

Final PEARL Framework and Sourcebook Document

Work Package 1

Deliverable Report 1.2

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Abstract (for dissemination, 100 words)	A sourcebook for end-users that encompasses examples of disaster root cause – from European as well as international events – to improve practical application. The sourcebook will provide ideas of how the approach of the RRCA might be integrated into local development and risk management planning processes and priorities
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1 Final PEARL Framework

1.1 Summary of IPCC conceptual Framework set out in Deliverable 1.1 for understanding the integration of the physical and social drivers and dimensions of flood risk.

The framework to integrate conceptual work across the PEARL project is taken from the IPCC Fifth Assessment Report (2014), which in turn uses a schema derived for the IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (or SREX) (2012). The schema is presented in Figure 1 (below). The IPCC schema is a high-level and holistic schema which allows for the integration of work across a range of disciplinary domains with the requisite flexibility for the detailed application of respective scientific work within and across each domain.

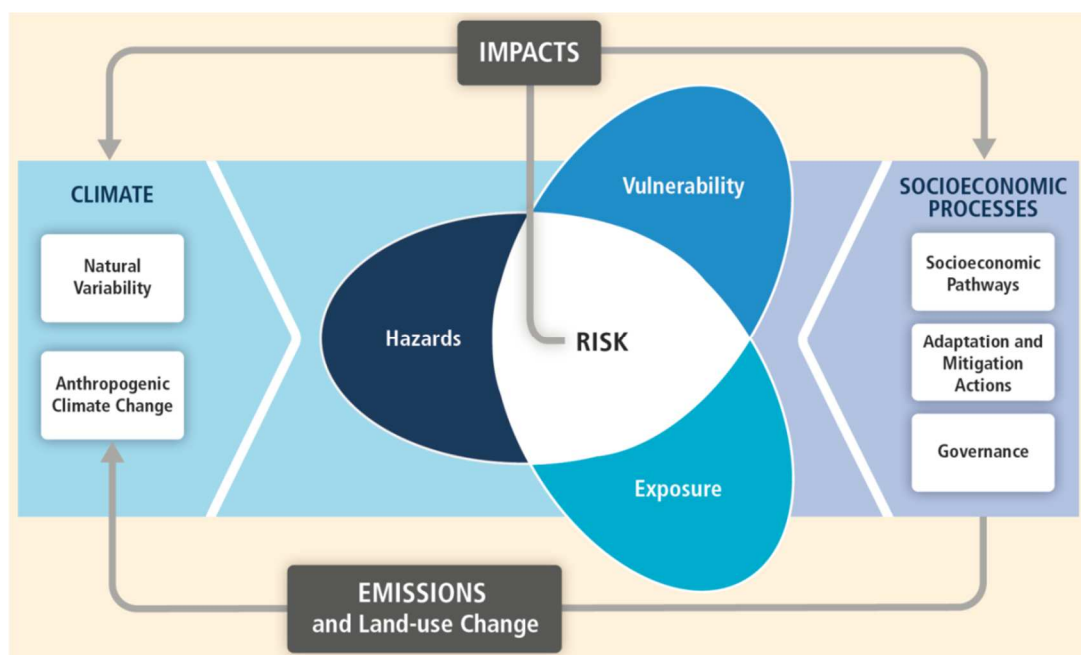


Fig. 1 The IPCC Model of Risk

Source: IPCC 2014

1.2 Summary of the Risk Root Cause Analysis Framework as developed in Deliverable 1.1.

The following figure (Figure 2, below) sets out the Risk and Root Cause Assessment Framework (RRCA) for PEARL. It is divided into three parts: (A) Overall concept, (B) Process, (C) Methodological Approach.

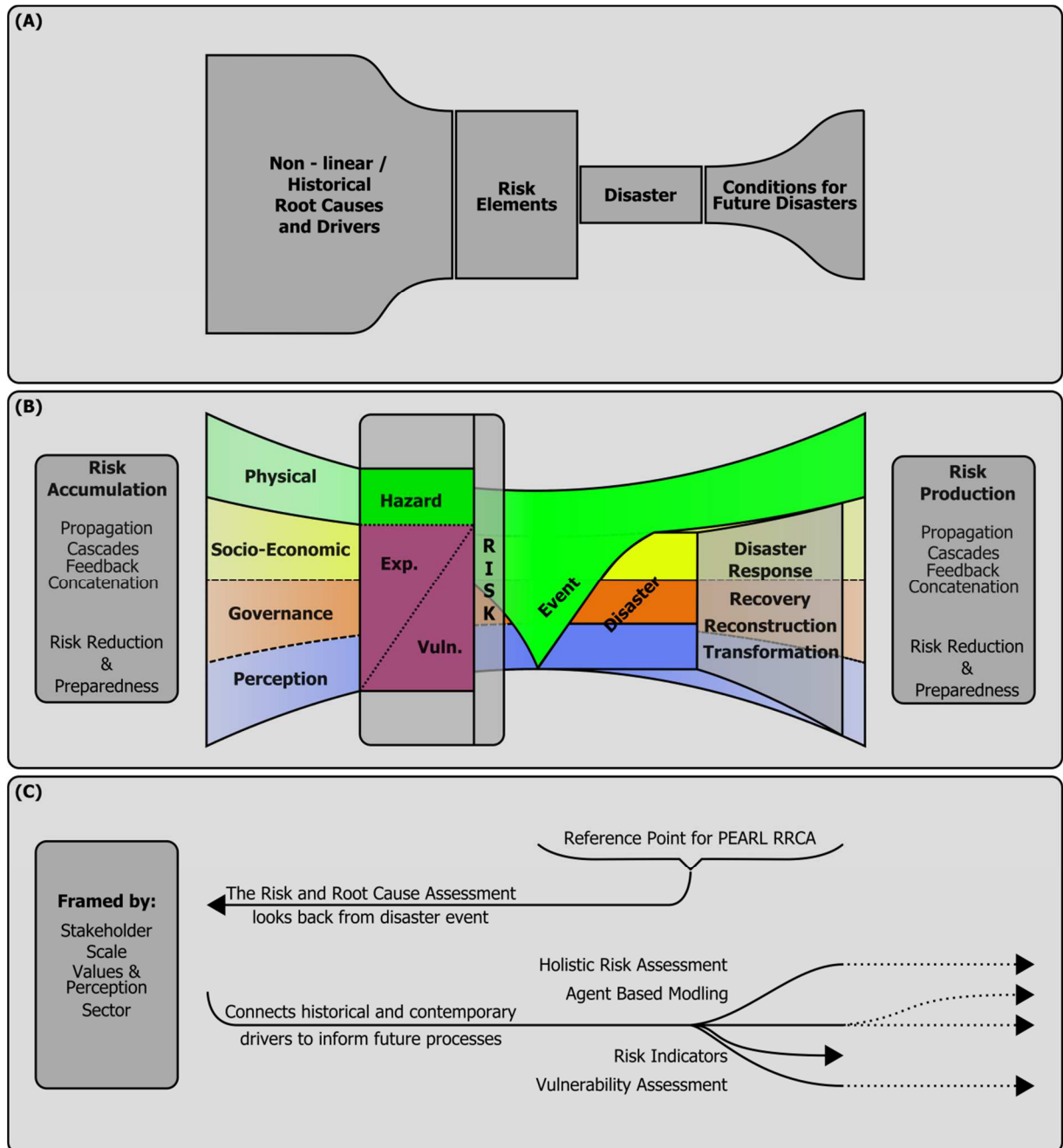


Fig. 2 Proposed RRCA Framework for PEARL

(A) Concept

The overall concept of the RRCA framework is that the historical **root causes** of **risk** are translated by the **drivers of hazard, vulnerability and exposure** into a situation of endangerment (risk). Risk at any given time is an evolving process that can be traced back to its root causes. The occurrence of a disaster and the disaster response sets the conditions for the future, and the magnitude and form of any future disasters.

