere Uwakwe (Female, Nigeria)	Methodology for the characterization of elements-at-risk for physical vulnerability to natural hazards and exposure analysis in Saint Lucia. Case study: Castries City
Mujeeb Alam (Male, Pakistan)	Application of hazard and risk information in spatial planning in Grenada
Xsa Anacio Cabria (Female, Philippines)	Weathering and its contribution to rock falls in the pyroclastic rock masses along coastal road cuts in Dominica and Saint Vincent
Rahmat Aris Rratomo (Male, Indonesia)	Response of Flash Flood Behaviour to Hazard Reduction in a Small Island: a Case Study in Grenada

4.8.4 Link with the RiskChanges Spatial Decision Support system

The RiskChanges Spatial Decision Support system for the analysis of changing risk to hydro-meteorological hazards, which is being developed through two EU projects (EU FP7 Marie Curie ITN CHANGES project: www.changes-itn.eu and EU FP7 Copernicus SPACE project INCREO www.increo-fp7.eu), will also be used in the CHARIM project. The web-based system allows ends users to upload their own hazard and asset data and link this with existing vulnerability curves (or generate new vulnerability curves). The user can generate loss maps and risk maps, which can be visualized either as maps or risk curves. Users can define different planning alternatives, which very closely link to the use cases related to the topics indicated in chapter 3. The users can then analyse the change in risk for the various alternatives, and compare these with the existing risk. The user can then carry out a cost-benefit analysis and multi-criteria evaluation in order to select the best alternative for the use case. Users can also analyse the changes in risk depending on certain scenarios for land use change, population change and/or climate change. The system can be viewed at the following URL: http://changes.itc.utwente.nl/SDSS/.

The current version doesn't allow uploading data yet, and the version is mainly allowing user to see the various components of the user interface. The usefulness of this system will be evaluated once it has been completed in January, and then the decision will be made to actually include it in the Handbook or not.

Figure 4.2 gives an impression of the user interface of the RIskChanges Spatial Decision Support system. Left are the various components: input data, risk evaluation, query and visualization, cost-benefit analysis and decision making.



4.9 Annexes: data overview tables

In the following pages a detailed overview is given of the data for the 5 target countries.

Dominica - Description of Available Data and Data Characteristics

No	File name	Main types	Available data type	Characteristics of the data	Quality of the data	Completeness of the data	Remarks
1	Contour10	Base data	Contour map	Vector (line shapefile), with 10 meter contour interval.	Moderate. It has been generated from a raster DEM, and contains many errors, and blocky contours. Code consistency is OK	10 meter interval contour for entire country	Elevation contours created from the 10m DEM based on SAR satellite measurements.
2	Heights	Base data	Spot Heights	Vector (points, shapefile), point, height, morton. No further description on attribute data	Low	67 records spread over entire country. Not on top of hills but along a number of lines over the country	Spot heights for DEM validation created as part of the 1995 CIDA-funded GIS project.
3	Mountain	Base data	Mountains	Vector (point shapefile), height, name. for some mountains height information missing	Low	9 records	Location of mountains in Dominica. Created in 1995 as part of a CIDA funded GIS project.
4	mriver	Base data	Rivers	Vector (line shapefile), Length	Moderate	1630 records of main rivers for the country	Rivers digitized from paper topo-maps in 1995.
5	Hydrology	Base data	Hydrology	Vector (line shapefile), length, type	High	River/stream network for the entire country	
6	waterfal		Waterfall	Vector (point shapefile), waterfall name	Low	Incomplete - 6 records for 6 districts only	Locations of waterfalls
7	watrbdsp	Base data	Lakes	Vector (Polygon shape files), names of the lakes, area	Moderate	7 records	Lakes in Dominica. Created as part of a CIDA funded GIS project in 1995.
8	isoyetes_mm _utm_1		Isohyets rainfall in mm	Vector (line shapefile), Rainfall (in mm)		17 records for the country	Digitized in 1995, origin unknown.
9	Rainfalp		Rainfall Estimates	Vector (Polygon shapefile), not well defined fields	Low	covering entire country	Digitized in 1995, origin unknown.
10	Soilp		Soil Survey	Vector (polygon shapefile), soil types and other characteristics of the soil.	High	Covering entire country	Digitized as part of the 1995 CIDA funded GIS project from 1972 soils survey data.

