CHARIM

Caribbean Handbook on Risk Information Management

Proceedings of the 2nd CHARIM workshop in Saint Vincent and the Grenadines

Kingstown

29 September to 3 October 2014

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1 Introduction

This document reflects the meetings, discussions and conclusions of the workshop that was held in Kingstown, St. Vincent and the Grenadines in the week of 29 September to 3 October 2014. This workshop is the second of a series of three workshops foreseen in the CHARIM project and as such it was an important mid-term gathering of all stakeholders to reflect upon the work carried out so far and to discuss the way forward.

1.1 About CHARIM

Within the Caribbean Risk Information Program with a grant from the ACP-EU Natural Disaster Risk Reduction Program the World Bank launched the initiative to develop a handbook for hazard, vulnerability and risk assessment in the Caribbean region in February 2014. The task of its development was given to a consortium led by the University of Twente (ITC). The consortium consists of the following partners: the University of the West Indies (UWI), University of Bristol (SSBN), the Asian Institute of Technology (AIT) and EnviroSense. The acronym CHARIM that is used to identify this assignment stands for Caribbean Handbook for Risk Information Management.

Objectives

The main objective of this project is to build capacity of government organizations in the Caribbean region, and specifically the Ministries of Planning and Public Works 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 handbook for the assessment of landslide and flood hazards and risk will support the generation and application of hazard and risk information in planning and infrastructure design. By using the book the governments of the five participating governments will have an improved understanding of the fundamentals of hazard and risk. Nine national scale flood (5) and landslide (4) hazard maps will be developed .

1.2 Activities carried out thus far

Preliminary Assessment Report

In the initial phase of the project the consortium has been active in compiling available maps and spatial data related to natural hazards (specifically related to flooding and landslides) for the five target countries. Part of this data was made available through the World Bank, and part through the various geospatial data initiatives (e.g. the so-called GeoNode data portals for the various countries).

The consortium compiled all the available data and described them in a preliminary assessment report.

The consortium obtained a series of recent very high resolution satellite images (so-called Pleiades images from 2014) for the four island countries. The consortium also worked on the proper geo-referencing of the original data, so that the image data fit with the various thematic digital maps and Digital Elevation Models. The improved datasets (for the four island states) have been made available to the representatives of the countries.

Figure 1 Covers of the report of the first CHARIM workshop and the preliminary assessment report

Initial data analysis

One of the aims of the project is to generate national scale landslide and flood hazard maps for the five target countries. ITC works on the development of the national flood and landslide maps for the four island countries and the University of Bristol will generate the flood hazard map for Belize. The consortium has started this work by interpreting landslides from the high resolution satellite data. The British Geological Survey (BGS) is involved in this activity for the countries of Saint Lucia and Grenada through a collaboration between the European Space Agency and the World Bank. BGS will also generate a detailed Digital Elevation Model for the Ladyville area in Belize, and land use / land cover maps from satellite images for Saint Lucia, Saint Vincent and Grenada. Field data collection campaigns are foreseen for the period September-October.

Kick-off workshops

Kick-off workshops were organized in each of the five target countries in the period May-June with in total 5 two-day meetings:

- May 19-20: Saint Lucia
- May 22-23: Saint Vincent
- May 26-27: Dominica
- May 29-30: Grenada
- June 24-25: Belize.

The purpose of this set-up of the meetings was to get a better understanding of the situation in each country and to get to know the key stakeholders. By visiting the countries one by one the team obtained an idea of how the experts were dealing with spatial information in their (daily) work related to landslide and flood hazards and risk. During the meetings the team presented the aims and objectives of the CHARIM project and through questionnaires and discussion sessions the consortium

obtained a good idea on the role that hazard and risk information is playing in the physical planning and public works. Through field visits and discussions also a good idea was obtained on specific problem sites. After the workshop the participants of the workshops were invited to join a Google Drive where the relevant information for their country was stored. The University of the West Indies has been in contact with a number of the participants since then. Based on the findings of these meetings a final report of the first meeting was submitted to the World in August 2014.

Figure 2 Group pictures taken during the first CHARIM workshop

2 The second CHARIM workshop

At the time of this second workshop - 29 September to 3 October 2014 - the project has already progressed into its sixth month. This was a good moment to bring all the key experts from the five target countries together with the following objectives:

- To present a general assessment of the current practices in the target countries regarding hazard and risk assessment and its use in planning and engineering;
- To present the first outline of the handbook in the form of an extended table of contents with a synopsis of the use cases, the methodology book chapters and the data management book structure.
- To provide training to the countries' experts on hazard and risk assessment in general and on the handbook in particular;
- To collect feedback on the achievements so far, and
- To prepare for (field) data collection activities on the four island countries with support from the local and national authorities.

2.1 Development of the outline for the handbooks

One of the main objectives of this project is to develop a Handbook on the creation and use of flood and landslide hazard risk data for planning in Caribbean countries. This handbook will comprise three components that will be organized in a web-based platform:

- **Use Case Book**, which illustrates the steps required to generate and apply hazard and risk information the planning and infrastructure sectors. The use case book is the principal starting point for representatives from the Ministries of Public Works and Physical Planning aiming at providing guidance with a specific problem. This book is closely interlinked with the methodology and the data management book in order to provide further details and information at numerous stages of each use case. The use case book is aimed to be used by representatives from government sectors, specifically from the Ministries of Physical Planning and Public Works.

- **Methodology Book**, which focuses on the methods for generating landslide and flood hazard and risk information for different scales (nationwide, and for detailed areas) and taking into account different situations of data availability. The methodology book is aimed to be used by technical staff from government organizations.

- **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. The data management book is targeted to technical staff from government organizations.

2.2 Participants

For the workshop the following persons were invited from each country:

- **Chief planners**. The chief planners from the five target countries were invited to participate for the whole duration from 29 September (afternoon) to 3 October (morning).
- **Geospatial experts**. From each country a GeoNode manager or key coordinator of geospatial data was invited to participate for the whole duration from 29 September (afternoon) to 3 October (morning).
- **Chief Engineers**. The countries' chief engineers were invited to participate in the CHARIM workshop on October 2 and 3, subsequent to the OECS Engineering Association Meeting which was being held on St. Vincent from Monday 29 September to Wednesday 1 October.

The following persons participated in the workshop:

Country	Name	Participants' group
Dominica	Miguel St. Ville	Planner
	Lyn Baron	GIS Expert
Belize	Gina Young	Planner
	Carren Williams	GIS Expert
	Irving Thimbriel	Engineer (2 and 3 October only)
St. Lucia	Karen Augustin	Planner
	Phillip Hippolyte	GIS Expert
	Lydia Glasgow	Engineer (2 and 3 October only)
Grenada	Fabian Purcell	Planner
	Khamal Daniel	GIS Expert
	John St. Louis	Engineer (2 and 3 October only)
Saint Vincent and the Grenadines	Anthony Bowman	Planner
	Dornet Hull	GIS Expert
	Dwane Allen	GIS Expert
	Cornelius Lyttle	GIS Expert
	Sylbert Frederick	GIS Expert
	Duane Brent Bailey	Engineer (2 and 3 October only)
	Desmond Pompey	Engineer (2 and 3 October only)
	Marla Mulraine	Engineer (2 and 3 October only)
	Andy Baptiste	Engineer (2 and 3 October only)
	Howie Prince	Director NEMO

Resource persons were present during the workshop:

Organization	Name	Area of expertise	email
ITC	Cees van Westen	Landslide Hazard assessment and management specialist	westen@itc.nl
	Victor Jetten	Flood Hazard assessment and management specialist	Jetten@itc.nl
	Robert Hack	Geological Engineering	Hack@itc.nl
	Mark Brussel	Civil Engineering and Urban planning	Brussel@itc.nl
UWI	Charisse Griffith-Charles	Land use planning	Charisse.Griffith-Charles@sta.uwi.edu
	Tarick Hosein	Geo-data management	Tarick.Hosein@sta.uwi.edu
SSBN	Mark Trigg	Flood Hazard assessment and management specialist	Mark.Trigg@bristol.ac.uk
	Andy Smith	Flood Hazard assessment and management specialist	andy.smith@bristol.ac.uk
AIT	Manzul Hazarika	Geo-data and remote sensing management	manzul@ait.asia
	Naveed Anwar	Structural Engineering	nanwar@ait.ac.th
WB	Melanie Kappes	Disaster Risk Assessment Specialist	mkappes@worldbank.org
	Fernando Ramirez-Cortez	Sr. Disaster Risk Management Specialist	framirezcortes@worldbank.org
	Bishwa Pandey	Sr. Data Management Specialist	bpandey@worldbank.org
	Niels Holm-Nielsen	Lead Disaster Risk Management Specialist	nholmnielsen@worldbank.org
BGS	Tom Dijkstra	Engineering Geologist/Geomorphologist	tomdij@bgs.ac.uk
	Colm Jordan	…	cjj@bgs.ac.uk

3 Workshop program:

3.1 General program:

Monday 29 September

Activity:	Welcome and introduction to the project
Participants:	Chief planners and Geo-Spatial Experts
Resource Persons:	CHARIM team, WB-staff

Tuesday 30 September

Activity:	Use-Case training day
Participants:	Chief planners and Geo-Spatial Experts
Resource persons:	Cees van Westen (ITC)

Wednesday 1 October

Activity:	Discussion on the use of hazard and risk information in three parallel sessions: 1) Chief planners 2) Geo-Spatial Experts
Participants:	Chief Planners and Geo-Spatial Experts
Resource persons:	1) Mark Brussel (ITC) and Charisse Griffith-Charles (UWI) 2) Manzul Hazarika (AIT) and Tarick. Hosein (UWI)

Thursday 2 October:

Activity:	Morning: Review of the Handbook proposal Afternoon: parallel sessions on the use case discussions for: 1) Chief planners 2) Chief Engineers 3) Geo-Spatial Experts
Participants:	Chief Planners, Chief Engineers and Geo-Spatial Experts
Resource Persons:	
Morning:	ITC and AIT staff;
Afternoon:	1) Mark Brussel (ITC), and Charisse Griffith Charles (UWI) 2) Robert Hack (ITC), Naveed Anwar (AIT) and Mark Trigg (SSBN) 3) Manzul Hazarika (AIT) and Tarick Hosein (UWI)

Friday 3 October

Activity:	Reporting from the sessions and planning for the coming period
Participants:	Chief Planners, Chief Engineers and Geo-Spatial Experts
Resource Persons:	Cees van Westen

3.2 Monday 29 September: Introduction

The workshop started in the afternoon so that the participants could arrive in the morning. The main purpose of the afternoon session was to update the participants on the advances of the CHARIM project, its activities so far, introduction of the resource staff and the purpose of this workshop.

Program Monday 29 September

Time	Topic	By:
13.30 – 13.40	Call to order and National Anthem	Master of Ceremony
13.40 – 13.50	Welcome remarks	Minister of Housing, Informal Human Settlements, Lands & Surveys and Physical Planning
13.50 – 14.00	Welcome remarks	World Bank
14.00 – 14.30	Summary of the results of the 5 kick-off workshops & explanation on the program and objectives of the workshop	Cees van Westen (ITC-UT) and Mark Brussel (ITC)
14.30 – 15.00	National scale landslide hazard assessment: proposed methodology	Cees van Westen (ITC-UT)
15.00 – 15.30	Coffee break	
15.30 – 16.00	National scale flash flood hazard assessment for the island countries: proposed methodology	Victor Jetten (UT-ITC)
16.00 – 16.30	National scale flood hazard assessment for Belize: proposed methodology	Mark Trigg & Andrew Smith (University of Bristol & SSBN)
16.30 – 17.00	Discussion session	

After the welcome words by the hosts and the staff of the World Bank, the afternoon was used to introduce the CHARIM team to the audience, as well as the objectives of the CHARIM project and the work carried out so far (as are summarized in chapter 1 of this report). In the work that was carried out so far, the team encountered substantial differences between the five target countries, e.g. in the availability of spatial data, institutional agreements on sharing spatial data, agreements on responsibilities of department for primary data, GeoNode development, and integration of spatial data in the actual work of the departments. It was concluded that the current practice in the countries of not sharing information related to most of the hazard and risk related resulted in duplication of efforts where one office does not know what information is available in a neighboring office. Also most of the data that was collected and created, including input data for analyses, intermediate and final results, was not shared with the responsible office while only the end results were presented and often not as spatial information but only as images in a report. We also encountered examples that data was lost, and that the same existing data was re-used over and over again without being updated or checked for their quality.