(B) Process

The RRCA framework is centred on dynamic **physical, socio-economic, governance** and **perception** processes. These four are interlinked in a non-linear fashion and in continuous exchange. Therefore the **risk** – as a function of **hazard, exposure** and **vulnerability** – is displayed at a single point but could be assessed at any given time step (depending on the availability of data). Investigating and learning from the interaction of root causes that lead to an expression of risk (or loss) at any one moment is the analytical focus of the PEARL RRCA. A disaster is signified in the model by the intersection of hazard with social processes. The hazard event impacts on these spheres causing losses and damages.

Following the disaster, **Disaster Response, Recovery, Reconstruction** and **Transformation** processes both influence the physical, socio-economic, governance and perception factors within a spatial entity and are influenced by the historical physical, socio-economic, governance and perception context. These aspects contribute – either positively or negatively – to the accumulation and production of risk. The disasters ‘cycle’ refers to the stages of pre- and post- disaster response, with appropriate actions at all stages necessary to mitigate disaster losses and damages. This cycle of **Risk Reduction and Preparedness** encompasses response, recovery, reconstruction and transformation as well as mitigation and preparedness measures taken in anticipation of a disaster event, but not necessarily following a disaster. Risk reduction and preparedness is therefore represented in both the Risk Accumulation and Risk Production boxes as a process that unfolds before and after an event. While the terms Risk reduction and preparedness are often used to refer to the application of a narrow set of pre-disaster management tools, here they are used in the fullest and most meaningful sense to describe the purpose of all disaster management tools, or the highest order goal of the disasters cycle.

In taking disaster response, recovery and reconstruction measures valuable opportunities arise to reduce and prepare for risk in ways that not only build back to ‘normal’, or the state of affairs prior to the disaster event, but ‘build back better’, preventing the disaster from re-occurring, or at least to the same magnitude. This is captured by the inclusion of the term Transformation, to refer to the process of re-aligning the structures underpinning the disaster to ensure a resilient and sustainable future in a given context. The notion of resilience – the goal, or robustness of a particular system to cope with and recover from disaster events – is therefore subsumed by the term transformation. Sustainable refers not only to environmental sustainability but also social justice and equity, for both current and future generations.

The terms to the left and right of the figure indicate the dynamics of the way in which risks occur. **Risk propagation** refers to the influence of risk over wide spatial and temporal domains, or how risk may have systemic impacts which may not be easily identifiable and may manifest themselves at different points in time to the actual disaster event. **Risk cascading** refers to the cascade of effects of risk from first order, direct impacts to second order, indirect impacts and to third order, systemic risks. **Feedback** refers to the ways in which both the disaster and post-disaster processes (including disaster risk management itself) have impacts that may feed back into the underlying conditions for ongoing risk and subsequent disasters, potentially altering the nature of these conditions. **Concatenation** refers to situations where one extreme event precipitates one or more other extreme events. **Risk accumulation** refers to the potential result of these processes, where risks concentrate across different spatial and temporal scales.

It is important to underline the possible non-linear nature of the processes underlying risk. In a risk cascade, for example, there is no necessary linear relationship between first order and second order impacts. The physical, socio-economic, governance and perception drivers of risk may inter-connect to create risk in non-linear ways. In addition, there is uncertainty at any given moment in time about future risks and disaster events either due to

information deficits or disagreements about what is known or knowable. Such uncertainties shape how risks are estimated and affect decision-making and actions in the governance and socio-economic domains.

(C) Methodological Approach

The reference point for the PEARL RRCA is the study of disaster impacts and losses and post-disaster development trajectories. This focal point in time is bracketed in the RRCA Figure. It provides a critical 'window' through which the historical drivers of risk can be assessed, and their manifestations in the contemporary context analysed. This perspective is then used to inform future risk scenarios. The interpretation of the event, disaster and post-disaster processes is framed by the perspectives and values of different stakeholders, sectors and the scale of the analysis. The Risk and Root Cause Assessment, with its focus on bringing a historical perspective into the present, feeds into other methodologies in PEARL which will be used to benchmark and project future risks. These are a) a vulnerability assessment b) an agent-based model and c) risk and root cause indicators which can be used to assess efforts to address disaster root causes over time.

1.3 Summary of the Holistic Risk Assessment methodological Framework described in Deliverable 3.1 and the integration of Root Cause Analysis in the Framework.

Rather than focusing on specific system components or subsystems, the PEARL Holistic Risk Assessment Framework and Ontology (RAFT) framework focuses on gaining understanding of the structure and behaviour of the system as a whole and it will allow accumulation of knowledge to develop a holistic view on risk, its formation, propagation and cascading. Thus, RAFT framework connects technology with the social dimensions and the natural processes of risk. The drivers of hazard include natural and anthropogenic climate change or variability; whereas, drivers of exposure and vulnerability include socioeconomic pathways, climate change adaptation and mitigation actions and governance (IPCC, 2014a). The two sides of drivers are also related through different governance structures such as land-use policies and emissions. In the framework, the FORIN approach (IRDR, 2011) is used to scientifically investigate the disaster root causes and through process identifies relevant actors, domain knowledge, systems and theories. The framework spans system development over a long period of time (i.e., strategic planning level in relation to policies which implementation/effects may take longer period of time) and relate to emerging system characteristics relevant during a disaster event (operational level).