11	landsldp	Hazard	landslide	Vector (Polygon shapefiles), types (debris flow, rock fall) class (scarp, deposit), status (definite). Some attribute codes are not defined	Moderate	810 records covering entire country	Source is unknown
12	landsldv	Hazard	Landslide	Vector (Polygon shapefile), length, class code. No definitions available	Moderate to low	Incomplete dataset - 831 records covering entire country	unknown, overlaps almost completely with landslide
13	landsldc	Hazard	landslide	Vector (point shapefiles), types (debris flow, rock fall) class (scarp, deposit), status (definite). Some attribute codes are not defined	Moderate to low	810 records covering entire country	Unknown
14	landslide_5c	Hazard	Landslide susceptibility map	Vector (Polygon shapefile), 5 Landslide risk classes (code 1o 5). No definition or description available	Moderate to low. Vectorized from raster data set	Incomplete definition. covering entire country	Created as part of the 2006 USAID multi-hazard mapping project.
15	flood_3c	Hazard	Inland flood hazard	Vector (Polygon shapefile), flood risk code. No definition of codes	Moderate to low. Vectorised from raster data set	Incomplete description, covering entire country	USAID Flood Hazard Mapping from October 2006.
16	earthquake_4c	Hazard	Earthquake hazard	Vector (Polygon shapefile), earthquake class (very low to high).	Moderate	4 records. 4 zones covering entire country. No definition of earthquake classes	USAID Earthquake Hazard mapping from 2006.
17	surge_hazard	Hazard	Storm surge hazard	Vector (Polygon shape files), No attribute information defined.	Low	Incomplete description, covering entire country	USAID Multi-Hazard Mapping from October 2006.
18	volcanic_4c	Hazard	Volcanic hazard	Vector (Polygon shape files), 4 zones (low hazard zone to very high hazard) and 3 classes (high medium, low). No description about the actual meaning of the hazard.	Medium	covering entire country	USAID Multi-hazard assessment data.
19	wind_5c	Hazard	Wind hazard	Vector (Polygon shape files), No attribute information defined.	Low	Covering entire country	Wind hazard in Dominica created as part of a 2006 USAID multi-hazard mapping project.

20	composit_utm	Hazard	Composite Hazard	Vector (Polygon shapefile), risk classes (high to very low), grid code. No further details on risk classes or grid code	Low	14022 records for the entire country. No detailed risk information. No metadata	2006 USAID multi-hazard mapping project, composite of all hazards (landslide, earthquake, volcano, flood, storm surge, wind)
21	buildings_final2013	Elements_at_risk	Roseeu Buildings	Vector (Polygon shapefile), shape length, shape area. complete attribute data not available	Low	Incomplete data (5681 records). Data is available only for Ro se au (a small part in St. George parish) of the city of Roseau	Roseau buildings digitized from 2010 high resolution WorldView-2 satellite imagery. Created as part of a CIP-Worldlink Internship.
22	bldgareadensity	Elements_at_risk	Density of Buildings	Vector (Polygon shapefile), budging area. No description and any clear information.	Low	1440 records. Only small part in Roseau city in St. George	Building density (sq. m area of buildings per 100m x 100m block). Created from 2010 buildings layer (Roseau Buildings).
23	hc	Elements_at_risk	Health Centres	Vector (point shapefile), ID, name, xy coordinates. No any description about ID.	Low	53 records, points spread over country	Locations of Health Centres, vintage and source unknown.
24	Health	Elements_at_risk	Health facilities	Vector (point shapefile), class code, name. No description about class code.	Low	Incomplete (only 10 records)- data not available for some districts	Health facilities including Hospitals, Clinics and Centres. Created as part of the 1995 CIDA funded GIS database project.
25	roads	Elements_at_risk	Roads	Vector (polyline shapefile), length, road type (primary, secondary, Footpath). Some attribute codes are not defined.	Moderate	2400 records all over the country.	Roads from the Lands and Surveys Division. Digitized from British Ordnance Survey Topographic maps (1970s-1994)