There was general consensus that these issues need to be resolved and possibly the handbook could play a role in this by stressing the importance of spatial data collection, management and sharing. Also training is required on the use of hazard and risk data in spatial planning and critical infrastructure development. The CHARIM team would like to involve key-experts from the countries in every step of the process as much as possible, to adhere to the open data policy and to use open source software.

In the later part of the afternoon the work on the national scale landslide and flood hazard maps was presented by the experts Cees van Westen (landslides, 4 island countries), Victor Jetten (floods, 4 island countries) and Andy Smith (floods, Belize). Their presentations are shown in ANNEX 2 of this report. In his presentation Cees provided an overview of the most common types of landslides on the

islands, the triggers and preparatory factors that favor the occurrence of landslides on the islands and an introduction to an inventory-based approach to landslide hazard assessment. In his presentation on flood hazard assessment in Belize Andy Smith outlined a method using the LisFlood-FP model that has been used in similar areas with a similar (scarce) dataset. The main input is a (SRTM-derived) DTM (corrected for vegetation cover) and rainfall, discharge and storm surge data. For the other four countries a grid-based combined 1D-2D model was suggested by Victor Jetten in his presentation. This model works very well at the scale of the islands and hydrological modelling (converting rainfall information into streamflow) and a hydraulic model to propagate the flood wave over complex topography. All three presenters addressed the challenges regarding the data availability.

3.3 Tuesday 30 September: Use-Case training day

The purpose of this day was to introduce the participants to the concepts of hazard, vulnerability and risk assessment for floods and landslides.

Program Tuesday 30 September.

Time	Topic	By:
09.00 – 9.30	Risk Reduction Initiatives: Challenges & Opportunities. Introduction to a new risk reduction initiative: its challenges and opportunities; the key role of achieving agreement between the engineering community and the Ministries of Works on the standards needed to produce and use hazard/risk information; how the CHARIM handbook could add an important piece to this puzzle.	Fernando Ramirez (WB) Niels Holm-Nielsen (WB
09.30 – 10.00	World Bank – European Space Agency (ESA) demonstration project on use of satellite data for hazard and risk assessment. Generation of land use maps, landslide inventory maps and Digital Elevation Models	Colm Jordan (BGS) and Tom Dijkstra (BGS)
10.00 – 10.30	Introduction to training session. Risk assessment framework; components of risk assessment; hazard assessment; return periods; hazard intensity; vulnerability assessment; risk analysis; economic risk; population risk; risk evaluation; risk acceptability.	Cees van Westen (UT-ITC)
10.30 – 11.00	Coffee break	
11.00 – 11.45	Start with exercise: installing software and dataset.	All participants
11.45 – 12.30	Lecture: quantitative risk assessment method; elements-at-risk; cost estimation; population estimation; vulnera-bility curves; exposure analysis; loss estimation; risk estimation; risk curves; average annual loss calculation.	Cees van Westen (UT-ITC)
12.30 – 13.30	Lunch	
13.30 – 14.15	Hands-on exercise: risk analysis.	All participant
14.15 – 15.00	Lecture: formulation of planning alternatives; engineering solutions, ecological alternatives; relocation. Cost estimation of alternatives; Cost-benefit analysis.	Cees van Westen (UT-ITC)
15.00 – 15.30	Coffee break	
15.30 – 16.15	Hands-on exercise: Cost-benefit analysis.	All participants
16.15 – 17.00	Wrap-up session & discussion Analyzing future development & climate change scenarios; analyzing the changes in hazard and risk for these; combining planning alternative with future scenarios: which decision are most change proof.	Cees van Westen (UT-ITC)

The training consisted of a mix of lectures and hands-on GIS exercises using a simple GIS. On the basis of a hypothetical use case study of a part of an island country the methods used for assessing flood and landslide hazards were examined and exposure, vulnerability and risk were assessed. The next step was to formulate several alternatives for risk reduction planning, and evaluate the risk reduction after the implementation of these measures. Also future development scenarios were formulated and the consequences for these on hazards and risk are evaluated. The use-case presentation and exercise was coordinated by ITC.
This training took place in a joint session with the OECS Engineering Workshop including all participants from both events. All participants had brought their own laptop in order to carry out the training. Software and data were provided on USB-sticks by the consortium.

The overall aim of the case study was to evaluate possible changes in risk to different natural hazards, in an area along the coast of a small Caribbean island state, by analyzing the effect of different possible future scenarios related to land use change, population change, and climate change, and evaluating the effect of possible intervention alternatives on top of these possible future scenarios.

The case study consisted of the following five components:

Part A: Analyze the input data required for such an analysis:

- Hazard intensity and probability maps
- Elements-at-risk maps in the form of land parcels and their attributes (land use type, economic value and number of people)
- Vulnerability curves
- Planning alternatives: in order to reduce the current risk three alternatives have been defined (engineering solutions, ecological solutions, and relocation)
- Possible future scenarios: four possible future scenarios have been developed for this area: business as usual (rapid unplanned growth), risk informed planning (growth that follows the chosen alternative), worst case scenario (rapid unplanned growth combined with climate change) and climate change adaptation scenario (planned growth in a changing climatic situation)

Part B: Analyze the current risk to different hazards:

- Calculate the number of elements-at-risk exposed to each of the hazard types and each of the return periods
- Apply vulnerability matrices for estimating the vulnerability to the various hazard types.
- Calculate the losses for each hazard type and return period
- Integrate the losses for different return periods into annualized risk
- Calculate the risk as population risk and economic risk.

Part C: Analyze the effect of possible risk reduction alternatives:

- Re-calculate the risk after implementation of the risk reduction alternatives;
- Determine the annual risk reduction;
- Calculate the costs for implementing the risk reduction alternatives: investment costs, period of investment, maintenance costs, project lifetime;
- Carry out a cost-benefit analysis to identify the optimal alternative in terms of NPV (Net Present Value) and IRR (Internal Rate of Return)
- Evaluate other factors (indicators) that are relevant in the final selection of the optimal alternative using a multi-criteria evaluation approach.

Part D: Evaluate the changes for the different scenarios.

- Analyze the changes in land use for the different scenarios in a number of future years (2020, 2030 and 2040) and explain the trends and possible drivers;
- Analyze the changes in economic values for the different scenarios in a number of future years (2020, 2030 and 2040)
- Analyze the changes in population for the different scenarios in a number of future years (2020, 2030 and 2040)
- Analyze the changes in risk for the for the different scenarios in a number of future years (2020, 2030 and 2040)

Part E: Evaluate which of the risk reduction alternatives would behave best under possible future scenarios.

- Analyze the changes in risk for risk reduction alternatives for the different scenarios in a number of future years (2020, 2030 and 2040);
- Calculate annualized risk for each combination of risk reduction alternative and future year;
- Calculate annualized risk reduction (benefit) for each combination of risk reduction alternative and future year by subtracting the annualized risk with and without the risk reduction alternative;
- Use these different values for annualized risk reduction (benefits) in a cost-benefit analysis that compares risk reduction alternatives by taking into account their behavior under different possible future scenarios;
- Determine the most “change proof” risk reduction alternative.

3.4 Wednesday 1 October: Use of Spatial Information - Parallel sessions

During this day two parallel sessions were held, one with the chief planners and one with the geospatial experts. The purpose of these sessions was to discuss the current practice in the target countries with respect to the use of hazard and risk information in the physical planning process (with the planners) and to learn more about the current situation with respect to the spatial data infrastructure in the countries (with the geo-spatial experts).

3.4.1 Session with chief planners:

In the invitation to this workshop the chief planners were requested to:

- Hold a presentation of 30 minutes on the physical planning situation in their countries, where they should address issues such as: national level planning, local level planning, legislative aspects, examples where hazard information is required, obstacles in using hazard information.
- Bring examples of planning documents for different projects as examples.

The morning session

The morning session was dedicated to the participants' presentations, complemented with examples from the Netherlands (by Mark Brussel, ITC) and the Caribbean Region (by Charisse Griffith Charles, UWI).

Program for the chief planners (morning session)

Time	Topic	By:
09.00 – 09.20	Introduction of the program, objectives and setup	Mark Brussel (UT-ITC) and Charisse Griffith-Charles (UWI)
09.20 – 09.40	Hazard and risk information in Planning: St. Vincent	Anthony Bowman
09.40 – 10.00	Hazard and risk information in Planning: Grenada	Fabian Purcell
10.00 – 10.20	Hazard and risk information in Planning: Belize	Gina Young
10.20 – 10.40	Hazard and risk information in Planning: Dominica	Miguel St. Ville
10.40 – 11.00	Coffee Break	
11.00 – 11.20	Hazard and risk information in Planning: St. Lucia	Karen Augustin
11.20 – 11.50	Examples on hazard and risk information in planning in the Netherlands	Mark Brussel (UT-ITC)
11.50 – 12.10	Issues related to land management and hazard & risk information in the Caribbean	Charisse Griffith-Charles (UWI)
12.10 – 12.30	Discussion	
12.30 – 13.30	Lunch	

The afternoon session
The afternoon program was dedicated to discussing the examples from the countries focusing on the needs and requirements for hazard input in the planning process.

Program for the chief planners (afternoon session)

Time	Topic	By:
13.30 – 14.15	Wrap up of morning session: common issues and challenges across the 5 countries in generating and using hazard and risk information in planning.	Charisse Griffith-Charles and Mark Brussel
14.15 – 15.00	Participants discuss needs and requirements for hazard and risk information in the planning process for: 1. National level physical planning 2. Local area development plans 3. Land subdivision 4. Building permit provision	Chief planners, moderated by Charisse Griffith-Charles and Mark Brussel
15:00 – 15:30	Coffee break	
15:30 – 16:30	How and Who? For each of the planning processes, participants discuss implications of the use of hazard and risk information in terms of legal/institutional arrangements, who is responsible for data provision, how can it be organized?	Chief planners, moderated by Charisse Griffith-Charles and Mark Brussel
16:30 – 17:00	Presentations of outcomes for each planning process. Wrap up, conclusions and way forward	Chief planners, moderated by Charisse Griffith-Charles and Mark Brussel

Conclusions

Belize

Ms. Gina Young presented on behalf of Belize. In Belize, physical planning still operates on the basis of the 1947 Physical Town Planning Act and the 1998 Coastal Zone Management Act, the only two acts that have been approved and are operational. The National Planning Bill of 2004 and the Municipal Governance Bill of 2010 have never been approved, whereas the Integrated Land Use Planning Framework for Land Resource Development of 2011 still has a status of “proposed” and is under discussion in parliament. This situation provides limitations for land use planning (and the use of hazard and risk information), as the institutions that should take up this role are not in place.

A lot of land use planning in Belize therefore takes place in the land subdivision process, in which land use change can be regulated and additional requirements and/or limitations can be put on development in what are considered hazardous areas. There are no real hazard related planning standards in place except standards that indicate the distance of development to water bodies.

Notwithstanding the above, some local land use planning has recently taken place in the framework of the Belize City Downtown Rehabilitation Project, the Sustainable Tourism Program (STP) and the Belize Municipal Development Project (BMDP). In the latter program, municipal development plans have been made for 7 municipalities (three of them coastal: Corozal Town, Dangriga and Punta Gorda, and four of them inland: Belmopan, Orange Walk Town, San Ignacio - Santa Elena and Benque Viejo del Carmen). In these plans flood risk zonation plays a clear role in determining development options.