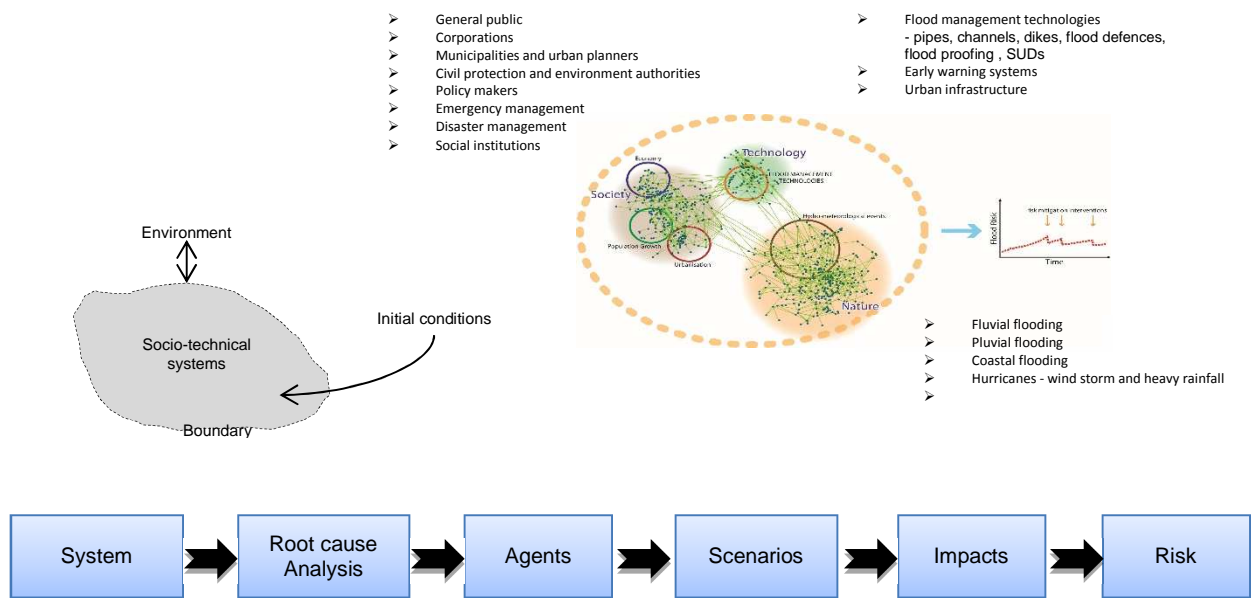


Figure 1 Overall RAFT framework

A very important initial step in the holistic flood risk assessment (HFRA) is to understand the drivers/root causes of hazard, vulnerability, exposure and risk by looking at a range of factors and their interdependencies and interrelations. The framework starts with the system definition, and continues with the identification of key stakeholders using the root cause analysis methodology. The analysis of the stakeholders together with the Ontology provide the input to the formalization of the MAIA metamodel. The MAIA framework generates the rules and behaviour for the agent-based models that are developed in PEARL. Once all Agent attributes, relations among the Agents and Agent actions and interactions are defined, an agent-based model can be formalised. After that, different initial conditions or scenarios can be assessed to quantify Impacts and Risk.

Once the basic information of actors, governing directives, policies, strategies, regulations, plans, decisions and relationships are collected, defined and conceptualized, the next step is to replicate and thoroughly understand the system. That can be achieved through computational simulations. In the holistic framework, an agent-based modelling (ABM) computational simulation approach will be implemented as ABMs provide a platform to integrate subsystems to a whole and visualize, understand and reason about implications of underlying processes.

2 Sourcebook for PEARL Risk Root Cause Analysis (RRCA)

2.1 Introduction, aims and structure

Part 2 presents a user-friendly sourcebook that encompasses examples of disaster root cause drawn from the PEARL project to improve practical application. The sourcebook aims to provide ideas of how the approach of the RRCA might be integrated into local development and risk management planning processes and priorities, in particular informing next steps in the EU Flood Directive Implementation Agenda (flood risk management planning). It presents the RRCA Framework as a practical way to analyse the multiple interactions, feedbacks and thresholds that characterise the relationship between risk and sustainable development, moving beyond dominant approaches to risk assessment that map hazard onto risk in a linear fashion.

The structure of the sourcebook is designed to provide a step-by-step guide to Root Cause Analysis for researchers and policy-makers who are new to the topic. It takes the reader through core questions such as 'what is Root Cause Analysis?' and 'who should be involved in doing it?' Two final sections provide a question and answer guide and user-friendly references guide. The material provided for the Deliverable Paper will be condensed into a brochure which can be published separately on the PEARL website, to increase the visibility and accessibility of the document.

2.2 What is Root Cause Analysis?

There is still limited knowledge about the underlying causes of flood risk and disaster. Existing disaster assessment and evaluation methodologies provide important overviews of current vulnerabilities, capacities and post-disaster conditions, but stop short of investigating why risks and vulnerabilities arise. Root Cause Analysis provides a structured investigation that aims to identify the true cause of a problem as well as lay out a basis for addressing it.

Root causes are the structures and processes that go beyond an individual crisis or event. They can be distinguished from *drivers*, which are the more proximate activities and processes that translate root causes into *unsafe conditions*, or the specific forms of vulnerability to risk that occur at particular moments and in particular places. For example, a first order explanation of disaster loss and damage might focus on the poor application or lack of knowledge of building standards and controls. However, Root Cause Analysis interrogates the underlying economic models and governance structures that manifest in the lack of application of such codes. There are different frameworks to guide Root Cause Analysis. The FORIN (or the FORensic INvestigations of disasters) approach, for example, provides a framework around which to structure core questions about a historic disaster event focussed on risk governance, risk assessment, understanding and awareness and outcomes and impacts. A second Root Cause Analysis model, developed by UNU-EHS (DKKV, 2012), maps the relationship between root causes, drivers and resulting exposure and vulnerability.

The approach described in this sourcebook relates to the framework developed for the PEARL, or the Preparing for Extreme And Rare events in coastal regions, project. The PEARL Root Cause Analysis framework is centred on the physical, socio-economic, governance and perception processes that give rise to risk and disaster. It investigates how these processes map onto flood hazard, exposure and vulnerability, as often latent conditions which manifest in a disaster when triggered by a hazard event. Disaster risk management policies and practices related to response, recovery, reconstruction and transformation (as a long-term process of structural change)

are included amongst the conditions that give rise to risk, recognising that that policies such as insurance or early warning may be as important to the depth and impact of a disaster as the direct hazard impact. The PEARL model aims not only to trace the historical root causes of disaster but also reflect on the role of these factors in driving risks in the present and into the future. Beyond a linear model in which a hazard event results in risk, it provides a framework through which the multiple interactions, feedbacks and thresholds that characterise the relationship between risk and sustainable development can be analysed.

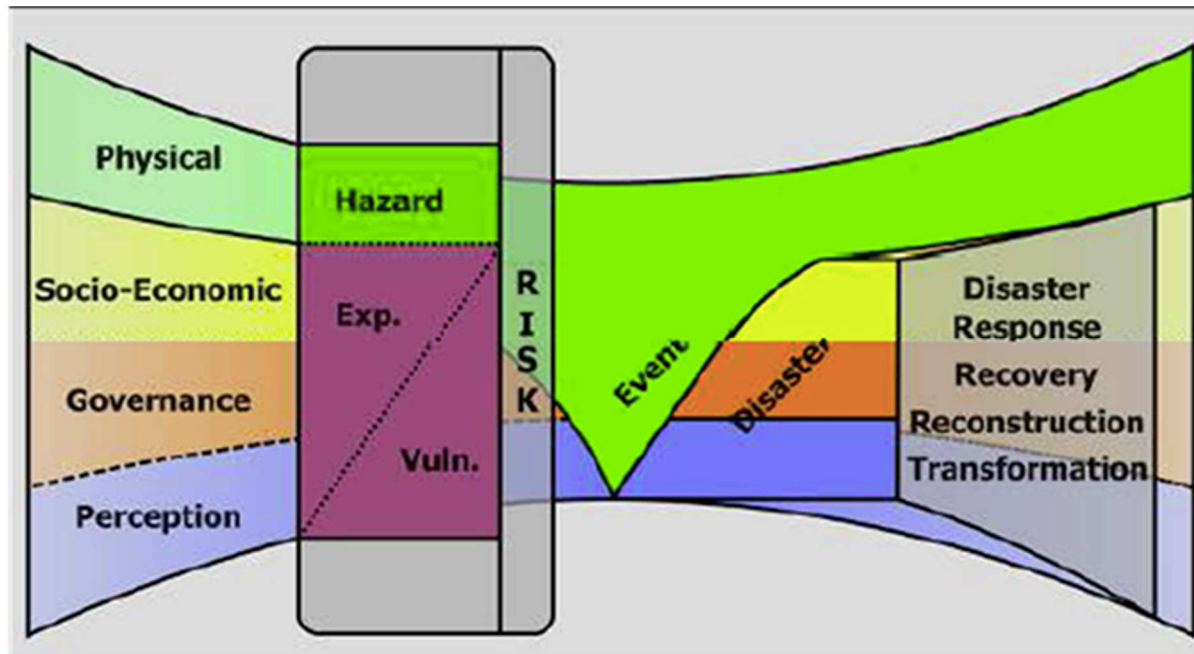


Fig. 4 PEARL Root Cause Analysis Framework based on the FORIN approach

Source: Fraser et al. 2014

A specific feature of the PEARL Framework was its application to small-scale but high-impact disasters. These may not trigger national emergencies but are felt strongly at the local level in terms of the impacts on lives and livelihoods and managed predominantly by local-level governance actors.