26	schools2012	Elements_at_risk	Schools	Vector (point shapefile), school name, floors, construction type, roof type,	Moderate	194 records spread over all country. No data on number of students and staff needed for risk analysis and preparedness	School locations from the Ministry of Education and Ministry of Public Works Databases. Schools in Roseau are missing from this dataset. Initial locations were collected in November 2012 by the Education Planning Unit. Additional data was collected during the 2013 hurricane shelter assessments.
27	town_points	Elements_at_risk	Settlements	Vector (point shapefile), names of main towns, class (rural, suburban, capital, urban), code. Description of code undefined	Moderate	131 records in the entire country	
28	police2008	Elements_at_risk	Police Stations	Vector (point shapefile), station names, codes undefined	Low	Incomplete (18 records). No information on no. of staff	Locations of Police Stations, collected in 2008.
29	shelters_public	Elements_at_risk	Hurricane Shelter Assessment 2013	Vector (point shapefile), name, type (school, Church, community centre, Dwelling House etc.), name of the community, name of the responsible person	High	137 records spread all over the country	Hurricane shelters assessed conducted by the Ministry of Public Works.
30	beach	Elements_at_risk	Beaches	Vector (point shapefile), attributes: name, location, length, width etc.)	Moderate	44 records - covers entire country, estimated no. of persons visiting beach missing	Location and names of beaches in Dominica. Created in 1995 as part of a CIDA funded GIS project.
31	Bus Stands	Elements_at_risk	Roseeu Bus stands	Vector(point shapefile), location name	Low	Incomplete data (14 records) .Bus stand data available only for Roseeu in St. George	Part of a Canadian Institute of Planners/CIDA funded internship research project.
32	census_parishes		Census Divisions	Vector (Polygon shapefile), name, shape length, shape	Moderate	11 records. Complete for entire country	Areas used in the 2011 National Census.

				area			
33	coralseagras		Coral and Sea grass	Vector (Polygon shapefile), type name, class code, area. No description on class code	Low	14 records covering most parts of the country	Coral and sea grass bed locations. Source unknown.
34	health_districts		Health Districts	Vector (Polygon shapefile), name, ID	Low	7 records. Health districts for entire country	Source unknown, likely from 1995.
35	mestatep		Estate boundaries	Vector (Polygon shapefile). Not well defined records	Low	199 records for entire country	Estate boundaries from pre-independence (1978). Digitized in 1995.
36	nature_reserve		Nature reserve boundary	Vector (Polygon shapefile) - no any descriptive information	Low	Incomplete - Only 1 polygon in the centre.	Current nature reserve boundary
37	parishp		Parishes	Vector (Polygon shapefile), names of Parish, Area	High	10 records (polygon), covering entire country	Location of parishes in Dominica, polygons. Created in 1995.
38	touatt3		Tourist Attractions	Vector (point shapefile), tourist attractions such as sulphur spring, hot water spring, Botanical garden, Valley of desolation etc.	Moderate	16 records for 7 districts only	Various tourist attractions in Dominica. 1-Waterfalls 2-View Points 3-Scenic Routes 4-Sulfur Springs 5-Historic Buildings
39	plfieldo		Playing Fields	Vector (point shapefile), playing field name. some attributes not well defined	Low	57 records covering all over the country	Locations of playing fields. Type 1 - Playing Field Type 2 - Basketball - Hard Court
40	prtareap		Protected areas	Vector (Polygon shape files), names of the protected parks, forest	Moderate	4 records in the central part of the country.	Protected areas in Dominica to include national parks and forest reserves.
41	quarry		Quarry Locations	Vector (point shapefile), name, operator name. description of many attributes unknown	Low	Incomplete (15 records). Missing information	Quarry locations digitized in 1995 from 1978 OS Topo-maps.
42	coastp		Coast polygon	Vector (Polygon shapefile), Area - no any attribute information	Low	1 polygon	Coast polygon from the Lands and Surveys Division.

43	point_merge_cleaned		unknown		Low	Incomplete data	
44	Google Earth Image	Image	Colour image	Raster data set downloaded from Google Earth	Moderate	Has approximately 10 percent cloud cover.	
45	Pleiades images	Image	Panchromatic and Multi Spectral		Moderate	Has approximately 10 percent cloud cover. Only covers the NW part of the country	From 2014. Still trying to get the images for the whole island
46	WorldView images	Image	Panchromatic and Multi Spectral		Moderate		From 2014. Still trying to get the images for the whole island