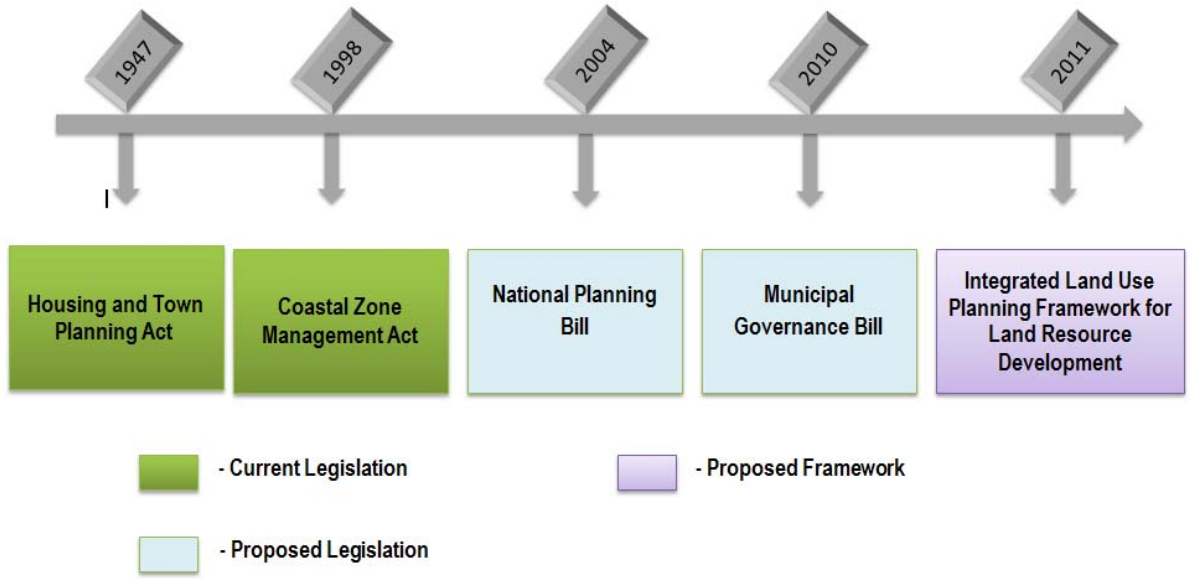


Figure 3 Overview of the development of the policy and legislative framework for planning in Belize (Source: Gina Young)

The Belize City project is the most extensive project that is ongoing in Belize. The plan that has been developed is geared to ensure that flood risk (both coastal and riverine) is taken into consideration in all future developments. This has been done through an approach that prioritizes combines structural and non-structural plans through (i) spatial planning to avoid placing new development in risk areas, (ii) strategies to minimize the probability and severity of a flood (control) and (iii) review strategies to minimize the potential consequences of a flood on occupants and properties (mitigation).

Dominica

Mr. Miguel St. Ville, Planner, presented on behalf of the Physical Planning Division of Dominica. The institutional and legislative framework for the physical planning process in Dominica was described. The Physical Planning Act provides authority for the Physical Planning Division and the Physical Planning Board to regulate and guide development both in terms of land use and building construction in both urban and rural areas of Dominica. The Act also provides for land acquisition for planning purposes. Because of the limited availability of hazard and risk information, decisions regarding approvals for use and building applications are usually made on the basis of evidence and prior experience of the planner after field visits. It is hoped that a new land policy that is due to be implemented offers support for the establishment of new procedures for including hazard and risk information in physical planning and development control. There is a draft Physical Planning Building Code and a draft Minimum Property Standard in development as well as Building Guidelines for the design and construction of small residential buildings and small retail shops and these can provide a framework for the inclusion of hazard and risk information in the approval process. There are also maps that can give limited input of hazard and risk to the existing process including a Volcanic map, Wind map, Storm surge map, Inland flooding map and an Inventory of all landslides which needs updating. The organizational structure was detailed as presented in Figure 4. The application process was also briefly outlined as shown in Figure 5.

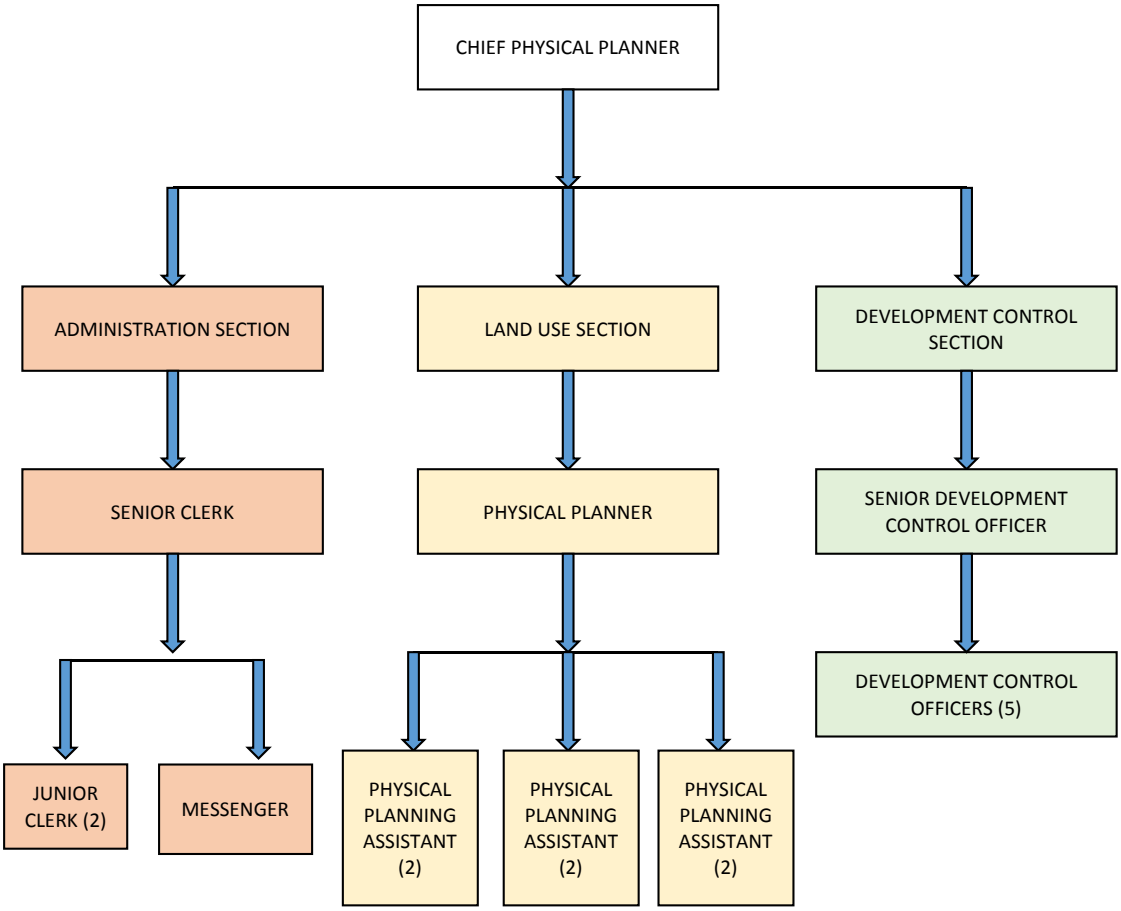


Figure 4 Organizational structure of physical planning in Dominica (Source: Miguel St. Ville)

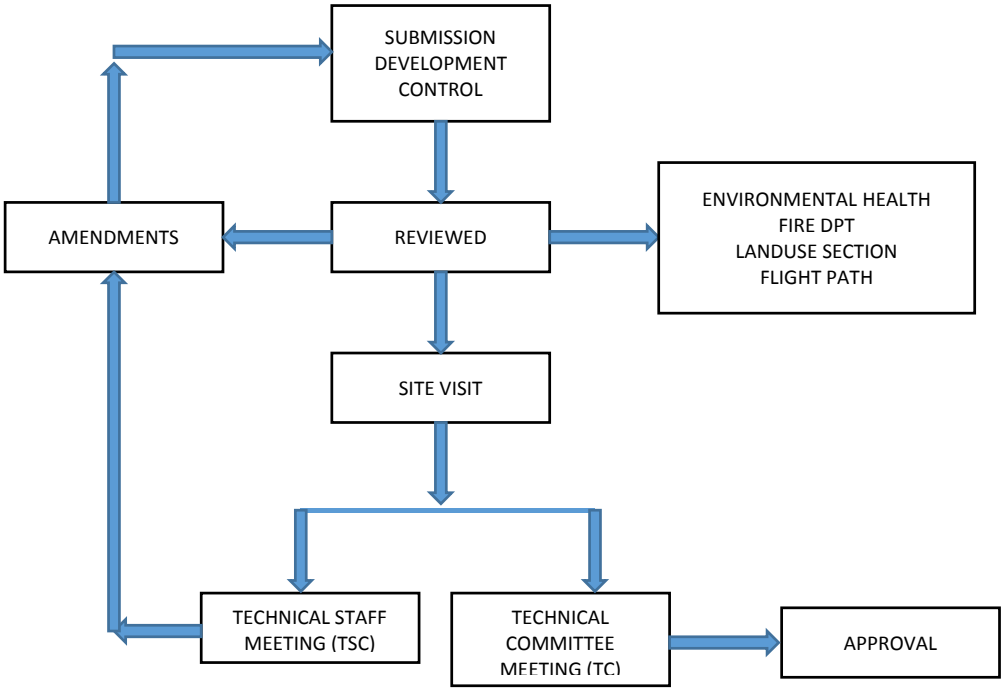


Figure 5 The application process in Dominica (Source: Miguel St. Ville)

The particular challenges that Dominica faces that impact on the incidence of hazard and risk include the indiscriminate clearing and squatting on both private and state land. Natural disasters that are increasing in frequency and intensity as a result of climate change impacts also affect the ability to plan effectively in Dominica. Illegal subdivisions, lack of awareness of the public about the impacts of their actions, political interference in planning decisions, unplanned land use and lack of capacity to enforce planning regulations were all cited as issues in physical planning. A case study was discussed where two persons died from the impact of landslides in the Bellevue Chopin area. The families that remained in the vulnerable areas were subsequently relocated to newly constructed state housing in a safer environment.

Grenada

Mr. Fabian Purcell presented the situation in Grenada. He pointed out that in Grenada the Planning Act of 2002 is in operation, which essentially has two elements: (i) Development Planning and (ii) Development Control. The first one is setting out the vision of how a region should develop and is used to guide decision making for development proposals; the second is the approved set of legislation, regulations and standards to guide the physical development.

Both activities are carried out by the Planning and Development Authority (PDA), that has the full mandate in planning. Its objectives are to guide the future development of land through physical Development Planning initiatives at National, Regional & Local Levels and to ensure orderly and progressive development of land. Like in the other nations, there is little discussion of hazard and risk in the planning act itself, however these are now part of the current policy regulations which involve attention for hazard and risk assessment in their formulation:

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

At the national level, Grenada has created a National Physical Development Plan that describes for each of the territories of the country what the permissible and planned developments are. The land use concept map is shown in figure 6.

