Review of Comoros

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UNISDR Working Papers on
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Working Papers describe preliminary results or research in progress by the author(s) and are published to stimulate discussion on a broad range of issues on disaster risk reduction.

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List of Acronyms

AAL	Annual Average Loss
CAPRA	Comprehensive Approach for Probabilistic Risk Assessment
CATSIM	CATastrophe SIMulation
CBA	Cost Benefit Analysis
CCA	Climate Change Adaptation
DRM	Disaster Risk Management
DRR	Disaster risk Reduction
EIA	Environmental Impact Assessment
EU	European Union
GAR	Global Assessment Report on Disaster Risk Reduction
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
HFA	Hyogo Framework for Action
ICT	Information and Communication Technologies
IIASA	International Institute for Applied System Analysis
IMF	International Monetary Fund
IOC	Indian Ocean Commission
NGO	Non-Governmental Organization
NPV	Net Present Value
PML	Probable Maximum Loss
RSBR	Risk Sensitive Budget Review
SIDS	Small Island Developing States
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations Office for Disaster Risk Reduction
WB	World Bank
WCDRR	World Conference on Disaster Risk Reduction

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This report was mainly drafted and coordinated by Ms. Kazuko Ishigaki (UNISDR) and Lezlie Morienere. Inputs for Chapter 4 to 6 were provided by Ms. Abdallah Fatouma, Mr. Salim Soilihi and Mr. Said Kadafi. Annex B and C were drafted by Ms. Junko Mochizuki, Mr. Stefan Hochrainer, Mr Reinhard Mechler, Mr. Keith Williges (Annex B only) and Callahan Egan (Annex C only) of International Institute for Applied Systems Analysis (IIASA). Mr. Sylvain Ponserre from UNISDR drafted Chapter 2). Many valuable inputs were received from Ms. Mabel Cristina Marulanda Fraume from UNISDR (disaster risk of Chapter 3). The overall project including organizing a series of workshops was coordinated by Mr. Julio Serje (UNISDR). Ms. Lezlie Moriniere edited the publication.

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Executive Summary

In 2013, following a grant agreement signed between UNISDR and the Indian Ocean Commission, a joint UNISDR/ISLANDS project was started entitled “Strengthening Capacities for Unified Climate Change Adaptation and Disaster Risk Reduction Through the Facilitation of Risk Transfer and Financing Mechanisms”. It was implemented within the “ISLANDS Programme for Financial Protection against Climatic and Natural Disasters”. It also forms a part of UNISDR’s global project for around 30 countries: “Building Capacities for Increased Public Investment in Integrated Climate Change Adaptation and Disaster Risk Reduction: 2012-2015” financed by the European Union.

Four island countries in the Indian Ocean as well as the Government of Zanzibar participated in the ISLDNDS programme composed of three components: the establishment of reliable disaster loss database (Component 1), risk evaluation and probabilistic risk assessment profiles (Component 2) and incorporation of risk management into public investment planning (Component 3). Economic analysis and policy reviews were developed as a package. This report aims to summarize all activities implemented in the project with a focus on public investment planning (Component 3) while a technical report on Components 1 and 2 is also available[1].

As a first step (Component 1), a total of 105 data cards on disaster events and losses in the Comoros between 1980 and 2013 were registered in the national disaster loss databases. Economic loss totalled USD 9.8 million (2012 constant price). When intensive and extensive losses are combined, cyclone causes 58% of total losses, followed by flood (35%) and storm (4%). In the following probabilistic risk analysis (Component 2), Average Annual Loss (AAL) for tropical cyclonic wind and earthquake was estimated at USD 0.16 million and USD 0.21 million respectively. Compared to the earthquake risk, tropical cyclonic winds represent a less important hazard since the associated losses for the same return periods are lower than those for earthquakes.

This loss and risk information pointed to the need to reduce risk to natural hazards. However, in itself it did not suggest policy guidance. Grounded in the loss and risk analysis, a thorough policy review and economic analysis were implemented (Component 3).