Saint Lucia - Description of Available Data and Data Characteristics

No	File name	Main types	Available data type	Characteristics of the data	Quality of the data	Completeness of the data	Remarks
1	dem50	Base data	Digital Elevation Model	Raster map with 50 meter cell size	Low. 50 meter resolution is very low for a DEM.	covers entire country	No source information is available.
2	Contour1	Base data	Contour lines	Vector(line shapefile), with 2.5 meter contour interval	High	Only available for the North part of the country	From Physical planning office.
3	Contour2	Base data	Contour lines	Vector(line shapefile), with 2.5 meter contour interval	High	Only for the middle part of the country	From Physical planning office.
4	Contour3	Base data	Contour lines	Vector(line shapefile), with 2.5 meter contour interval	High	Only for the lower part of the country	From Physical planning office.
5	watershds	Base data	Watersheds	Vector(polygon shapefile), hof watersheds in the country	High	46 watersheds	Source unknown
6	River sections	Base data	Rivers	Vector (line shapefile), Length	High	26131 records of rivers for the country	Within Geodatabase
7	Shoreline	Base data	Shoreline	Vector (line shapefile), length, type	High	Shore lines for the entire country	Within Geodatabase
8	water surfaces	Base data	Water surfaces	Vector (polygons shapefile), with lakes, rivers and basins	High	473 records, covering entire country	Within Geodatabase
9	Rainfall stations	Base data	Rainfall data	Scanned map of rainfall stations	High		
10	Rainfall data		Rainfall data	Excel files with hourly rainfall data for 24 stations with varying periods. Maximum period is 2003 to 2014	High	Most stations have data from 2003 to 2014	Digitized in 1995, origin unknown.
11	Queens Chain	Base data		Vector (lines) of coastal vegetation		Covers entire coastline	Source unknown
12	Vegetation	Base data		Vector file (polygons) but strangely organized in blocks	Low	Not covering whole country, and strangely organized in blocks.	Source unknown
13	Landuse_tm	Base data	Land use	Vector file (Polygons)	Low	Covering entire area, but rather general classification	Probably based on image classification from LandSAT tM data?

14	Land use and vegetation	Base data	Land use	Raster map, scanned paper map 1:50000 scale		Covers entire area. From 1984	Map generated in a CIDA project
15	Geology	Base map	Geology	Vector map (polygon based)	Moderate	Covers entire country	Lithological description.
16	Geology_oas	Base map	Geology	Scanned map	Moderate	Covers entire country	Generated by OAS in 1984
17	Soils	Base map	Soil Survey	Vector (polygon shapefile), soil types and other characteristics of the soil. Quite detailed map with many attributes	High	Covering entire country, and also quite detailed	UWI from 1966
18	Land distribution and tenure	Base map	Land distribution and tenure	Scanned map 1:50000	Moderate	Covering entire country	OAS study from 1984
19	Land capability	Base map	Land capability	Scanned map 1:50000	Moderate		OAS study from 1984
20	landslides-2010_satellite imagery	Hazard	landslide	Vector (Polygon shapefiles), with locations.	High	550 records covering entire country of the landslides in 2010. Not clear if these represent the ones after Hurricane Thomas. Landslides are mostly in the central part	Source is unknown
21	landslide inventory 1995	Hazard	Landslide	Vector (Point shapefile), with type information.	High	713 records covering entire country	Source unknown
22	landslide	Hazard	landslide	Vector (polygon shapefiles) with 4 classes	Moderate to low	Cover entire country but is very general and doesn't show clear relation with actual landslide inventory	Unknown
23	Debrisflow_1995, debris flows, debris_risk_1995	Hazard	Debris flow susceptibility map	Vector (Polygon shapefile), 5 debris flow susceptibility classes (including not mapped)	Moderate to low. Large part of the island has "no class"	Incomplete definition. covering entire country	Created apparently in 1995. Not clear if it deals with initiation or run out. No intensity or probability information
24	flood_maps, several files	Hazard	Inland flood hazard	Several Vector (Polygon shapefile), flood intensity maps for different return periods. codes	Moderate to low. Vectorised from raster data sets	Incomplete description, covering only some parts of the country (e.g. Corinth North part of the country). Other have no coordinates	FLOW-2D modelling results from 2011