2.3 Why do Root Cause Analysis?

Tackling the underlying factors that lead to risk is critical to reducing disaster loss and damage. This is increasingly recognised in international, EU and national flood risk management policies – the Sendai Framework for Disaster Risk Reduction 2015-2030, for example, acknowledges that a range of underlying causes and drivers give rise to disaster risk. While quantifying hazard, exposure and vulnerability has long been a critical part of risk assessment and reduction, Root Cause Analysis is a structured method for deepening these efforts, moving from addressing the symptoms to addressing the causes. In turn, Root Cause Analysis supports the design of structural and holistic solutions to flood risk that have lasting and far-reaching results, beyond short-term, partial interventions that most often focus on response to the detriment of longer-term risk reduction and preparedness efforts.

Root Cause Analysis undertaken by the PEARL project illustrates these points. Root Cause Analysis was conducted for Genoa, Italy, Rethymno, Crete, and St Maarten, Dutch Caribbean. In all three cases, the analysis highlighted the long-standing, development-related causes of risk in these urban, coastal zones: the inter-linked processes of urbanisation, economic development and associated political visions and narratives as well as the influence of urban migration on risk awareness and preparedness. Each case study revealed different ways in

which particular governance structures and cultures interacted with physical, socio-economic and behavioural change to create risk, and how local-scale risks were linked to macro-scale economic and institutional change.

- Root Cause Analysis of annual flooding events in **Rethymno, Crete**, highlighted how flooding related to storm waves and flash flooding, was also linked to the challenges of maintaining existing risk mitigation infrastructure and moving to a more holistic risk governance approach, including greater public awareness-raising. The analysis highlighted how these challenges reflected a long-standing history of weak governance capacity at the local level, political organisation that precluded wide stakeholder engagement and institutional fragmentation of disaster risk management at higher levels of governance. As well as the interactions and feedbacks between these processes, the historic analysis also revealed the discontinuities and non-linear nature of such processes: an earlier period of infrastructure investment by the EU in risk mitigation measures was superseded by a more recent period characterised by the impacts of austerity. However, austerity measures are also rupturing pre-existing political relations, opening up new possibilities in the future for public engagement in disaster risk management in the town.
- Root Cause Analysis focused on the flooding events of 2011 and 2014 in **Genoa, Italy** points up the vital role of early warning systems and structural mitigation works in protecting against rapid-onset flooding due to the complex morphology and climate of the city – which contains multiple river catchments with steep slopes and a small coastal fluvial plain. In particular, the analysis highlighted the governance issues that prevented structural mitigation projects planned as far back as the 1990s from being realised. The interplay between legal and financial issues generated a deadlock that prevented local authorities from effectively reducing risk. The progressive increase of extreme events and the presence of a flexible institutional structure allowed this root cause to be addressed through a change in the criteria for funding allocation and by creating new institutional units to reduce hydrogeological risk. The holistic nature of the Root Cause Analysis brought to the fore issues often hidden from local narratives about the flooding disasters, namely the human resources constraints for the authorities in charge of disaster risk management.
- Root Cause Analysis in **St Maarten, Dutch Caribbean**, brings to the fore the inter-relationship between different aspects of the disaster risk management policy cycle and different types of flood risk. Focussed in particular on flood events in 2014 and 2005, but also the influence of a series of destructive hurricanes in the 1990s on flood risk governance, the analysis showed how improved hurricane communication, preparedness and emergency response measures were not met by improved government land use policies and infrastructure development, despite better construction by citizens and the private sector since the 1990s. The St Maarten case study confirmed the findings of the other case studies that local political cultures and economic interests were highly influential in shaping flood governance systems that impact on how hazards interact with social exposure and vulnerability.
- A desk study of root causes in the **Elbe Estuary and Hamburg, Germany**, highlighted the major shift in governance that occurred after flooding in 1962 – when all flood and storm protection systems were made state property – and has persisted until the present day. As well as identifying historic root cause pathways, the desk study pointed to new and emergent risk drivers, such as climate change, pressure on land for retention areas and public perceptions of security, and presented different viewpoints about the capacity of the current system to manage these risks.

2.4 Who should be involved in doing Root Cause Analysis?

The method for undertaking Root Cause Analysis will vary from place to place. Ideally, however, Root Cause Analysis should be conducted by an organisation or institution able to access many different stakeholders and seen as credible by those stakeholders. This may be an academic institution, or research organisation with experience in social science analysis. Root Cause Analysis may be conducted by an international team, but knowledge of the context is also vital to identifying the right stakeholders to interview and refining the research questions. Building relationships with stakeholders is also important to promoting the uptake of Root Cause Analysis in relevant policies and practices.

A key principle is the inclusion of multiple stakeholders from different disciplinary perspectives. The table below shows the types of stakeholder interviewed for each PEARL Root Cause Analysis case study:

Table 1: Example of stakeholders interviewed for PEARL Risk and Root Cause Analysis Reports

PEARL case study	Stakeholders interviewed
Rethymno, Crete	Water resources and civil protection agencies, former mayor and prefect, NGO representatives, port authority, hotel and restaurant owners, local households
Genoa, Italy	National civil protection and environment agency; Regional civil protection centre, environment agency and coastal ecosystem and water cycle management team; Municipal civil protection, urban planning and communications office; River basin authority; Sustainable education and citizens' participation office; Flood protection voluntary organisation and other NGO representatives; Specialist academics and lawyers; International centre on environmental monitoring.
St Maarten, Dutch Caribbean	Independent expert consultants; Ministry of Public Housing, Spatial Planning, Environment and Infrastructure; Ministry of Public Health, Social Development and Labour; Fire Department; Meteorological Office; Ministry of Economic Affairs; Department of Communications; NGOs; Business sector bodies; Insurance companies; Port, Harbour and Marina companies

The involvement of stakeholders from the start of the research process not only lends validity to the research, but may influence stakeholder recognition and take-up of the findings.

2.5 What methods should be used?

As stressed above, a range of methods can be used for Root Cause Analysis, and the exact choice of methods will depend on the context for and aims of the analysis. Qualitative methods capture depth, context and meaning but, as discussed further below, can also be used in conjunction with quantitative methods, for example to understand the strength of different causal factors, or model actor relationships globally. The method for Root Cause Analysis in PEARL centred on qualitative methods but varied according to the context of each case study:

- In Genoa, Italy, the analysis drew on 17 semi-structured telephone interviews with key stakeholders to supplement a review of the vast existing literature in Italian on the floods and flood history in Genoa, including technical reports, planning documents, legal documents and scientific reports and articles as well as analysis of relevant media reports, which covered more than 150 articles published online between 2010 and 2015.
- By contrast, in St Maarten, Dutch Caribbean, in-depth primary material was not readily available and the analysis focussed on face-to-face interviews.