CATSIM analysis developed by IIASA identified that the fiscal resource gap year (*i.e.* the return period at which the government will face difficulty in raising sufficient funds for reconstruction) for tropical cyclone and earthquake hazards to be 56 to 77 years. This corresponds to the middle risk layer (*i.e.* between intensive and extensive risks) and means that Comoros must target risk reduction investment and development of risk financing mechanisms simultaneously.

The subsequent probabilistic cost benefit analysis (CBA) presents how CBA can support concrete and specific decision-making. As an example, the CBA of house retrofitting to withstand flood and tropical cyclonic wind found that the retrofitting would be a cost-inefficient project. However, there are a number of factors regarding the data and assumptions that potentially limit the validity of the figures found in this project. For example, we have no concrete data on housing value, retrofitting costs and flood exposure.

To explore the financial aspects of DRM policy, Comoros also estimated the current investment in disaster risk management by applying a DRM Marker method in an examination of national budgets, proposed for the OECD by the World Bank in partnership with UNISDR. The risk-sensitive budget review revealed that the Government of Comoros may be investing up to 7% of its annual budget on elements and efforts that contribute to DRM. However, as most of this appears to be invested in “principle” activities and as “response” it is a good time for the country to start exploring the value of investing in and in mainstreaming risk reduction.

During several meetings with the Ministries of Finance in the IOC region, it was established that a scattered approach to DRM is inefficient and there is need for stronger collaboration between the DRM agency, Ministry of Finance and other key sectoral ministries. Continuous capacity building on risk terminology and concepts, loss and risk information management and economic analysis was recommended by Ministries of Finance in the region.

[1] For component 1 and 2, please see UNISDR /IOC (2014). Component 1 and 2: Comoros, Madagascar, Mauritius, Seychelles and Zanzíbar. Building capacities for increased public investment in integrated climate change adaptation and disaster risk reduction: 2012-2015. European Commission - Directorate General for Development and Cooperation. Geneva, Switzerland.

The loss and risk information should be examined from the perspective of both DRM policy maker and financial planners. Given the importance of public investment in DRR, continuous refinement of loss and risk information should be promoted through regular dialogue with data users. In the process of economic analysis, Ministries of Finance understood and appreciated the importance of loss and risk information. On some cases, they identified several mistakes and inconsistencies in the records in disaster loss databases and the data were corrected. Such exchanges of information will improve overall quality of knowledge management to support DRM decision making.

Government needs to develop investment and financing strategies to address both extensive (small scale but high frequency) and intensive (low frequency but high impact). Climate change will increase risks in terms of frequency, geography and intensity. Understanding risk structures and the expected economic impact in the country is the critical first step to determine the optimum policy mix for each risk layer. In developing investment and financing strategies to address disaster risk, DRR investment and risk financing should not be considered separately. Depending on risk layers, the most appropriate policy mix changes and DRR investment and risk financing are not mutually exclusive. For example, DRR investment often decreases insurance premiums.

This packaged approach with a focus on financial planners in government will be standardized and replicated in Asia, Africa, Latin America and other regions in the coming years and the knowledge is planned to be archived and presented globally in a working paper series of UNISDR on “Public Investment and Financing Strategy for DRR”. The report summarizing activities in IOC region will thereby contribute to increasing the global knowledge base.

1. Introduction: Conceptual Framework [2]

In 2012, the UNISDR started a project called “Building capacities for increased public investment in integrated climate change adaptation and disaster risk reduction: 2012-2015” under the financial sponsorship of EC-Development and Cooperation (EC-DEVCO). The initiative supports approximately 30 countries in Asia, Pacific, Africa, Latin America and the Caribbean to systematically account for disaster loss and to develop probabilistic estimations of future risk. It provides a baseline for an economic approach toward better public investment planning.

In the Indian Ocean Commission (IOC) region, this initiative has been separately planned and implemented in 2013-2015 in the cooperation with ISLANDS, in accordance with the project design developed by UNISDR and implemented through the “ISLANDS Financial Protection Programme against Climatic and Natural Disaster Risks”.