25	Flood work	Hazard	Flood hazard	Several reports, with maps related to flooding in three areas in Saint Lucia	High	Study on possible drainage structures, and flood retention structures for Fond St. Jacques, Dennery and Soufriere for the Ministry of Infrastructure, Port Service and Transportation	Generated by EGIS in December 2013. Work related to the effects of Hurricane Thomas in 2010
26	Coastalhzrd	Hazard	Coastal hazards	Vector (Point shape files), indication of multi-hazards (volcano, floods, storm, landslide earthquake)	Low	46 records	
27	volcanic susceptibility map	Hazard	Volcanic hazard	Scanned map	Medium	covering entire country	Generated by the Seismic Research Centre
28	Drought susceptibility map		Drought hazard	Scanned map	Medium	Covers entire country. Method unknown,	Generated by Dr. Christopher Cox
29	wind storm maps	Hazard	Wind hazard	Vector (Polygon shape files), No attribute information defined.	Low	Not clear. Vectorised from raster maps. Show rather strange patterns.	Wind hazard in Dominica created as part of a 2006 USAID multi-hazard mapping project.
30	buildings	Elements_at_ risk	Building map	Vector (Polygon shapefile), with area and building height. No occupancy classes or structural types.	High	Complete data (82527 records). Seems complete but no attribute information on occupancy class and structural types	Within Geodatabase
31	Retaining wals	Elements_at_ risk	Retaining walls	Vector (Polygon shapefile), no attributes	High	6562 records for whole country	Within Geodatabase
32	Culverts	Elements_at_ risk	Culverts	Vector(line shapefile), no attributes	High	14150 records for whole country	Within Geodatabase
33	Dams	Elements_at_ risk	Dams	Vector (Line shapefile), no attributes	High	2 records only	Within Geodatabase
34	roads	Elements_at_ risk	Roads	Vector (line shapefile), with paved/unpaved information	High	11902 records all over the country.	Within Geodatabase
35	Parth_section s	Elements_at_ risk	Footpaths	Vector (line shapefile) with type	high	1510 records spread over all country.	Within Geodatabase
36	Airport	Elements_at_ risk	Airport	Vector (line shapefile) without attributes	High	12 records for the lower part of the country (single airport)	Within Geodatabase
37	Bridges_and_t unnels	Elements_at_ risk	Bridges and tunnels	Vector (line shapefile), no attributes	High	229 records, for whole country	Within Geodatabase

38	Churches	Elements_at_risk	Churches	Vector (point shapefile) , with names	high	83 records	
39	beach	Elements_at_risk	Beaches	Vector (point shapefile), attributes: name, location, length, width etc.)	High	193 records - covers entire country, estimated no. of persons visiting beach missing	Location and names of beaches in Saint Lucia, and information on the use of the beach (e.g. sand mining, recreational).
40	Districts		Districts	Vector (Polygon shapefile), name, shape length, shape area, and population attributes	High	10 records. Complete for entire country	Population data for several years.
41	St Lucia settlement project			Vector (Polygon shapefile), name, shape length, shape area, and population and household attributes	High	547 records	
42	health_facilities		Health facilities	Vector (Point shapefile), name, ID	High	39 records. Health facilities for entire country	Source unknown
43	Pharmacies		Pharmacies	Vector (Point shapefile), name, ID	High	20 records. Health facilities for entire country	Source unknown
44	Hotels		Hotels	Vector (Point shapefile). Names	High	45 records for entire country	Source unknown
45	Police stations		Police stations	Vector (Point shapefile). Names	High	13 records for entire country	Source unknown
46	Schools		Schools	Vector (Point shapefile). Names	High	116records for entire country	Source unknown
47	Google Earth Image	Image	Colour image	Raster data set downloaded from Google Earth	Moderate	Has approximately 10 percent cloud cover.	
48	Pleiades images	Image	Panchromatic and Multi Spectral		Moderate	Has approximately 10 percent cloud cover. Only covers the NW part of the country	From 2014. Still trying to get the images for the whole island

Saint Vincent and the Grenadines - Description of Available Data and Data Characteristics

No	File name	Main types	Available data type	Characteristics of the data	Quality of the data	Completeness of the data	Remarks
1	gsvg5m_final	Base data	Digital Elevation Model	Raster map with 5 meter pixel size, also covering Grenada	High, but misses central part of the country	Covers both Saint Vincent and the Grenadines as well as Grenada. Pixel size is 5 m. And rows columns are: 14787, 30977.	No source information is available.
2	Lidar dataset	Base data	Lidar data points	LIDAR data points in the form of text files, and raster files (which are not correct)	High	It wasn't possible yet to analyse the completeness of the data due to the wrong format of the data, and reformatting would take a lot of time.	
3	SVG_Clifftops	Base data	Cliffs	Vector(line shapefile)	High	Difficult to assess	
4	SVG_Cliffbottom	Base data	Cliffs	Vector(line shapefile)	High	Difficult to assess	
5	Waterpipes	Base data	Water pipes	Vector(line shapefile),	High	233 records	
6	SVG_Streams	Base data	Rivers	Vector (line shapefile), two types: narrow or wide	High	covering entire country	
7	SVG_fw_streams_2007	Base data	Streams	Vector (line shapefile),no attributes	Low	Does not fit with other stream datasets. Seems to be derived from DEM with bad algorithm	
8	SVG_fw_streams_1970s	Base data	Streams	Vector (line shapefile),no attributes	Low	Does not fit with other stream datasets. Seems to be derived from DEM with bad algorithm	
9	SVG_coastline	Base data	Shoreline	Vector (line shapefile), length, type	High	Shore lines for the entire country	
10	SVG_waterbodies	Base data	Water surfaces	Vector (polygons shapefile), with lakes, rivers and basins	High	60 records, covering entire country	
11	SVG_vegetation_limits	Base data	Vegetation	Vector file (lines) but no information on vegetation type. Only the boundaries are given	Moderate	No information on the central part of the country	Source unknown
12	SVG_Landuse	Base data	Land use	Vector file (Polygons) with 11 land use classes.	Low	Does not cover entire area. Has whole in the middle, and also doesn't overlay with other maps.	Probably based on image classification from LandSAT TM data?