- In Rethymno, Crete, findings from face-to-face interviews with individual experts and stakeholders were corroborated with findings from a stakeholder workshop.
- In Hamburg, Germany, stakeholder fatigue meant that the study was based on a desk-based review of existing literature rather than new interviews with experts.

The interview questions and Root Cause Analysis reports were structured around the Root Cause Analysis framework discussed above, and focussed as far as possible on understanding the causes of specific disaster events. The following method points discuss these aspects of the interview process.

Method point 1: Using the PEARL Root Cause Analysis framework to structure interviews

PEARL Root Cause Analysis used the following, simple thematic table based on the PEARL Root Cause Analysis Framework to structure questions in face-to-face interviews as well as the findings in the final Root Cause Analysis reports. Under the governance category, questions were asked about the role of disaster preparedness and response policies and actions in influencing risk.

Table 2: Framework for Root Cause Analysis interviews

<i>Category of root causes</i>	<i>Pathway</i>	<i>Temporal expression</i>
Root causes and Drivers of hazard	Physical	Historic
		Contemporary
		Future
	Socio-economic	Historic
		Contemporary
		Future
	Governance	Historic
		Contemporary
		Future
Root causes and Drivers of exposure	Physical	Historic
		Contemporary
		Future
	Socio-economic	Historic
		Contemporary
		Future
	Governance	Historic
		Contemporary
		Future
Root causes and Drivers of vulnerability	Physical	Historic
		Contemporary
		Future
	Socio-economic	Historic
		Contemporary
		Future
	Governance	Historic
		Contemporary
		Future

As the method focussed on interviews with relevant experts rather than affected households and individuals, root causes and drivers related to perceptions, values and beliefs were not systematically explored and not included in the table. However, the analysis highlighted that often conflicts of perception formed part of the governance root cause category, while socio-economic and related demographic change influenced

perceptions, values and beliefs. Root Cause Analysis was also conducted in conjunction with a household-level vulnerability assessment - for a discussion of the use of the two methods together see below.

The general PEARL template was adapted for the local context through the design of more detailed interview questions. Box 1 illustrates the types of questions developed for the Genoa case study after an in-depth review of the secondary literature, including existing academic literature and media reports, which revealed a gap in understanding governance drivers, in particular related to the role of particular aspects of risk management policy and practice. In each case study, interview questions were then applied according to the type of stakeholder being interviewed, and their anticipated areas of knowledge and expertise. The sections on event and causal analysis were common to all interviewees. Questions on risk mapping, management, warning systems and risk awareness/preparedness were tailored by stakeholder type. For example, the head of the Regional Civil Protection Functional Centre was mainly asked about warning systems. However, when interviewees had knowledge about multiple sectors, the opportunity was taken to ask them about different issues. For example, the officer for Regional Coastal Ecosystem & Water Cycle Management had previously worked for civil protection so she had a lot of relevant knowledge about emergency management.

Box 1: Example of interview questions developed for the Genoa, Italy, Risk and Root Cause Analysis

Event

- What were understood to be the immediate, proximate causes of the disaster of the initiating events?
- Was the event forecast or predicted?
- Was the existing knowledge available and accessible? Were there any decision-makers who were unaware of the information (or less aware than they might have been)?
- How was the risk of this event perceived and understood by all the categories of stakeholders?
- What strategies, laws, policies or measures had been considered to prevent the impact of the event or reduce its consequences? Were any options rejected? To what extent had strategies, policies or measures actually been implemented and put in place? Were they effective? How and to what extent?
- What was the economic/social status of the community immediately before the event and how did it change subsequently? Was there any sense of unfairness or discrimination in the community before, during or after the event? Are there contrasting or conflicting views?

Causal analysis

- What were the critical transitions in recent history (preconditions) that increased and changed the distribution of impact?
- How did economic and political status influence the disaster risk? How did culture and societal norms influence the disaster risk?
- What were the drivers of disaster prevention/resilience by broad categories: social characteristics, economic activity and livelihoods, levels of investments that reduced risk, institutional and governance structures, environment, infrastructure (critical infrastructure and residential environments), community competence (including prior experience with events, social cohesion, and social networks).
- Were there barriers to disaster risk reduction? If yes, what were they?

Risk management

- How are you/is your organisation dealing with the risks of floods in Genova and/or Liguria region (depending on the organisation and its mandate)? What kinds of prevention and mitigation measures are at place? What kinds of precautions have been taken to ensure people and buildings? What has been the number one concern and priority in risk management? What will be number one concern and priority in the future?
- Does the local administration have the capacity to deal with flood risk? How could this capacity be improved? What do you think are the current constraints in managing flood risk?
- Are there regional guidelines for flood risk management? Do you have access to them? Do you apply them? What are your views on the support received from regional and national levels for risk identification, communication and management? Is it adequate? If not then what more needs to be done?
- Do you think that the funding for risk management is enough? Is there a fair distribution of funding for structural and non-structural measures/ among towns in the Liguria region/ among Italian regions?
- Do you think there are any legal conflicts related to flood risk management? Did recent legislation enacted after the 2011 and 2014 events contribute in changing the situation? If yes, how?

Risk mapping

- How are the basin plans and the watershed plans implemented in practice?
- What, in your opinion, is the main purpose of mapping flood risk? How will the maps translate into policy? What scale is appropriate for what kinds of uses?
- Who will make most use of the maps, and what problems might arise?
- What do you think about the availability of this data/services? How easy are they to use/understand? What challenges/problems do you encounter in the use of the maps?

Warning systems and emergency management

- Does the local administration have the capacity to deal with emergencies? How could this capacity be improved? What do you think are the current constraints in managing emergencies?
- Are there regional guidelines and municipal plans for emergency management? What are your views on the support received from regional and national levels for risk identification, communication and management? Is it adequate? If not then what more needs to be done?
- Do you think that the funding for emergency management is enough? What have been the priorities in the past and what will be the priorities for the future? Why?
- How do you/your organisation deal with the scientific (but also legal and social) uncertainty related to the warning system and emergency management?
- Do you think that citizens are well prepared? How could they be better prepared? What is the role played by new technologies and social media in emergency management? How is it changing? Should responsibility for emergency management be reallocated? How? Should better communication protocols be prepared? How?

Risk awareness, citizens' involvement and participation in risk and emergency management

- How do you think the locals respond to the risk – has it changed over the years? In what way has it changed your practice and sense of risk? Do you think that you have a good information and training on how to deal with the danger of floods?
- In your opinion, is the public aware of flood risk? Do you think they trust the public authorities to protect them against this risk? Are there environmental groups or citizen groups that advocate for more protection? What is the role of the political parties? What kinds of conflicts among the stakeholders have arisen?
- Are citizens responsible for any aspects of risk mitigation or emergency management? Should they be? How do they participate in the decision making process?
- What role did the European Flood Risk Directive play (if any) in improving stakeholder engagement in flood risk management?