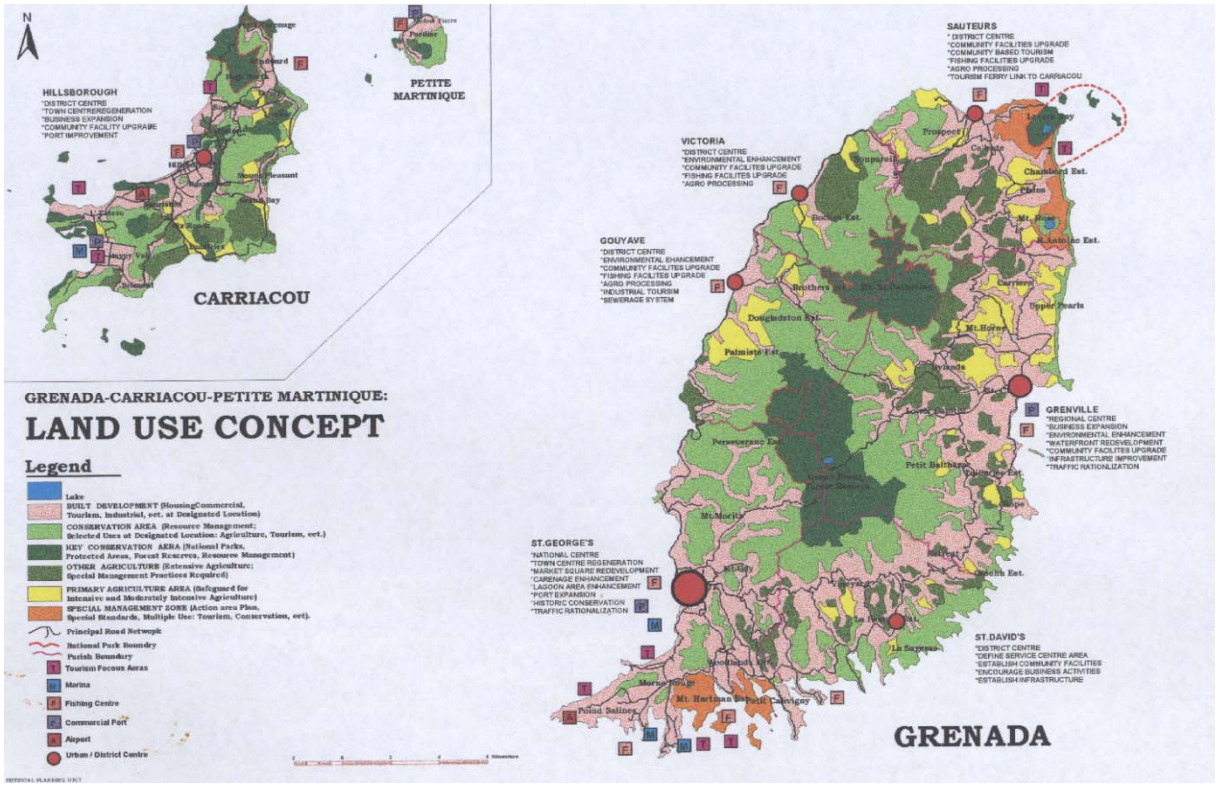


Figure 6 Land use map (concept) of Grenada (Source: Fabian Purcell)

At the local level more detailed land use planning activities are ongoing, in which the characteristics of the area are described and analyzed to arrive at a local area development plan. This is done for example for the area of Grenville, in which several natural hazards (coastal, riverine and local flooding, landslides) have been mapped. These maps are taken on board in the planning process in discussions with the various stakeholders involved to see which types of development are possible in those areas and which types are not.

Saint Lucia

Mrs. Karen Augustin, Chief Planner in Saint Lucia presented the perspective of physical planning in Saint Lucia. The legislation related to physical planning derived from the Town and Country Planning Ordinance 1961, which was supplanted by the Land Development "Interim Control" Act 1971, and subsequently the current Physical Planning and Development Act No. 29 of 2001 and its amendments of 2005. The legislation gives the Board the authority to regulate development. The Board of the Development Control Authority comprises 13 members appointed by Cabinet. These members are: the Chief Medical Officer, Chief Agricultural Officer, Chief Engineer, St. Lucia National Trust, Chief Sustainable Development Officer, Permanent Secretary Physical Development, 6 persons and a Chairman from the private sector, Electricity services representative who has observer status, and a WASCO representative who also has observer status.

The Development Control Authority is legally responsible for regulating use on land including land for conservation, agriculture, residential, industrial, commercial, touristic, institutional, recreational, or any other purposes. The responsibilities of the Authority are to provide for: the development of infrastructure, buildings, open spaces and other public sector investments, and to provide input on

the layout and design of development schemes, as well as State policies, proposals and programs contained in development strategy. The legislation requires that in the course of preparation of a draft physical plan the Head of the Physical Planning and Development Division shall:

- take reasonable steps to consult with any person with an interest in the matters for which proposals may be made in the plan, including but not limited to the management of water and other natural resources, Crown lands, the natural and cultural heritage, environmental protection, agriculture, industry, tourism, commerce, urban development and transportation; and
- take into account the national development strategy in effect for Saint Lucia.

The presentation noted that the hazards impacting on Saint Lucia included: landslides, flooding, sea level rise, excessive rainfall, high winds, drought, earthquakes, volcanic eruptions, storm surges. In the course of its duties, the Authority interacts with and obtains inputs from the: National Emergency Management Office- NEMO, Metrological Office, Water Resource Management Agency, and the Ministry of Sustainable Development. For development that affect particular sectors, the Authority can also interact with: the Ministry of Infrastructure (road and drainage), the Ministry of Agriculture (agriculture), and Saint Lucia National Trust. The legislation also provides for the preparation of Physical Development Plans that can be inspected by the public. The plan is approved by affirmative resolution in the House of Assembly and can be reviewed and revised at any time. The authority is required to give principle consideration of these plans in approving applications for development. The Government is also required to be guided by the plan in developing public sector projects and the plan remains in effect until rescinded.

St. Vincent and the Grenadines

Mr. Anthony Bowman presented the status of St. Vincent's planning environment. St. Vincent's town and country planning was introduced by the British colonial government in 1946. In the 1950s the legislation was renamed the Planning and Development Act and again in 1976, the Town and Country Act. The Physical Planning Unit was established and in 1992 the legislation was revised, repealing the 1976 Act. There have been several amendments since then.

Two levels of planning exist: development or forward planning including prescriptive sectorial plans and development control which is regulatory in focus. There are three tiers of planning beginning with the national physical development plan and leading to regional plans and on the lowest rung, the local area plans. The legislation provides for the form of plans to be both in text and in maps. Development planning comprises building code and regulations, planning guidelines and other regulatory instruments such as environmental impact assessment regulations and a Coastal Zone Management Handbook. The elements of the national, regional and local area plans include settlement information, transportation and communication, soils mapping, landslide susceptibility maps and land use and land cover maps.

The hazard and risk information that is used in the preparation of plans include the information gleaned from more than 20 years of compiled historical records on hazards. Current volcanic hazard maps, landslide susceptibility maps, soils maps, topographic maps and some limited mapping of flood plains and rivers are also all used to inform the preparation of development plans. The hazard information that exists is however, limited and isolated to particular areas. There is also no single repository where all the information is held and there are capacity deficiencies that prevent the information from being fully incorporated into decision making.

Mr. Bowman highlighted the fact that there were opportunities for improving the incorporation of hazard and risk information into the planning process in St. Vincent such as development of a spatial data center to house the hazard and risk information, providing training for staff in this area at the Ministry of Housing and other ministries and local companies to build awareness of the impact of hazard and risk in development. There should also be an expansion of the local GIS community by providing national policies for data development and data sharing. He presented examples of large scale development plans for the country in projects such as the International Airport Development/Windfarm, Lowman Bay, the Gellizeau local plan in Bequia and the Green Hill housing project.

3.4.2 Session with geospatial experts

During this parallel session the geospatial experts discussed the current situation with respect to spatial data infrastructure in the countries, as well as the future developments, and the requirements for the data management component of the handbook. This session was coordinated by AIT (M. Hazarika) and UWI (T. Hosein).

The morning session was dedicated to short presentations on the current status of the use of geospatial information in each country, addressing questions regarding the current usage of geo-spatial data in their country, how is data shared, what are major the major challenges regarding the use and sharing of geo-spatial data and what geo-spatial data is missing or of insufficient quality. These presentations were complemented by demonstrations by the CHARIM resource persons Manzul Hazarika (AIT), Mark Trigg (SSBN) and Tarick Hosein (UWI).

Program for the geospatial experts (morning session)

Time	Topic	Responsible
09.00 – 09.15	Introduction of the program of the day, objectives and setup	Manzul Hazarika (AIT) and Tarick Hosein (UWI)
09.15 – 10.30	Presentations from five target countries focusing on problems related to data (10-15 minutes each): • Belize • Dominica • Saint Lucia • Saint Vincent and the Grenadines • Grenada	Geospatial experts from each country
10.30 – 11.00	Coffee Break	
12.00 – 12.30	A demonstration of data integration for the 4 island countries and presentation of the homogenized data sets and high resolution images for the target countries. Handing over of new datasets to participants	Tarick Hosein (UWI),
12.30 – 13.30	Lunch	

In the St. Vincent presentation the importance of good data was stressed, especially now while the country in in transition from a ‘simple’ agricultural based economy towards a complex more diversified society. This requires alternative strategies for land management, ownership and usage. Various offices require spatial information, ranging from the physical panning unit to the tax office. There are initiatives for data sharing, e.g. the GeoNode, but there remain still major challenges in the

e.g. data acquisition, data sharing, GIS-policy, software and staff training and development. With respect to hazard and risk on the island, floods and landslides are major problems, but there is lack of information regarding e.g. land use and soils.

In the Grenada presentation Mr. Khamal Daniel discussed the use of spatial information in his country. Most of the offices use the spatial data that they have in-house themselves (appr. 50%); other sources of data are other governmental units (15%), non-governmental users (20%) and foreign providers (15%). Most of the geo-spatial data is generated by the Physical Planning Unit, the Agricultural Department and the Statistics Department. Data sharing is achieved through setting up a GeoNode and through workshops. Unfortunately most data is outdated.

For Belize Mrs. Carren Williams presented the National Spatial Data Initiative (NSDI) using GeoNode and provided some background information regarding its purpose, pilot studies, how it will work and for whom it is intended. The NSDI project was started in 2011 followed by a series of training and workshops. It was considered important to have a good mix of stakeholders who all have the willingness to share their data. In principle everyone is welcome to participate and the aim is to have a network of complimentary organizations of data providers. The benefits of this collaboration are foreseen in e.g. disaster management, planning, utility management, education and research, crime management, natural resources management and health.

For St. Lucia Mr. Philip Hippolyte presented the current status of the national geospatial framework, addressing data availability, challenges in use and interoperability, current use and collaborations, gaps and areas of improvements and the status of the national GeoNode. The main source of geospatial data in the country are the governmental departments and offices, such as the Survey and Mapping Department, the Physical Planning Department, etc. However there are challenges with respect to the data harmonization, base map production, lack of standardization and lack of resources. Also there is no central authority on data management. Main areas of improvement planned for the near future are: New elevation model (lidar), Soil mapping, standard coordinate system and mapping projection and a data management framework.

Mr. Hosein presented some of the problems he encountered with the data from the different islands. The presentation was followed by a demonstration and discussion of transformation and projection from the local coordinate systems to UTM/WGS84.

The afternoon program

The afternoon program was dedicated to discussing the examples from the countries focusing on the needs and requirements for better usage of spatial data. The following topics were discussed:

- Data standards
- Data quality, and requirements for geo-referencing
- Organizational requirements
- Technical implementation of GeoNode
- Requirements for the Data Management Handbook

Program for the geospatial experts (afternoon session)

Time	Topic	Responsible
13.30 – 14.00	OpenDRI – Problems and opportunities in the five target countries	Bishwa Pandey (World Bank)
14.00 – 15.00	Group discussion on issues related to: • Data projection (problems in map projection, datum etc.); • Data homogenization (available/preferred data formats);	Tarick Hosein (UWI) & Geospatial experts
15:00 – 15:30	Coffee break	
15:30 – 16:30	Discussion continues • Data quality/accuracy (required level of data quality/accuracy); • Data updating (frequency of updating); • Data sharing (problems in data sharing – technical and institutional issues)	Geospatial experts
15.30 – 16:00	A demonstration of data requirements for flood hazard and risk assessment	Colm Jordan (BGS) and Tom Dijkstra (BGS)
16:00 – 16.30	A demonstration of data requirements for flood hazard assessment in Belize:	Mark Trigg & Andrew Smith (University of Bristol & SSBN)
16:30 – 17:00	Spatial data requirements for Hazard and Risk Assessment	Manzul Hazarika (AIT)

Summary of the discussions

Belize

Mrs. Carren Williams gave an overall presentation of the geospatial infrastructure and institutions in Belize. The presentation included a summary of their achievements in developing an NSDI and presented a framework of their geospatial policies, procedures and standards towards an overall goal of data sharing. She elaborated about the Belize process of the NSDI development to ensure interest of all stakeholders. The NSDI initiative started as a small pilot study, to define meta-data standards such as the ISO 19115 metadata standards and uniform parameters such as the datum/projection based on WGS84. The presentation concluded with look at the future of how Belize expects to further stimulate the sharing and use geo-spatial information in other decision making procedures.