13	SV_Landslide_Incidents	Hazard	landslide	Vector (point shapefiles), with locations, and few descriptions of types (incomplete).	High	501 records covering entire country	Source Boruf and cutter
14	SV_Landslide_vulnerability	Hazard	Landslide	Vector (Polygon shapefile), with value between 0 and 1. General boundaries	Low	Few units only which do not correlate well with landslide points.	Source Boruf and cutter
15	SV_Flood_vulnerability	Hazard	Inland flood hazard	Vector (Polygon shapefile), with value of 0 and 1. General boundaries	Low	Simple map	Source Boruf and cutter
16	SV_Fire_vulnerability	Hazard	Wildfire susceptibility	Vector (Polygon shapefile), with value between 0 and 1. General boundaries	Low	Simple map	Source Boruf and cutter
17	SV_Volcano_vulnerability	Hazard	Volcano susceptibility	Vector (Polygon shapefile), with value between 0 and 1. General boundaries	Low	Simple map	Source Boruf and cutter
18	SV_Surge_vulnerability	Hazard	Coastal surge susceptibility	Vector (Polygon shapefile), with value between 0 and 1. General boundaries	Low	Simple map	Source Boruf and cutter
19	SV_Surge_vulnerability	Hazard	Tsunami susceptibility	Vector (Polygon shapefile), with value of 0 and 1. General boundaries	Low	Simple map	Source Boruf and cutter
20	SVG_Hurricane_Tracks	Hazard	Hurricanes	Vector (line shapefile) with 34 tracks of storms and hurricanes in the period 1901 to 2003	Moderate	Incomplete, as data after 2003 is missing. Now contains 34 records.	Source unknown
21	SVG_buildings	Elements_at_risk	Building map	Vector (Polygon shapefile), with area. No occupancy classes or structural types or building height.	High	Complete data (52195 records). Seems complete but no attribute information on occupancy class and structural types	Within Geodatabase
22	SVG_roads	Elements_at_risk	Roads	Vector (line shapefile), without attributes	High	23204 records all over the country.	
23	SVG_roads_centerline	Elements_at_risk	Roads	Vector (line shapefile), without attributes, together with SVG_raods it is complete	High	5708 records all over the country.	
24	SVG_unpaved roads	Elements_at_risk	Unpaved roads	Vector (point shapefile) without attributes	high	2347 records spread over all country.	
25	SVG_Streetlights	Elements_at_risk	Street lights	Vector (line shapefile) without attributes	Moderate	385 records. Complete??	

26	SVG_Parish_boundaries		Parishes	Vector (Line shapefile), no attributes, and no polygons	High	6 records. Complete for entire country	
27	SV_Social_vulnerability	Vulnerability	Parishes, with vulnerability indicators	Vector (polygon shapefile) with indicators for social vulnerability	High		Source Boruf and cutter
28	SV_vulnerability_of_place	Vulnerability	Vulnerability indicators, overlay	Vector (polygon shapefile) with indicators for vulnerability, containing a combination of the susceptibility and vulnerability maps.	High		Source Boruf and cutter
29	Google Earth Image	Image	Colour image	Raster data set downloaded from Google Earth	Moderate	Has approximately 10 percent cloud cover.	
30	Pleiades images	Image	Panchromatic and Multi Spectral		Moderate	Has approximately 10 percent cloud cover. Only covers the NW part of the country	From 2014. Still trying to get the images for the whole island