A limitation of the method was that interviewees found it difficult to separate out some of the Framework's elements in practice, which are indeed inter-related. This applied to identifying drivers of exposure as distinct from vulnerability. Governance, economic and social drivers are also difficult to separate – the legal controversies which have stopped the disbursement of funds to build risk mitigation measures in the Genoa case, for example, are both economic and governance-related. Physical drivers, too, interact with socio-economic pathways, with flood risks in the case studies affected by poor drainage or stream clearance, or the deepening of ports for economic activities. It was also difficult for some stakeholders to identify future scenarios as different to contemporary conditions.

Table 3 illustrates how the Framework was then used to present the findings in the case of Rethymno, Crete:

Table 3: Illustration of the RRCA findings according to RRCA Framework elements for Rethymno, Crete

Category of root causes	Pathway	Temporal expression	Manifestation for Rethymno
Drivers of hazard	Physical	Historic	Long-term dynamics of physical processes. Geographic location of town: extremely vulnerable to winds and storm surges from the sea, and in a drainage basin (and therefore vulnerable to three streams overflowing during winter and carry large quantities of sediment)
		Contemporary	Combination of physical processes with more pressure from extreme rainfall patterns due to climate-change
		future	Climate-change and sea-level rise
	Socioeconomic	historic	Rapid urbanization in the last three decades in a disorganized fashion. Lack of drainage capacity and poor maintenance.
		Contemporary	
		future	
	Governance	Historic	Rapid urbanization in the last three decades in a disorganized fashion. Lack of drainage capacity and poor maintenance.
		Contemporary	n/a
		future	n/a
Drivers of exposure	Physical	Historic	Absence of infrastructure to prevent floods Since the 1960s decentralization of responsibility to local authorities in Greece did not mean more funding. However things changed with EU funding in mid-1990s.

		Contemporary	Maintenance of existing infrastructure
		future	Austerity measures might stall new infrastructure plans
	Socioeconomic	Historic	Rapid urbanization, local economic interest groups influence siting of port in vulnerable area.
		Contemporary	Lack of efficient maintenance of the infrastructure
		future	Austerity measures might stall new infrastructure plans
	Governance	Historic	Planning and land-use decisions not suitable for preventing loss and damage from natural hazards. The construction of infrastructure usually followed the rapid urbanization in Rethymno. Most of policy decisions focus on economic growth, tourist development and certainly not civil protection, non-structural measures for disaster preparedness and vulnerability reduction. Transfer of power to Fire Dept inhibits preventative measures
		Contemporary	Lack of human resources due to the austerity measures, institutional fragmentation and bureaucracy EU finance does not filter down to local level Weakness of national-level frameworks where no monitoring or enforcement for implementation, lack of emphasis on preparedness and vulnerability and lack of multi-stakeholder engagement
		future	Challenges posed from the emergence of civil society organizations and their role in changing the party politics that has governed flood-related decisions
Drivers of vulnerability	Physical	Historic	Inadequate urban planning, location of harbor
		Contemporary	Poor maintenance of infrastructure due to austerity measures and lack of human resources
		future	
	Socioeconomic	Historic	Lack of awareness as new population moved into Rethymno. Most of them were originated from mountainous areas and carried local

			knowledge for preventing from other types of disasters mainly forest fires and landslides, not urban flooding or storm surges. In addition to that floods in Rethymnon did not occur very often and locals in many cases developed the feeling that were safe. As a consequence their economy was not resilient to this kind of shocks leading to loss and damage of assets.
		Contemporary	As above. Lack of awareness also includes restaurant owners/residents in the old town that do not maintain properly the infrastructure and do proper waste disposal etc.
		future	
	Governance	Historic	Since the 1960s decentralization of responsibility to local authorities in Greece did not mean more funding. However things changed with EU funding in mid-1990s. Transfer of power to Fire Dept inhibits preventative measures
		Contemporary	The construction of infrastructure usually followed the rapid urbanization in Rethymno. Most of policy decisions focus on economic growth, tourist development and certainly not civil protection, non-structural measures for disaster preparedness and vulnerability reduction. EU finance does not filter down to local level Weakness of national-level frameworks where no monitoring or enforcement for implementation, lack of emphasis on preparedness and vulnerability and lack of multi-stakeholder engagement Clientelism and party politics inhibit state-civil society engagements at the local level
		future	Different levels of local governance disorientate from the accomplishment of integrated disaster risk management. The institutional fragmentation will probably persist with the economic crisis and lack of political will to reform the existing policy context.

Method point 2: Focussing on the causes of specific disaster events

Interviews for PEARL's root causes analysis work focussed where possible on eliciting personal and organisational opinions about the causal factors behind specific disaster events. For example, interviews in Genoa focussed on the 2014 and 2011 flooding episodes, and interviews in St Maarten on the effects of 2014 Hurricane Gonzalo and flash flooding in November of the same year. This interview technique was designed to draw out specific causal attribution and the relationship between causes and impacts, moving beyond the broad-brush opinions of respondents and pre-existing conceptions by researchers and stakeholders about possible causes. The thinking behind it was that disaster events act as a 'window' through which hidden causes of risk are often revealed. However, despite the focus on historical disaster events it was important to also link historic causes with contemporary risks and vulnerabilities, especially where the physical, governance and socio-economic dynamics of risk were changing, and this was emphasised in interview questions. Other challenges included recognising that different disaster events may have different causes and differential impacts even in the same place. In St Maarten, for example, 2014 Hurricane Gonzalo had major consequences for the local marine sector, but produced a very different kind of flooding event to flash floods in 2005 that affected hillside districts due to torrential run-off. In the selection of relevant events to study, on the one hand it was more difficult to see the effects of the response to more recent events, but on the other, not all stakeholders were able to reflect on more historic events. In St Maarten, for example, interviews were therefore conducted with current government officials who managed current and recent responses to risk but also past officials and individuals who could recall the impact and influence of hurricane events in the 1990s, which had shaped the disaster risk management system into the present.

2.5.1 Who should be interviewed?

In all the PEARL Root Cause Analysis case studies researchers identified key institutions and individuals from the secondary literature and 'snowballed' out from initial interviews, asking respondents for further recommendations of who to interview. The over-riding guiding feature was to capture as representative a selection as possible of the diverse viewpoints held by different stakeholders, recognising that different groups may have different values, beliefs and interests that influence how they view the causes of particular events. Through multiple interviews, initial research findings can also be triangulated and verified and viewpoints shared. The box below discusses some of the challenges to accessing stakeholder groups using examples from the PEARL Root Cause Analysis case studies.

Box 2: Challenges to accessing stakeholders

In attempting to reach multiple stakeholders, PEARL case study research highlighted common challenges of language barriers, timing interviews to suit busy interviewees, managing the impacts of staff turnover and unexpected events, and stakeholder fatigue with being interviewed. These issues must all be borne in mind when deciding who will undertake the research, deciding on appropriate methods and scheduling interviews. In addition, vulnerable groups and their representatives are often the most hard to reach. Governance issues may also be particularly sensitive topics to draw out and discuss, especially with local stakeholders.

2.5.2 Developing new methodologies for Root Cause Analysis

A number of methods for Root Cause Analysis were not applied in the PEARL project, but may prove applicable and useful for other Root Cause Analysis research projects and exercises:

- **Focus group exercises:** Although PEARL Root Cause Analysis focussed on individual expert interviews, exercises with focus groups can also provide important insights, and group exercises such as actor or causal mapping may provide a useful starting point for the research. If relying on focus group interviews alone, it should be remembered that the composition of the group will influence the responses, and that marginalised viewpoints may be excluded.