Grenada

Mr. Khamal Daniel gave a short presentation that provided an overview of the GIS users in Grenada. The presentation highlighted that primarily the Physical Planning Unit is using GIS. The presentation also included a review of different geospatial stakeholders and their objectives and contribution in the generation of geospatial data. The presenter highlighted data sharing through GeoNode as an achievement while human resource and lack of metadata on existing data still pose significant difficulties when using existing data. Finally the presentation concluded with an overview of the challenges including outdate data, lack of data and development of a land parcel GIS.

Saint Lucia

Mr. Philip Hippolyte outlined a detailed inventory of data that is available for St. Lucia, along with the scale, year and data source. The presentation also included reference to the OAS (Organization of Americamn States) Atlas and its use in the fields of consumer safety and health. A number of challenges around the use of spatial data were presented such as the need for a geodetic framework, normalized cadastral basemap, data standards and metadata. The presentation also included some information of local challenges which included lack of support from government, reduced budget allocations, interoperability and lack of coordination between government agencies. However, there was mention of sharing of data and resources between state and private stakeholders which is proving to be beneficial. A number of areas were highlighted for improvement including: soil/geological maps; local geodetic system; LiDAR data; Data Management Framework and Risk related data collection. Finally, a number of areas were highlighted as needing more attention which included: data maintenance; data storage and sharing software and hardware (GeoNodes); data collection and geospatial framework policies (NSDI).

St. Vincent and the Grenadines

The group GIS experts from St. Vincent (Dornet Hull, Dwane Allen, Cornelius Lyttle and Sylbert Frederick) provided an outline of the GIS users and services offered, followed by a presentation of achievements which included work towards GIS policies and the establishment of an NSDI, further development of the GeoNode and capacity building. Challenges the country is facing as it relates to GIS and data management primarily relate to data acquisition, data sharing, software, formal training and the lack of GIS policies. The presentation concluded with an identification of data gaps such as hazard, roads, land use and soil data.

Dominica

Lyn Baron presented about the recent developments in Dominica with respect to GIS systems and GIS datasets and current activities to create and update these spatial information. Lack of human resources was considered as a major problem in further development of the GIS data.

The afternoon program was concluded by presentations of the BGS, SSBN and AIT. Colm Jordan and Tom Dijkstra from the BGS gave an overview of the work that will be done for the project related to landslide and land cover mapping. An overview of the methodology and expected results were

presented. Similarly, Dr. Trigg (SSBN) presented on the planned methodology by which flood modelling will be done for Belize, with emphasis on the data requirements. Dr Hazarika (AIT) gave a presentation of the data needs for hazard and risk modelling.

3.5 Thursday 2 October: Review of the Handbook

The countries' chief engineers were invited to participate in the CHARIM workshop on October 2 and 3, subsequent to the OECS Engineering Association Meeting which was being held on St. Vincent from Monday 29 September to Wednesday 1 October.

The purpose of this day was deepen the discussion on the Handbook, its structure in general and the role of the use cases in particular. The conclusions of these discussions would subsequently play a guiding role in the further development of the Handbook, its structure and content. During the morning session the draft outline (proposal) of the Handbook was presented. In the afternoon three parallel discussion sessions were held for the planners, engineers and geo-spatial specialists in order to discuss specific use cases of interest.

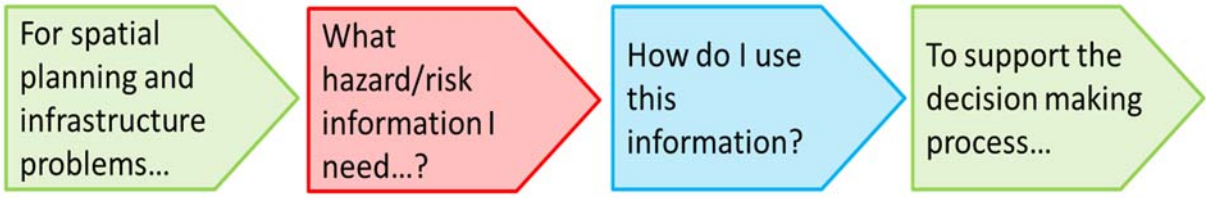
3.5.1 Morning: presentation of the Handbook and Use Cases

Morning program Thursday 1 October

Time	Topic	Responsible
09.00 – 09.15	Introduction of the program of the day, objectives and setup. Explanation of the purpose of the afternoon sessions for chief engineers, chief planners and geospatial experts	Cees van Westen (UT-ITC)
09.15 – 09.45	Presentations of the handbook • Structure of the handbook • Web-based platform • Example of a use case structure	Cees van Westen (UT-ITC)
09.45 – 10.30	Presentation of the table of contents for the use case book	Victor Jetten (UT-ITC)
10.30 – 11.00	Coffee Break	
11.00 – 11.30	Presentation of use cases related to Land use planning and management and the relation with the methodology book	Mark Brussel (UT-ITC) and Charisse Griffith-Charles (UWI)
11.30 – 12.00	Presentation of use cases related to critical infrastructure and the relation the methodology book	Robert Hack, Victor Jetten, Naveed Anwar
12.00 – 12.30	Presentation of the use-case ideas for data management and the Data Management Handbook	Manzul Hazarika (AIT) and Tarick Hosein (UWI)
12.30 – 13.30	Lunch	

Proposal for the Handbook

The objective is to create an on-line handbook to support the generation and application of landslide and flood hazard and risk information in common physical and infrastructure planning processes, specifically targeted to small countries in the Caribbean region. The methodology is based on a series use cases of which each use case provides a conceptual framework and is accompanied by a practical examples – if applicable.



The Handbook consists of three separate volumes: 1) the Methodology Book, 2) the Use Case Book and 3) the Data Management Book that are strongly interconnected by hyperlinks. The Use Case Book plays a central role in the Handbook as it should act as the starting point for planners and engineers who are confronted with a practical problem that they need to solve. Through a series of use cases that illustrate various types of common problems that could be encountered in the target countries, the user selects the one closest to his or her particular problem. The use case book will address problems in the following application domains: 1) Land-use planning and management, 2) Critical infrastructure, 3) Evaluating different planning alternatives, 4) Disaster preparedness planning, 5) Risk assessment, 6) Hazard assessment, and 7) Data management – see also figure 7. The use cases will provide a real-world example (preferably from one of the five target countries), that will illustrate the step-by-step approach of incorporating hazard and risk information into the planning process. While some use cases are primarily conceptual and guide the user through the process purely with a step-by-step general guidance, multiple use cases illustrate the conceptual step-by-step approach with an example from one of the target countries and several of the use cases in addition include a fully elaborated GIS exercise.

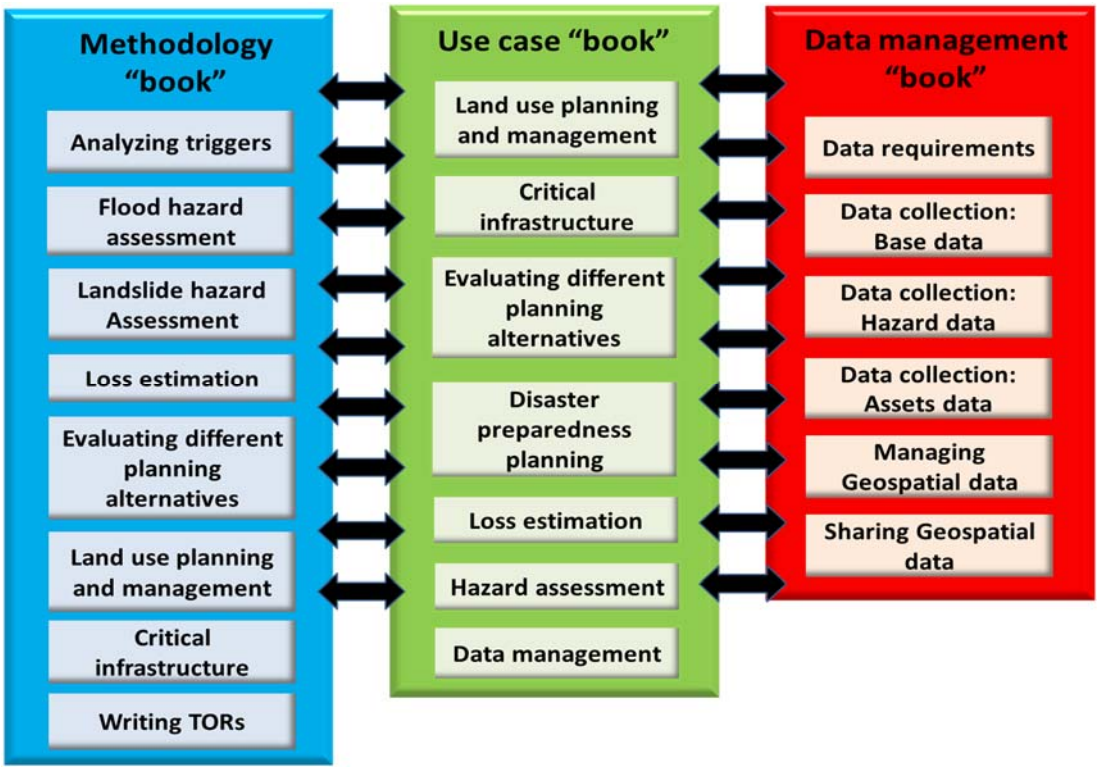


Figure 7 Conceptual outline of the Handbook

Each use case has a similar structure, comprising the following 9 components:

1) Introduction
2) Objectives,
3) Flowchart
4) Use case study area description
5) Problem definition and specifications
6) Data requirements
7) Analysis steps
8) Results
9) Conclusions

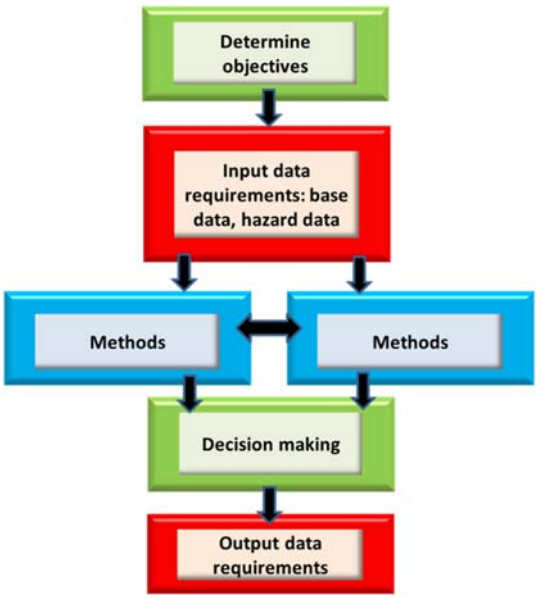


Figure 8 Conceptual structure of the use cases

The methodology book will complement the use-case book by focusing on the methods for generating landslide and flood hazard and risk information for different scales (nationwide, local and for detailed areas) and taking into account different situations of data availability. It contains the following sections: 1) Analyzing triggers, 2) Flood hazard assessment, 3) Landslide hazard assessment, 4) Loss estimation, 5) Evaluating different planning alternatives, 6) Land use planning and management, 7) Critical infrastructure, and 8) Writing TOR's.