Grenada - Description of Available Data and Data Characteristics

No	File name	Main types	Available data type	Characteristics of the data	Quality of the data	Completeness of the data	Remarks
1	demGREmaj2	Base data	Digital Elevation Model	Raster map with 10 meter pixels of the main island	Has geographic coordinates. Rows and columns: 3791, 2941	covers entire country	No source information is available.
2	Gre-PTS	Base data	Lidar data points	Large file with points containing X,Y, Z	High	Covers most of the coastal parts of Grenada, except for the NE part	
3	Carriacou.pts	Base data	Lidar data points	Large file with points containing X,Y, Z	High	Covers majority of Carriacou, except for the northern part	
4	pm.pts	Base data	Lidar data points	Large file with points containing X,Y, Z	High	Covers majority of Petite Martinique, except for the northern part	
5	Ridge	Base data	Ridges	Vector(line shapefile)	High	34 records	Within Geodatabase
6	River_water_course	Base data	Streams	Vector (line shapefile), two types: narrow or wide	High	1031 records covering entire areas	Within Geodatabase
7	River_water_course_on property	Base data	Streams	Vector (line shapefile),no attributes	High	1073 records covering entire area	Within Geodatabase
8	Drains	Base data	Drains	Vector (line shapefile),no attributes	High	360 records	Within Geodatabase
9	Drainage	Base data	Drainage lines incomplete	Vector lines , no attributes	Moderate	360 records, but incomplete, not forming a normal drainage network	
10	Lakes, ponds	Base data	Lakes and ponds	Vector (polygon shapefile)	High	260 records	
11	Coastline	Base data	Shoreline	Vector (line shapefile), length, type	High	Shore lines for the entire country	Within Geodatabase
12	Islands	Base map	Island boundaries	Vector (polygons) of the islands belonging to the country	High	28 islands	
13	Agriculture	Base data	Agricultural fields	Vector (polygons), without indication of the type of agriculture. 219 records	High	219 records, which seems very limited	

14	Built-up areas	Base map	Built-up areas	Vector (polygons), with indication of the main type (industrial, commercial, residential etc.) 482 records	High	482 records covering the main island and second island Covers entire country	
	wetlands_swamps	Base map	Wetlands and swamps	Vector (polygon shapefile) with indication of wetland or swamp	High	169 records	
15	Vegetation	Base map	Forest vegetation	Vector (polygon shapefile) with three classes (clear cut, forest, shrubs)	High	1036 records	
16	IITF_CJS44_grenada_landcov	Base map	Land cover	Raster map (img) probably generated from Landsat satellite images	Moderate	19 mapping units. Cell siz3 30 meters. Year unknown	USDA Forest Service study: http://fsgeodata.fs.fed.us/rastergateway/caribbean/
17	Rainfall data	Rainfall data	Rainfall data	Data for the following station:	Variable in coverage	Maribeau (2003 to 2004 hourly); Pearls 44 ba (2005-2006); La Sagesse Agricultural station; Kubalal; Cardi; Botanic gardens (2003 -2012)	#VALUE!
18	Buildings	Elements_at_risk	Building map	Vector (Polygon shapefile), without attributes	High	Complete data (68944 records). Seems complete but no attribute information	Within Geodatabase
19	Roads	Elements_at_risk	Roads	Vector (line shapefile), in three types (major road, minor road, trails)	High	17498 records all over the country.	Within Geodatabase
20	Road	Elements_at_risk	Roads	Vector (line shapefile), without attributes,	High	13175 records all over the country. Slightly less detailed than previous one. Doesn't contain the trails. Also doesn't contain a classification	Within Geodatabase
21	Airport_seaports	Elements_at_risk	Airports and seaports	Vector (polygon shapefile) without attributes	High	8 records for the lower part of the country (single airport)	Within Geodatabase
22	Jatties	Elements_at_risk	Jetties (marina's)	Vector (polygon shapefiles), no attributes	High	109 records	
23	Bridges	Elements_at_risk	Bridges	Vector (line shapefile), no attributes	High	379 records, for whole country	Within Geodatabase
24	Grenada parishes	Administrative units	Parishes	Vector (Polygon shapefile), no attributes, and no polygons	High	8 records. Without any other information	

25	Map boundaries for districts	Administrative units	Districts	Vector (lines) no attributes	High	292 records	
26	Google Earth Image	Image	Colour image	Raster data set downloaded from Google Earth	Moderate	Has approximately 10 percent cloud cover.	
27	Pleiades images	Image	Panchromatic and Multi Spectral		Moderate	Has approximately 10 percent cloud cover. Only covers the NW part of the country	From 2014. Still trying to get the images for the whole island