A map of actor relationships produced by stakeholders in Rethymno, Crete, illustrated and confirmed the findings of the interviews. For example, institutional fragmentation at the national level shown in the map has impeded effective implementation of flood risk governance, including the roll-out of the EU Flood Directive, while the municipal government has the main coordinating role. Qualitative analysis from individual expert interviews, however, was able to explain how these governance issues connected with physical and socio-economic dynamics, how they linked directly to the problematic of flood risk in Rethymno, and how such relationships were changing over time.

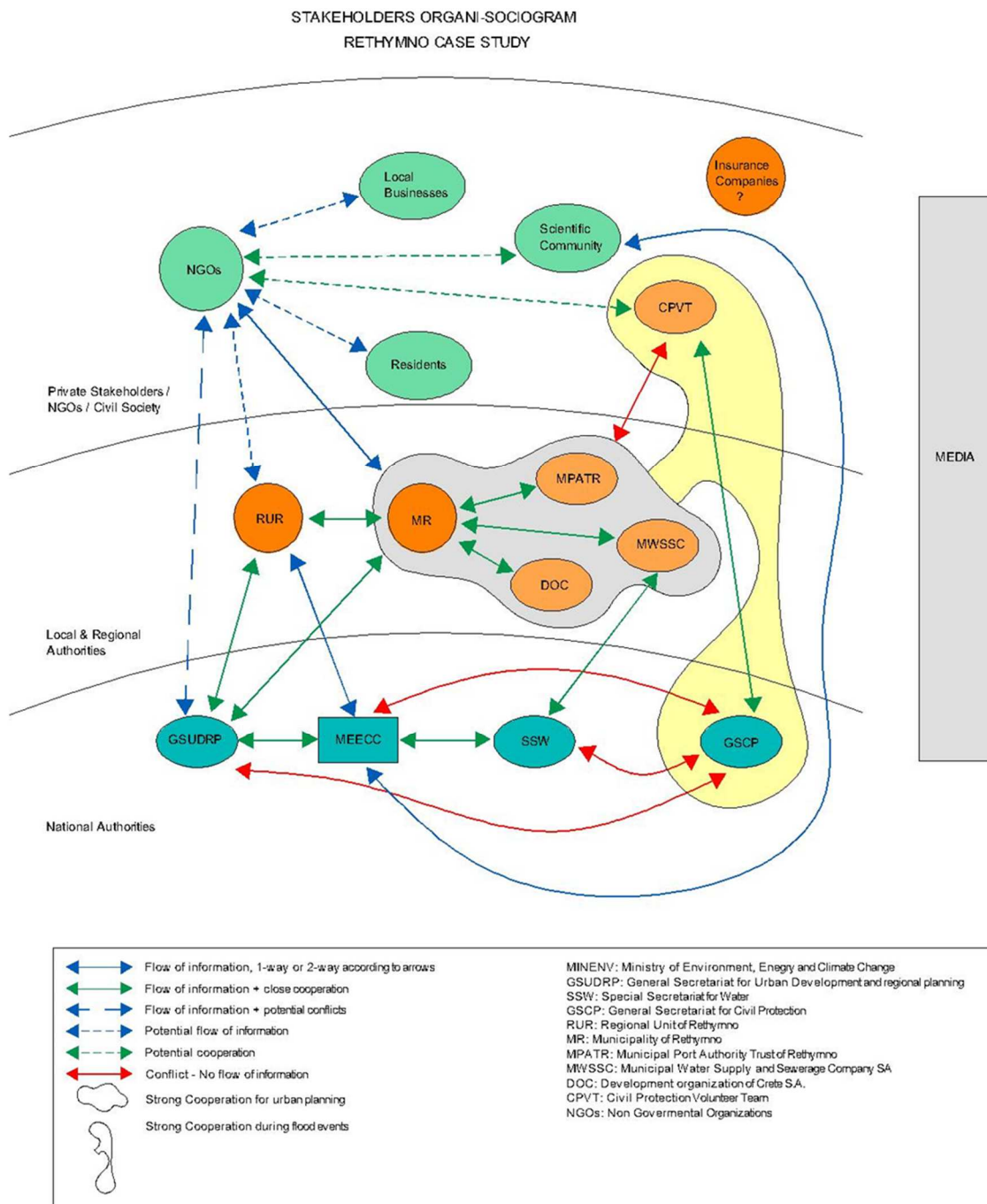


Fig. 5 Stakeholder organi-sociogram Rethymno, Crete

Source: NTUA

- **Weighting causal factors:** After initial research, root causes could be presented and stakeholders asked to award values to different causal attributes. This approach would retain the complexity of root causes but would need careful structuring to prevent assumed and past relationships being projected into the future.

There is also a strong possibility of stakeholder bias, with institutional stakeholders likely to downplay the institutional role in influencing negative outcomes, and overplay positive effects. There is also a need to differentiate between the different vulnerability input variables and output descriptions for each location. The use of this method will depend on stakeholder expertise, interest and availability. On the back of the outlined methods, it would be possible to compare 'standard' indicators of vulnerability and exposure and those generated through a 'Root Cause Analysis informed' analysis and potentially quantify the additional effect of 'root cause indicators' in capturing historical losses.

In addition, this brief has focussed on the production of a Root Cause Analysis study. However, a key plank of Root Cause Analysis is comparative research that can draw common conclusions about the pathways to disaster events. The FORIN (or the FORensic INvestigations of disasters) project promoted by the Integrated Research on Disaster Risk programme identifies two types of analysis that aim to draw out common conclusions from multiple sets of case studies: meta-analysis (literature review across multiple cases to establish common causal pathways) as well as longitudinal analysis (observations of comparable events or events in comparable places). Section 2.7 discusses developing root cause indicators to understand generic root causes out of the PEARL case studies. Links to FORIN project publications can be found at the end of the sourcebook.

Qualitative Root Cause Analysis in PEARL also informs and complements other risk assessment methods. A vulnerability assessment based on a household survey as well as the collection of spatialized data from secondary sources (such as census data) provides insights into contemporary risk and household perceptions of risk. The aim of the survey was to assess how individuals respond before/during/after a flood, and thereby gain an understanding of various risk management strategies. The survey covered questions on the availability of information (e.g. early warning, evacuation routes), social networks and support from local authorities, as well as individual preparedness. The findings from the household survey confirmed major elements of the Root Cause Analysis for the case study sites – for example the lack of reported household insurance in the Genoa case is reflected in the RCA study findings that private insurance schemes are lacking in Italy, with state emergency aid being the main source of post-disaster finance. Other findings illustrated the differences in conceptions held by different stakeholders: household respondents in Rethymno, for example, wanted officials to take responsibility for better technical, protection measures, whereas the general consensus among officials in Rethymno was that there was a need to focus on awareness-raising and private activities that contribute to flood risk, including private violations of planning regulations.

Information from the Root Cause Analysis and vulnerability assessment also informs agent-based models (ABM) through analysis of the actors and institutions that influence flood risk, their motivations, roles and values. The ABM is of an evolving urban system, where flood risk is imminent, measures may or may not be taken, and the effect of strategy, governance and decisions may be tested at high-level with respect to their long-term effect on flood risk. The primary aim of the ABM modelling approach is to emulate, rather than to calculate (optimal) states of the system and to explore the possible development paths (i.e., possible states of the system or possible futures).