The data management book addresses issues related the collection, management and sharing of spatial data related to landslide and flood hazard and risk. This book will detail the types and quality of data needed to analyze hazards and inform planning activities at different scales and methods for data creation and sharing. It consists of the following chapters: 1) Data requirements, 2) Data collection: Base data, 3) Data collection: Hazard data, 4) Data collection: Assets data, 5) Managing geospatial data, and 6) Sharing geospatial data.

The Handbook will be implemented as a web-based platform at the following web-address: www.CHARIM.net (see also figure 9). The contents will be downloadable in the form of PDF documents, based on the selection of the user. The website will be designed to be easy to understand and to use with no user manual required, however a help section will be implemented to guide the first-time-user. As a web-based platform it can contain various media, depending on the subject and needs, such as text, images, graphs, maps, animations, video, audio and can be linked easily to external sources such as web-portals of the target countries and relevant websites, papers on various topics, etc.

Figure 9 User interface for Handbook

3.5.2 Afternoon program

The following three parallel sessions were held:

- **Chief planners** went through a number of use cases that deal with physical planning problems. Coordinated by ITC (M. Brussel) and UWI (C. Griffith-Charles).
- **Chief engineers** went through a number of use cases focusing on engineering problems. Coordinated by ITC (R. Hack) and AIT (N. Anwar);
- **Geospatial experts** went through a number of use cases on geospatial data management. Coordinated by AIT (M. Hazarika) and UWI (T. Hosein).

The aim was to discuss and work out three examples of use cases and get feedback on the presentation, level of detail required, and use case examples. The groups were given one hour to identify specific problems in their work and work out three examples in their countries, how they could be solved, which steps are needed and what are the (data) requirements. The results were presented in one flowchart per problem on Friday morning by one of the participants.

3.5.3 Session with the Chief Planners:

Afternoon program for Thursday 2 October: session with chief planners

Time	Topic	Responsible
13.30 – 14.00	Introduction of the process for the afternoon	Mark Brussel (UT-ITC)
13.40 – 15.00	Work out one of the use case cases related to national land use planning and hazard/risk requirements: design of flow chart with steps	Chief planners with support from Mark Brussel, C. Griffith-Charles, and Edward Smith.
15.00 – 15.30	Coffee Break	
15.00 – 16.00	Work out a second example of a use case cases related to local land use planning: design of flow chart with steps	
16.00 – 17.00	Work out a third example of a use case cases related to planning safe infrastructure: design of flow chart with steps	

Results of the discussion with the chief planners

The participants worked in two groups of two persons each. Mrs. Karen Augustin and Mr. Fabien Purcell produced a work flow for a physical planning framework that can incorporate risk and hazard information to assist in decision making. Mrs. Gina Young and Mr. Miguel St. Ville elaborated a use case work flow for relocation of a school as well as a flow work flow for the preparation of local area development plans.

Example 1: Physical Planning Framework - Incorporating risk and hazards

This example addresses the preparation of a National Physical Development Plan (NPDP) that incorporates hazard and risk information as is required in Saint Lucia. The NPDP presents the proposed development for the country and should take into consideration the potential for hazard occurrence as these can impact the ability for sustainable and secure development. The problem is not only to determine how the information on hazard and risk can be used in the development of a NPDP but also to determine its most appropriate location in the work flow. This example was aimed at discussing how and where this would be best.

The group discussed the inputs required for developing a physical planning framework and that these should at least include information on the characteristics of the country, the Terms of Reference for preparation of the NPDP, and a Strategic Impact Assessment. Existing policies that need to be reviewed for preparation of a national physical development framework are the Land use Policy and the Forestry policy. In addition revision is required for existing and future plans for coastal zone management, marine parks, protected areas, conservation guidelines, economic plans, agricultural plans and government strategies both short term and long term.

Existing data should also be gathered and reviewed for applicability to the process in terms of scale, precision, currency, comprehensiveness and completeness. The extensive data that are required include: the current population distribution throughout the country, the location, nature and adequacy of the transportation network, the location of drainage networks including drains, culverts, and bridges, and the road network. Data is also required on the location and nature of the water distribution network, the electricity and the telecommunications networks. In the social services sector, data is required on the location of education and health facilities, community centers,

emergency centers, sports facilities, and security (police) and fire facilities. Environmental data such as soil types, geology, natural drainage (rivers, streams, gullies, ponds, etc.), slopes, land formations, and topography are also required. Vegetation cover and land use of various types including forestry, fisheries, commercial, industrial, and residential are also required as well as data on the type of the existing beaches, whether they are stony or not and on the type of sand, whether they are white, grey, or black. In the agricultural sector, data is required on horticulture, animal husbandry, and other types of farming.

The next step is to incorporate the data on hazards and risks into the creation of the national physical development plan. Data are needed on all past (natural) hazardous events and their impacts, such as hurricanes and storms with high intensity rainfall that can cause flooding, soil erosion and landslides, (including rock falls and debris flows), and high intensity winds that cause the breaking of trees and damage the built environment, and drive storm surges in the coastal areas and beach erosion. And there are other non-hurricane related hazards such as drought, and excessive heat, volcanic eruptions and seismic activity.

If existing data is not sufficient for the analysis of these hazards, additional data need to be acquired. Ideally the spatial information system should include base maps, rainfall data, slope angles, and historical data (past hazard events, landslides, wind statistics, land cover, soil characteristics, present land use, statistics on population, households, and rainfall intensity in terms of quantity over at least the last 10 years). For the detailed analysis of stream flow there should also be data on cross sections of watercourses, river profiles, slope profiles, drainage networks, and drainage infrastructure such as culverts and bridges.

The results of an analysis that incorporates data on hazard and risk should include mapped data on past events. There should be hazards maps of floods, landslide, coastal erosion, volcanic activities, and earthquakes. This does not only hold true for the NPDP but also for the sector plans, the regional (watershed) plan, the local area plans, all the way down to the lot plan.

Example 2: Relocation Use Case

This example examines the relocation of a school on St. Lucia that was badly affected by floods. The key issue to be addressed is what hazard and risk information needs to incorporated in the relocation planning.

Several datasets are needed for the initial assessment of the relocation site of the school. The data on the demographics of the proposed area in which the school is to be relocated needs to be collected such as the number of children under the age of 14 as well as the size of the working population and the economic activities of the community. In addition an inventory is needed of the number and use of all existing public facilities in the vicinity including a structural valuation and an inventory of all available public land in the community. Each site is then put through an evaluation process that is illustrated by the flow chart prepared by the participants and shown in Figures 10 and 11.

The workflow for site relocation illustrates that the sites are first tested for size to assess their suitability for the construction of a school. If the site passes this hurdle, it moves on to the next stage. The data on hazard and risk is then incorporated as the second criterion for selection. If risk is moderate to high, the site is rejected. Otherwise it moves to the next stage, which is to test its connectivity to the existing road network. If the proximity is less than one mile to a road, the site

undergoes a geology test and a test of its current land use. If the site is vacant or has an agricultural value of less than 3rd class, or is covered in secondary forest it is considered acceptable for relocating the school. If it is covered by primary forest an additional environmental clearance is required before the school site can be selected.

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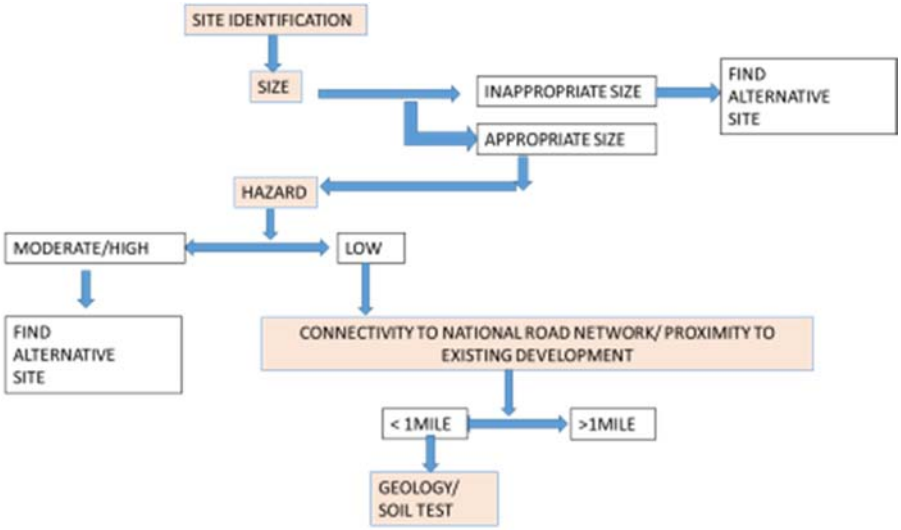

Figure 10 Site selection flow chart for school relocation; part 1: site investigation (Source: unknown)

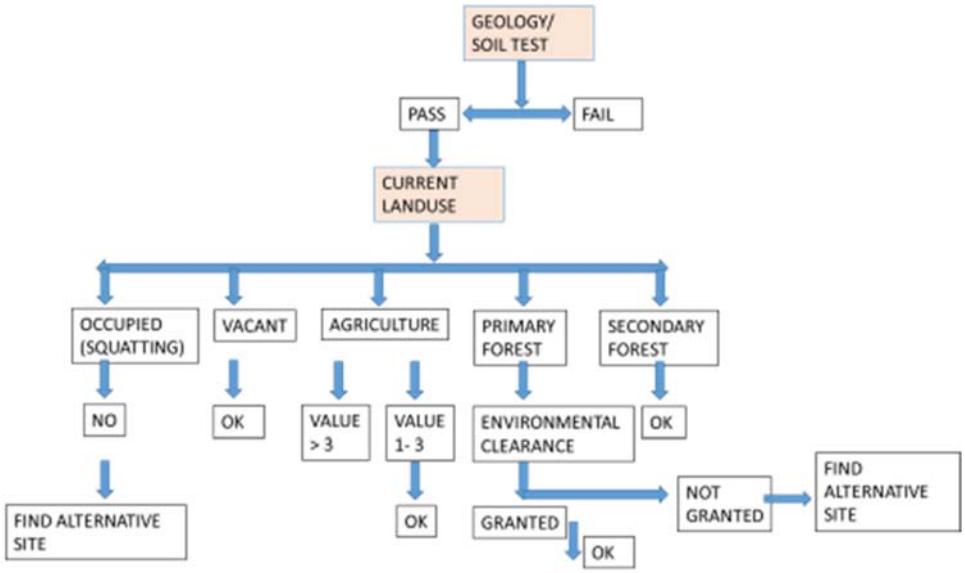

Figure 11 Site selection flow chart for school relocation. Part 2: Site selection (Source: Unknown)

Example 3: Local Area Development Plans

The preparation of a Local Area Development Plan (LADP) that incorporates hazard and risk information requires more detailed information than required for the NPDP. The participants discussed, prepared and presented a process for including these data.

It was determined that the types of hazard information required for this purpose would include, for countries of this region, flooding, volcanic activity, landslides, storm surges, debris flows, and wind, particularly from hurricanes. The participants selected flood hazard as example for a more detailed examination. To incorporate flood hazard information in the LADP requires of course flood intensity maps (e.g. flood depth) but also other spatial data such as elevation, current land use/cover, soils, ownership (cadastral), buildings, location of public buildings, road network, drainage (rivers, creeks, and other water bodies) and population. All of this data would be required at a large scale suitable for local area plans.

There would then be a need to estimate the future demand for land for different purposes including residential, green/open space, commercial, and tourism. The determination of the future residential needs would partially be based on population growth. The determination of the commercial, tourism and other uses would be partially based on past and present trends.

The flood intensity maps should be categorized in at least three categories, e.g. low, medium and high intensity flooding. Development would be steered away from the high and moderate intensity flooding areas but there would also be a need to decide if any use would be or could be permitted within these flood prone areas. The planners would set standards/parameters for development in moderate to high intensity flood hazard areas based on the premise that mitigation measures could be put in place for flooding. The planners would then conduct field verifications of the plan. They would also consult with relevant departments and agencies to assist with validation of recommendations for development/use.