Belize - Description of Available Data and Data Characteristics

No	File name	Main types	Available data type	Characteristics of the data	Quality of the data	Completeness of the data	Remarks
1	100m_polygons_ter_mar	Base data	Elevation	100 meter contour lines shown as height polygons	Moderate, too general for this purpose	Whole country	http://www.biodiversity.bz/mapping/warehouse/
2	ASTER_GDEM_V2	Base data	Elevation	ASTER GDEM 30 meters downloaded	Moderate	Whole country	http://gdex.cr.usgs.gov/gdex/
3	SRTM DEM	Base data	Elevation	SRTM DEM 90 meters	Low	Whole country	http://gdex.cr.usgs.gov/gdex/
4	GTOPO30	Base data	Elevation	GTOPO30 data	Low	Whole country	http://gdex.cr.usgs.gov/gdex/
5	Belize basemap	Base data	Administrative units	Main districts and islands	High	Whole country	http://www.biodiversity.bz/mapping/warehouse/
6	Belize rivers	Base data	River network	Detailed river network, with names of main rivers and stream ordering	High	Whole country	http://www.biodiversity.bz/mapping/warehouse/
7	Waterbodies	Base data	Water bodies	Water bodies	High	Whole country	http://www.biodiversity.bz/mapping/warehouse/
8	National waters	Base map	Sea	Sea of Belize	High	Whole country	http://www.biodiversity.bz/mapping/warehouse/
9	Ecosys_bze_2011	Base data	Ecosystems	Detailed map of ecosystems in Belize	High	Whole country	http://www.biodiversity.bz/mapping/warehouse/
10	Landuse 2011	Base map	Land use map	Detailed land use map	High	Whole country	http://www.biodiversity.bz/mapping/warehouse/
11	Kinglandsystem	Base Map	Land classification	Land classification according to King et al 1993	High	Whole country	http://www.biodiversity.bz/mapping/warehouse/
12	Protected_areas_all_2011	Base map	Protected areas	All parks and protected areas	High	Whole country	http://www.biodiversity.bz/mapping/warehouse/
13	Agriculture_soilQuality	Base map	Soil quality	Paper map of soil quality	Moderate	Whole country	http://biological-diversity.info/GIS.htm
14	Biological Corridors and Protected Areas	Base map	Biological Corridors and Protected Areas	Paper map	Moderate	Whole country	http://biological-diversity.info/GIS.htm
15	Aquaculture and Selected Crops	Base map	Aquaculture and Selected Crops	Paper map	Moderate	Whole country	http://biological-diversity.info/GIS.htm

16	Agricultural Land Value	Base map	Agricultural Land Value	Paper map	Moderate	Whole country	http://biological-diversity.info/GIS.htm
17	Key Biodiversity Areas	Base map	Key Biodiversity Areas	Paper map	Moderate	Whole country	http://biological-diversity.info/GIS.htm
18	Fire risk	Hazard map	Wildfire hazard	Detailed map of wildfire hazard with classes from 1 to 18	Difficult to assess	Whole country	http://www.biodiversity.bz/mapping/warehouse/
19	Flood Oct 2006 Meerman	Hazard map	Flooded area in October 2008	Flooded area in October 2008	Unknown	Whole country	http://www.biodiversity.bz/mapping/warehouse/
20	Newsreports events	Hazard map	Flood incidents reported	Survey of flood incidents that have been reported shown as points with attribute information	Very useful	306 records	from WB
21	River_rain_flood ARA	Hazard map	Flood events	Flood events? What is Area?	Looks low	Whole country	from WB
22	Flood Risk in Belize	Hazard map	Flood hazard	Paper map of flood hazard	Unknown	Whole country	http://biological-diversity.info/GIS.htm
23	Land degradation	Hazard map	Land degradation	Land degradation classification	Unknown	Whole country	http://www.biodiversity.bz/mapping/warehouse/
24	Land Degradation Potential			Paper map	Unknown	Whole country	http://biological-diversity.info/GIS.htm
25	Roads 1909	Elements-at-risk map	Roads	Historic Roads from 1909	High	Whole country	http://www.biodiversity.bz/mapping/warehouse/
26	Roads 2011	Elements-at-risk map	Roads	Road map with classification of road type	High	Whole country	http://www.biodiversity.bz/mapping/warehouse/
27	Settlement points 2010	Elements-at-risk map	Settlements	Settlement map as point file with attributes of district, name, type, population	High	Whole country	http://www.biodiversity.bz/mapping/warehouse/
28	Settlement_poly_2011	Elements-at-risk map	Settlements	Polygon map with names of settlements	High	Whole country	http://www.biodiversity.bz/mapping/warehouse/
29	2004_landsat_mosaic_band453	Satellite data	Colour composite	False colour composite image of Belize with pixel size of 30 meters	Moderate	Whole country	http://www.biodiversity.bz/mapping/warehouse/