2.6 How can the results of Root Cause Analysis be analysed and presented?

Transcripts and notes from Root Cause Analysis interviews and documents may be coded and synthesised either by hand or using computer software programmes such as atlas.ti. PEARL researchers used the PEARL framework to analyse case study material, drawing out common themes as well as identifying divergences of opinion. If quantitative forms of analysis are used, responses may be numerically weighted and the significance of particular relationships corroborated using statistical testing methods.

Case study reports and briefs draw together the analysis, and may be structured around the Root Cause Analysis Framework and the interaction between its components. PEARL reports and briefs included actor maps and tables of primary and secondary actors, as well as the findings from the research displayed in the format of the PEARL Framework table. Causal loop mapping may also be used to illustrate the inter-relationship between root causes. The Hamburg study included a causal loop map to illustrate the role of different stakeholders in the policy measures adopted over time (The map can be seen in Annex 1).

As well as producing actor maps like the one shown above, relevant actors and their relationships may also be visualised using mind maps, matrices showing the involvement, power, interest or other characteristics of different types of stakeholders, and timelines of policy measures (see Blaj 2014 for an illustration of these techniques for the Hamburg case). Such techniques provide useful ways of illustrating the role of different actors, characterising their relationships and showing a sequence of events, but need to be supplemented with full explanatory analysis of the meaning and motivation behind relevant decision-making processes and the deeper structural causes of such decisions.

2.7 How can Root Cause Analysis be integrated into planning and policy-making?

The process of conducting Root Cause Analysis involves multiple stakeholders and engaging them in how to integrate the findings into planning and policy-making processes ensures that this can be done in an appropriate way. The following table suggests possible modes of stakeholder involvement at the different stages of the research process:

Table 3: Issues to consider in involving stakeholders in research projects

Research phase	Proposed activities for stakeholder engagement
Research conception and design	Verification with stakeholders if the right questions are being asked, if more sources are needed and if additional stakeholders need to be involved.
Research execution	Confirmation with stakeholders that the practical arrangements for carrying out the research allow for full involvement, e.g. timing and language of interviews and workshops. Verification of research findings with stakeholders.
Research application, reflection and dissemination	Isolation of evidence and argument that might lead to changes in practical actions to reduce risks. Distribution of information to appropriate audiences at the appropriate moments, using appropriate media and communication styles. Development of strategies to ensure the main messages of the research have long-term impact.

Adapted from Parnell et al. 2015

A challenge for integrating Root Cause Analysis into policy is that Root Cause Analysis shows how the causes of risk arise across multiple sectors and multiple levels of governance, often well beyond the conventional remit of disaster risk management officials. PEARL case study analysis shows up how:

- Even when structural and non-structural risk mitigation measures are in place, urbanisation and economic development trends drive up risks. Across all PEARL case studies, tourism-related and other infrastructures are often developed without regard for land-use plans or building codes related to risk.
- Demographic shifts with urbanisation also change the requirements of non-structural measures such as awareness-raising drives. In St Maarten, for example, a recognised challenge is how to provide early warning and preparedness campaigns in multiple languages, as the island has attracted increasing numbers of migrants to support its tourism development. A less well recognised challenge is how to improve trust in government communications by such groups, who are often politically unrecognised and economically and socially marginalised, and how to improve settlement conditions which lead to greater exposure and vulnerability.

PEARL Root Cause Analysis also highlighted how large-scale economic and institutional shifts occurring at global, national and regional levels influence the nature of risks as experienced in local contexts. Austerity measures and decentralisation, for example, have had positive and negative impacts in all PEARL case study contexts – exacerbating resource constraints for disaster management, but in some cases also leading to the development of more appropriate risk knowledge or creating new opportunities for social involvement in risk reduction. The precise effects are context-specific. Nevertheless, they point to the need to:

- Find innovative local solutions.
 - In the Genoa case study, the research has led to practical recommendations about how data about funding flows for flood protection from different sources can be improved in order to maximise the use of funds and better monitor and track spending.
 - In Rethymno, Crete, the analysis emphasises the need to take advantage of a new moment of political opening in Greece's history to involve civil society actors in the development of more holistic flood management policies.
- Foster cross-country learning about innovation in flood protection in the context of resource constraints. The PEARL project has enabled stakeholders to share experiences through an online learning platform, such as a presentation by the Head of Disaster Management for St Maarten about the organisational structure for disaster response on the island.
- Engage stakeholders across all levels, including national level and supra-national level bodies such as the EU, and improve capacity at the local-level to access funding and knowledge often available at other levels of government. This can be challenging: in Rethymno, Crete, attempts to include national-level stakeholders in a participatory action-learning alliance fostered by the PEARL project were abandoned as due to political changes and financial crisis in Greece personnel in national-level ministries of importance were either absent or unwilling to participate (Sorg et al. 2015).

Root causes are also dynamic, and while historic factors shape the causes of risk into the present, there are discontinuities and shifts in governance and socio-economic pathways which mean that pathways are not determined into the future. This points to the need for Root Cause Analysis to be continuously reviewed.

A possible way to integrate, monitor and track the underlying root causes of risk in disaster management policies is through the development of root cause indicators. These may be generic – derived from other studies and applied in a particular case – or specifically derived for the context. For each root cause, a proxy indicator can be used to measure progress, although this will also depend on data availability.

2.8 Questions and Answers about Root Cause Analysis

- **What ethical issues do I need to think about during the analysis? Should interviewees' names be anonymous, for example?**

Research organisations may have different guidelines and procedures relating to ethical issues and these should be consulted. Issues to consider are informing interviewees of the purpose of the study and how the results are to be used; giving interviewees the option to remain anonymous; consent to video or audio record interviews and how to store and share transcripts and interview notes. There are a number of ways of treating interviewee anonymity which will depend on the context. You may wish to give interviewees the option to remain anonymous in name and position, especially if the discussions concern socially or politically sensitive issues, but list their organisation and the date of the interview, for example.

- **How many interviews should I do?**

There is no one number of interviews that should be undertaken. In-depth interviews are time-intensive, however (typically lasting between 1-2 hours) and time-consuming to transcribe and analyse (and possibly translate). The main aim is to undertake a threshold number of interviews that captures the different representative viewpoints on the problem. For the PEARL case studies that involved face-to-face interviews, the number of interviews ranged between 17 and 22.

- **Where can I get more support to undertake a Root Cause Analysis?**

Section 2.9 lists further web references for those interested in undertaking Root Cause Analysis.

2.9 Further Reading

- For documentation related to IRDR's Forensic Investigation of Disasters (FORIN) Project, including the first and second project reports with guides to objectives and methodology, a review of the FORIN project, and FORIN case studies, see: <http://www.irdrinternational.org/projects/forin/>
The latest framework and guide to research can be found at:
<http://www.irdrinternational.org/wp-content/uploads/2016/01/FORIN-2-29022016.pdf>
- For UNU's study about root cause analysis on behalf of DKKV (German Committee for Disaster Reduction), see:
[http://www.preventionweb.net/files/globalplatform/entry_bg_paper~studydetectingdisasterrootcausesweb.p
df](http://www.preventionweb.net/files/globalplatform/entry_bg_paper~studydetectingdisasterrootcausesweb.pdf)
- For more information related to the PEARL project, please visit <http://www.pearl-fp7.eu/>

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Annex 1

Causal loop map of stakeholders' role in structural flood risk management policy measures, Hamburg (Blaj, 2014)