For any future development in flood-prone areas, an application needs to go through an environmental clearance process from NEMO. There can be a grand-father clause for development that is already established before the creation of the local area plan. A specific time frame can be given for allowing development such as 5-10 years, and thereafter there is to be no development in the areas of medium and high intensity flooding. The issue of compensation for loss of value still remains, as well as relocation costs for established developments with excessive risk.

3.5.4 Session with the Chief Engineers

Afternoon program for Thursday 2 October: session with chief engineers

Time	Topic	Responsible
13.30 – 13.40	Presentation of aspects related to engineering geology and their relation to the Handbook. Influence of weathering on design of mitigation measures	Robert Hack (UT-ITC)
13.40 – 14.00	Presentation of aspects related to structural engineering and their relation to the Handbook. Incorporating landslide and floods in existing building codes.	Naveed Anwar (AIT)
14.00 – 14.20	Rainfall analysis, flow analysis and also some experimental hydraulic modeling of culverts along the George Prince Highway	Mark Trigg & Andrew Smith (University of Bristol & SSBN)
14.20 – 15.00	Work out one of the use case cases related to engineering aspects and roads: design of flow chart with steps and data requirements	Chief engineers with support from Robert Hack, Naveed Anwar, Mark Trigg, and Cees van Westen
15.00 – 15.30	Coffee Break	
15.00 – 16.00	Work out a second example of a use case cases related to engineering aspects and critical infrastructure design: design of flow chart with steps and data requirements	
16.00 – 17.00	Work out a third example of a use case cases related to engineering aspects and the design of mitigation measures: design of flow chart with steps and data requirements	

Results of the discussion with the chief engineers

Example 1: Roads in flood affected areas

The use case selected to be worked out was the need for a road to cross a watercourse (river, stream, creek etc.) and remain passable during heavy rainfall events. The main question is: What flow to use and how to calculate it? To answer it several considerations need to be taken into account. For instance, design is a balance between the likelihood of an event (its return period), the costs of designing and building the culvert and the importance of the road. The following steps were identified:

Identify catchment/watershed boundary.

For this contour maps or digital elevation models are required.

Determine catchment characteristics.

With the catchment boundary, it is possible to determine the catchment area, flow path length and what the characteristics are. It is also possible to determine other characteristics (if the data is available) such as: soil types, land use, vegetation types and geology.

Estimate design flow.

Using an appropriate relationship, the next step is to determine the design flow for a given design return period. Ideally a nationally developed approach would be used, else one could apply an approach from a country with similar climate conditions.

Assess required capacity.

Simple capacity calculators or Hydraulic models

Example 2: Future slope stability

As second example, a use case was discussed on the influence of degradation of slope material and the subsequent future instability of slopes. Any man-made slope resulting from an excavation, for example, road cuts and excavations for housing, are subject to degradation of the slope material. The material in the slope will undergo stress relief and the influence of weathering after excavation due to the changed stress regimes in the slope material and of being exposed to the influences of the hydrosphere, i.e. rain and temperature changes. Stress relief and weathering result in lower strength of slope materials, breaking up of rock and soil masses, and changes in mineral content. The degradation causes lower geotechnical properties of the material with time and slopes may become instable in the future. In particular, volcanic materials are prone to rapid weathering because part of the constituent minerals are instable under conditions at Earth surface. Some of these minerals change into clay minerals when exposed, hence a slope cut in a granular largely clay-free material at time of excavation may become a slope in clay-rich material within its engineering lifetime. Granular clay-free material sustains slopes with higher angles and larger height than slopes in clay-rich material. The climate with relatively high temperatures and humidity on the Eastern Caribbean islands, also increases the speed with which weathering occurs and increases the problem of changing material and subsequent instability of slopes. Figure 12 shows an Example of road cuts along the East Coast Road St Vincent, near the control tower of the new airport. The slopes have been excavated only a couple of years ago and show signs of instability due to degradation of slope material causing slumps of material and rock blocks to roll onto the road imposing a serious risk for the users of the road.

Various remedial measures can be applied to ensure the stability of slopes in the future and to reduce the risks for the users of the road. These range from expensive to relatively cheap. Expensive solutions are re-routing, i.e. making a new road on another location, tunnels (high initial investment, but low maintenance costs), or making galleries to avoid material falling from a slope onto the road. Cheaper solutions are for example, re-excavation in which the slopes are re-excavated with a bench along the road and with lower slope angles adjusted to the materials in the slope and anticipating future degradation of geotechnical properties (Figure 13). Another relative cheap solution is netting, in the case of which a net is hung over the slope in such a way that material detaching from the slope is not reaching the road but will fall onto the bench (Figure 14).

Figure 12 Example road cuts along east coast road St Vincent, near control Tower, new airport (Photo: Robert Hack, 2014)

Figure 13 Re-excavation of road cuts with benches along the road and lower slope angles to reduce risk for users of the road (photo Hack, 2014).

Figure 14 Netting to prevent loose material and rock blocks to fall onto the road (road in Falset area, Spain; photo: Huisman, 2002).

Example 3: Embankments

Embankments are mostly constructed with soil and rock excavated nearby. Much of the soil and rock excavated is often already in highly weathered state. This "cut-and-fill" material will disintegrate rapidly and intensified weathering will cause mineral changes (such as clay forming; see use case on slope stability before). Hence, calculations of stability of embankment material have to take future material changes into account. Alternatively, retaining walls or plateaus on piles can be used to provide the additional space required for roads and housing (figure 15).

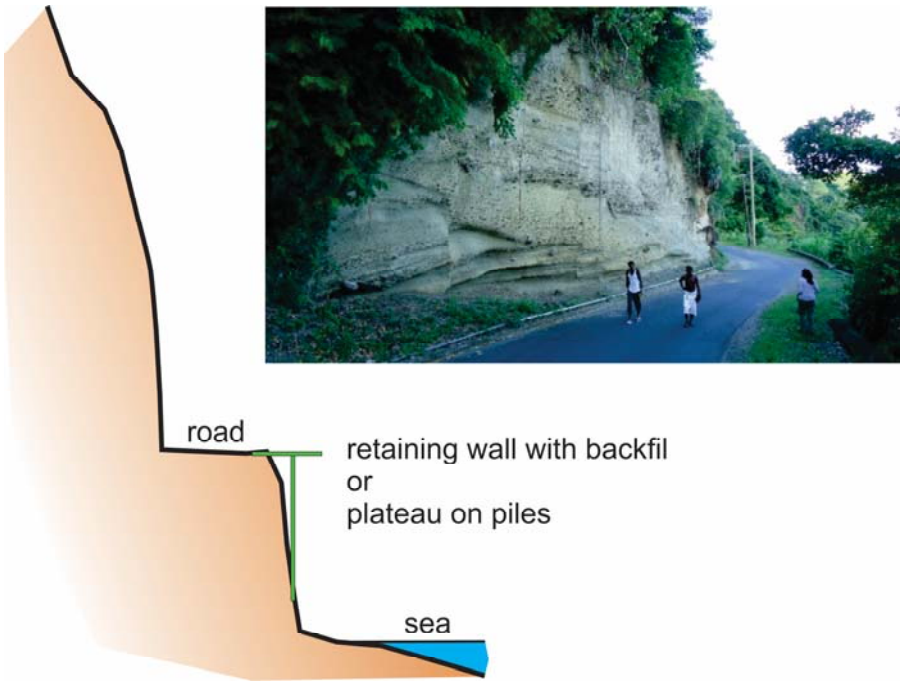

Figure 15 Road widening through retaining wall of plateau on piles instead of embankment of dumped material.

3.5.5 Session with the Geo-Spatial experts

Afternoon program for Thursday 2 October: session with geospatial experts

Time	Topic	Responsible
13.30 – 14.00	Introduction of the process for the afternoon	Victor Jetten (UT-ITC)
14.00 – 15.00	Identify issues related to spatial data in the countries that need to be addressed – and where the handbook could provide guidance / support	Geospatial experts with support from Manzul Hazarika (AIT), Tarick Hosein (UWI), and Victor Jetten (UT-ITC)
15.00 – 15.30	Coffee Break	
15.00 – 16.00	Discussion continued	
16.00 – 17.00	Wrap-up	

Results of the discussion with the geo-spatial specialists

The meeting began with a comparison of practices and general discussion on data management. Technically the islands use ArcGIS and/or QGIS as systems to work with spatial data. Since both software programs use common file formats (GeoTIFF, Shapefiles) this does not pose a problem. The choice for QGIS seems to be a financial one. A clear concern that was identified was the maintenance of data. Since the GIS units consist of only few persons, the practice is that much of the data resides on individual hard-drives and not on central servers or on the GeoNodes. Problems arising from a lack of data sharing include: the existence and availability of data is unknown and with government staff leaving their jobs data can be lost or inaccessible. The participants of the meeting voiced the need for a better data policy with clear guidelines. Where such policies do not exist, they must be created and where they do exist they need to be better implemented. This also relates to meta-data,

which is not always present, or lost over time. Also original data is sometimes lost, and only copies are available (while sometimes in the process of copying meta data is lost).

A second topic addressed, was the use of spatial data by the planning and engineering offices. According to the participants, the planners and engineers are usually not clients of the geospatial experts and the use of GIS data is not in their day to day workflow. If spatial data is used, it is on a hardcopy level. The spatial offices produce data for other departments and ministries, e.g. a map of rare species which was produced for the forestry department. This also results in datasets collected by other ministries that lack spatial attribute information, such the St Lucia list of bridges and culverts that does not contain the coordinates of the assets. This decreases its usability especially in combination with other spatial data such as hazard layers.

As third topic data quality was discussed. All participants recognized that there are data quality issues which exist on two levels. The first level are technical issues such as geo-referencing and projection problems that can be solved by the geospatial experts. They have sufficient capacity to make a consistent geo-spatial database. The second layer are issues related to the quality of the content, e.g. whether the correct river pattern is digitized, and if that pattern makes sense from a hydrological perspective. This resulted in a discussion on how far the involvement of the geospatial analysts goes. They clearly felt they could do more than provide correct basic spatial data, and perform this type of analysis about the correctness of the contents. Some experts suggested that some basic GIS-based flood analysis would be possible, whereas others indicated that flood hazard analysis was already a too complex task. All agreed that the analysis on geotechnical properties of a building site - with possible (legal and financial - liabilities, was clearly out of the question. These 'second level' issues are clearly a grey area, where more applied information could be generated, but some training would be needed.

The following key areas of issues were identified:

1) Data Homogenization (*Examples from Grenada and St. Lucia*)

Existing data is available in different map projections which make data integration difficult – if not impossible, especially for less-expert users. Furthermore, the available data is not uniform in terms of accuracy and precision and in many cases data quality is even unknown. There is adherence to data standards, such as ISO-19115.

2) Generation of Digital Elevation Model (Example *Grenada*)

Digital Elevation Models (DEM) are essential base data for almost all application domains of spatial information. Unfortunately existing DEMs are often of insufficient quality or are not uniform (part of the country is LiDAR, but other parts are e.g. derived from SRTM). Also, the source data is often unknown due to lack of meta-data. This means that there is no evaluation possible of their accuracy which impedes their use/integration with other data sources.

3) Use of satellite data (Example *Saint Vincent*)

Satellite imagery is often available but there is a lack of capacity to process the images and carry out analyses such as image classification for land cover mapping and create other value-added products.

4) Generation of Land use map (Example *Dominica & Saint Lucia*)

Land cover mapping requires a uniform classification scheme which is often lacking. Also linking the land cover with additional attribute information, such building use, agricultural crops, etc. is often not possible.

5) Generation of building and road maps (Example *Saint Lucia*)

On Saint Lucia high resolution satellite data are needed for the generation of a building and road database, as base maps to link attribute information to.

6) Generation of population map (Example *Belize*)

To have a better understanding of population density distribution, good land-use maps could help.

7) Landslide inventory mapping (Example *Saint Lucia*)

High resolution imagery could be useful for the generation landslide inventories.

3.6 Friday 3 October: Planning for the coming period

Program for Friday 3 October

Time	Topic	By whom?
09.00 – 09.30	Presentation of the worked out use case by the chief engineers group & discussion	Miguel St. Ville
09.30 – 10.00	Presentation of the worked out use case by the chief planners group & discussion	Karen Augustin
10.00 – 10.30	Presentation of the worked out use case by the geo-spatial expert group & discussion	
10.30 – 11.00	Coffee break	
11.00 – 11.30	Summary of the discussions and consequences for the Handbook	Cees van Westen (UT-ITC)
11.30 – 12.00	Follow up activities: - Fieldwork of the ITC MSc-students - Field visits of the CHARIM team experts - Intensive training course at ITC - Methodology workshop at WB in Washington	Cees van Westen (ITC-UT)
12.00 – 12.30	Final discussion on other topics	
12.30 – 12.45	Concluding remarks	Physical Planning & Works SVG, and World Bank
12.45 – 13.45	Lunch	

The morning started with the reporting back from the three parallel sessions of the previous day. The contents of some of the use cases were presented in sections 3.5.3 to 3.5.5 of this report.
A summary of the concluding remarks and follow-up activities is presented in the next chapter.

4 Concluding remarks and follow-up

4.1 Spatial data

During the first part of this project the CHARIM team has collected more than 150 GB of data. A lot of it might be repetitive, and we need to spend a lot of time in harmonizing the data. This data harmonization process includes - among other aspects – at least the following activities:

- Determine the projection parameters for the different countries.
- Re-project all data in UTM WGS84
- Do rubber sheeting for those layers that are still not fitting.
- New data will be collected and stored in UTM WGS 84
- Transfer of data to MSc students and partners
- Deadline: end of October.
- Make design for metadata (AIT & UWI)
- Prepare the final dataset, and make them available on the GeoNodes of the countries

The British Geological Survey (BGS) is currently working on image interpretation of satellite imagery for Grenada and Saint Luca that should result in the following layers of spatial information:

- Landslide inventory maps for the period 2010 – 2014 will be made available in early November to ITC team;
- Land cover maps for the current situation will also be made available in early November to ITC team.
- Final maps will be made available by the end of December.

4.2 National scale hazard maps

With respect to the national scale hazard maps of the four island countries, ITC will have worked out the methodological approach by mid-November and SSBN will do the same for Belize. ITC MSc students will carry out their fieldwork in the following weeks on the four island countries, collecting additional data that may be used in the generation of the hazard maps. Additional activities that still need to be carried out are:

- Detailed image interpretation for missing datasets will be carried out in November. Finalization: end of November
- Rainfall analysis will be carried out in the period: Mid October – Mid November.

For Belize, existing preliminary maps will be worked out in the coming period:

- including storm surges in the modelling
- Further rainfall analysis
- Further verification
- Analysis of results at local scale using high resolution data made by BGS: December

4.3 Use Cases

During the last two days there have been many discussions about possible use cases and some examples have been worked out – as were presented in this report. Many other ideas were generated as summarized in the following list. On most of these potential use case candidates, additional information is required and the MSc students will try to retrieve related documents in the coming weeks. Also members of the CHARIM team have visited some of the sites mentioned above in the days before this workshop, or they will go there in the following days. These visits are important to collect observations, field data and to discuss with local experts about the problems. The schedule of the visits of the CHARIM experts to islands is given in the following sections, as well as the field work schedule of the students.

Depending on the quality of the additional information, ITC will draft a final list of use-cases in an extended table of contents of the handbook by the end of October. The participants in the workshop are invited to continue to contribute to the development of the use cases and to send ITC any additional technical reports or records of damaging events that may be of use for the use case development. Of course their support to the students will be very important!

NOTE: At the time this report was written, the extended table of contents has been drafted and is attached to this report as annex 3.

The list of possible use cases:

Dominica:

- Shelter planning
- Building codes
- Building control and hazard information
- Culvert design along main road
- Stowe area: rock fall analysis along the road

St. Lucia

- Castries: local development plan.
- New road from Rodney Bay to Dennery
- Water supply for Gros Islet and Castries
- Bridge planning (bridges destroyed by Christmas eve storm)
- School planning: Canaries school, Bexon school etc.
- Relocation of schools: courthouse in Castries.
- St. Urbain, SW area in Saint Lucia: culvert design.

St. Vincent and the Grenadines

- Manning village: relocation planning.
- Milton Cato Memorial Hospital. New hospital planning
- Belmont landslide.
- Road cuts and slope stability.

Grenada:

- Grenville: Local land use planning
- Charmin: Local land use planning.

- New landfill site
- New bridge construction (after 2013 events)
- Balazar estate.
- Gouyave: flood hazard mitigation planning: alternatives
- St. Johns river: flood hazard mitigation planning
- St. Patrick road improvement project.

Belize

- Cayo district: Land subdivision process
- Ladyville area, Belize: design of culverts in low lying areas
- National scale flood assessment
- Loss estimation for river flooding in low lying areas

4.4 Visits of the CHARIM experts to the Island countries

In conjunction with the workshop the following visits by CHARIM experts have taken place (before) or will take place (after) the workshop. Also during the workshop some experts visited sites on St. Vincent.

St. Lucia:	Cees van Westen	20 Sept. – 24 Sept.	
	Naveed Anwar	27 Sept. – 30 Sept.	
	Robert Hack	9 Oct. – 13 Oct.	
St. Vincent:	Tarick Hosein	20 Sept. – 24 Sept.	
	Robert Hack	24 Sept. – 4 Oct	(incl. the workshop)
	Cees van Westen	27 Sept. – 4 Oct.	(for the workshop)
	Victor Jetten	27 Sept. – 4 Oct.	(for the workshop)
	Mark Brussel	27 Sept. – 4 Oct.	(for the workshop)
	Manzul Hazarika	27 Sept. – 4 Oct.	(for the workshop)
	Mark Trigg	27 Sept. – 4 Oct.	(for the workshop)
	Andy Smith	27 Sept. – 4 Oct.	(for the workshop)
	Tarick Hosein	28 Sept. – 4 Oct.	(for the workshop)
	Charisse Griffith Charles	28 Sept. – 4 Oct.	(for the workshop)
	Naveed Anwar	30 Sept. – 4 Oct.	(for the workshop)
Dominica:	Cees van Westen	4 Oct. – 8 Oct.	
	Victor Jetten	4 Oct. – 8 Oct.	
	Naveed Anwar	4 Oct. – 7 Oct.	
	Robert Hack	4 Oct. – 9 Oct.	
Grenada:	Mark Brussel	21 Sept. – 27 Sept.	
	Cees van Westen	24 Sept. – 27 Sept.	
	Victor Jetten	8 Oct. – 11 Oct.	

4.5 ITC students fieldwork schedule and their research topics

The ITC students will stay for a longer period on the islands to collect data for their MSc research and for the development of the use cases. The CHARIM team has requested support from the authorities to assist the students in their data collection efforts as much as possible.

St. Lucia	Jovani Bogale	20 Sept. – 4 Oct.
	Christoffer Lundegard	20 Sept. – 11 Oct.
	Anne Uwakwe	20 Sept. – 18 Oct.
	Mulenga	4 Oct. – 18 Oct.
St. Vincent:	Xsa Canria	20 Sept. – 4 Oct.
	Mulenga	20 Sept. – 4 Oct.
	Diana Lozana Zafra	20 Sept. – 4 Oct.
Dominica	Xsa Cabria	4 Oct. – 18 Oct
	Jovani Bogale	4 Oct. – 18 Oct
	Diana Lozana Zafra	4 Oct. – 18 Oct
Grenada	Mujeeb Alam	21 Sept. – 18 Oct.
	Aris Pratomo	21 Sept. – 18 Oct.
	Christoffer Lundegard	11 Oct. – 18 Oct.

MSc topics of the students

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?

- Collection of available historical landslide inventories;
- Image interpretation for 2014 & field checking;
- Collection of factor maps (lithology, land use maps, soils, Digital Elevation Model, roads, streams, rainfall data etc.)
- Landslide susceptibility assessment
- Landslide run out assessment
- Generation of landslide density per susceptibility class and per return period.

Jovani Yifru Bogale (Male, Ethiopia)
National Scale Landslide Hazard Assessment along the Road Corridors of Dominica and St. Lucia

- Collection of available historical landslide inventories;
- Collection of road maintenance records;
- Image interpretation for 2014 & field checking;
- Collection of factor maps (lithology, land use maps, soils, Digital Elevation Model, roads, streams, rainfall data etc.)
- Subdividing road into segments with similar characteristics;
- Landslide run-out assessment
- Generation of landslide density per susceptibility class and per return period.

Andreas Christoffer Lundegaard (Male, Denmark)
Flood hazard assessment and transport network vulnerability on St. Vincent and Grenada

- Collection of data on roads, culverts and bridges;
- Collection of rainfall data (> 1 day records);
- Collection of earlier flood modelling work;
- Collection of factor maps (land use maps, soils, Digital Elevation Model)
- Running a flood model for Saint Lucia for specific events and analyzing possible disruption in the road network;
- to identify the current role of the national and local agencies in relation to flooding
- to identify the transport network users who are most vulnerable to breaches in the network
- to identify the use of alternative transport if the road network is blocked

Rahmat Aris Rratomo (Male, Indonesia)
Response of Flash Flood Behavior to Hazard Reduction in a Small Island: a Case Study in Grenada

- Collection of land use maps
- Soil maps, and soils sampling (Ksat, porosity, grain size distribution)
- Cross sections along the river
- Rainfall analysis for specific storms
- Flood modelling using OpenLISEM for small catchments
- Testing in other catchments (using stream gauge data great river Baltazar estate, FEWS report)

Mujeeb Alam (Male, Pakistan)
Application of hazard and risk information in spatial planning in Grenada

- Determine current state of use of hazard and risk information in the physical planning of Dominica, Grenada, St. Lucia, St. Vincent, and Belize
- Conduct hazard and risk assessment for specific planning problem areas in Grenada
- Select suitable alternatives and future scenarios that incorporate hazard and risk information in spatial planning?

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

- Work with local disaster management committees
- Develop building database. Get data from Statistics
- Collaboration with WB work through ministry of statistics?

Chishala Mulenga (Male, Zambia)
Influence of weathering on geotechnical properties of road-cut slope mass and embankment fill in Saint Lucia and Saint Vincent

- Detailed surveys along outcrops of geotechnical units to describe rock and soil mass characteristics
- Derive geotechnical parameters from these
- Use these in the stability assessment of cut slopes
- Make prediction on future behavior of cut slopes

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

4.6 Scheduled follow-up activities

The following follow-up activities were decided upon:

1) An intensive training course for selected experts from the target countries (one planner and one engineer) to receive lectures and guided exercises on the following topics:
   - Disaster Risk Management for physical planning and infrastructure development
   - Spatial data for disaster risk management
   - Digital Elevation Models
   - Sources of spatial data
   - Spatial data management
   - Spatial modelling for flood- and landslide hazard assessment

   Tentative schedule: November – December 2014.

2) A 3-days workshop in Washington DC with CHARIM and WB staff to discuss the methodology for the national scale hazard mapping in further detail. Scheduled for December 2014

ANNEX 1 CHARIM workshop information for the invitation letter

See accompanying PDF document

ANNEX 2 Presentations on the national scale landslide and flood hazard maps

1) Cees van Westen National scale landslide hazard assessment for Dominica, Grenada, St. Lucia and St. Vincent

2) Victor Jetten National scale flood hazard assessment for Dominica, Grenada, St. Lucia and St. Vincent

3) Andy Smith National scale flood hazard assessment for Belize

See accompanying PDF documents

ANNEX 3 Draft Table of Contents of the Handbook

See accompanying PDF document