The initiative has three components:

- Component 1: disaster loss
- Component 2: probabilistic disaster risk assessment
- Component 3: public investment planning

Component 3 of this initiative considers disaster risks in economic analysis to support and facilitate risk-proof public investment decision-making. It especially aims to contribute to the progress of HFA priority areas monitored through core indicator 4.6 “procedures are in place to assess the disaster risk impacts of major development projects, especially infrastructure” and 3.3 “Research methods and tools for multi-risk assessments and cost benefit analysis are developed and strengthened”.

UNISDR has been in charge of designing methodologies for Component 3 and in the process, considered how natural science can be linked to social science to contribute to better decision making in public investment planning. In the Indian Ocean Commission (IOC) region, this project has been planned and implemented from 2013 to 2015 in cooperation with ISLANDS, in accordance with the project design developed by UNISDR.

This report summarizes all activities implemented for Comoros[3]. Chapter 1 introduces basic country structure as background. Chapters 2 and 3 outline loss and risk as the starting point of analysis. Chapter 4 briefly explains the DRR policies of the country. Chapter 5 outlines the current state of risk-sensitive public investment planning and risk financing policy as well as brief summary of three types of economic analysis implemented in the country.

In Component 3, we introduced tools a) to monitor DRM budgets to analyse the current state of public investment (called the “risk sensitive budget review”), b) to measure the impact of disasters on public finance and on the economy at the macro scale (CATSIM analysis), and c) to measure the impact of DRR investment on society (probabilistic cost-benefit analysis).

In Chapter 6, recommendations for policy makers are presented drawing from the analyses implemented. Annexes A, B and C provide theoretical and technical background and detailed case studies on each tool.

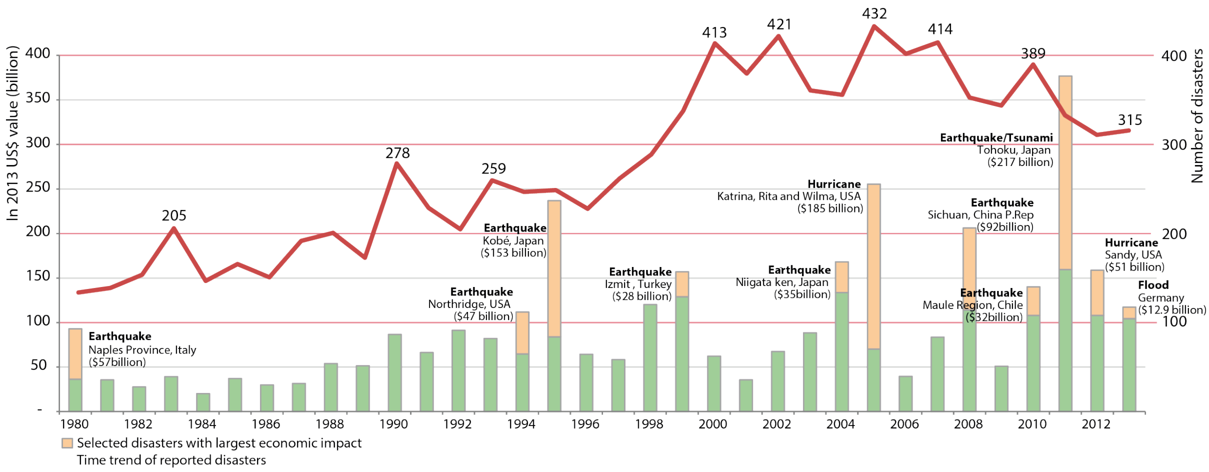
In this introductory chapter, the background, especially why we need risk-sensitive public investment, is explained. Then, the overall streamlined process from loss data analysis through probabilistic risk assessment into economic analysis is explained. Lastly basic concepts of economic loss are defined to provide a common understanding of key terminology.

[2] This chapter was drafted by Kazuko Ishigaki (UNISDR)
[3] A series of workshop/meeting implemented in IOC region are listed in Annex D.

A. Background: what are challenges?

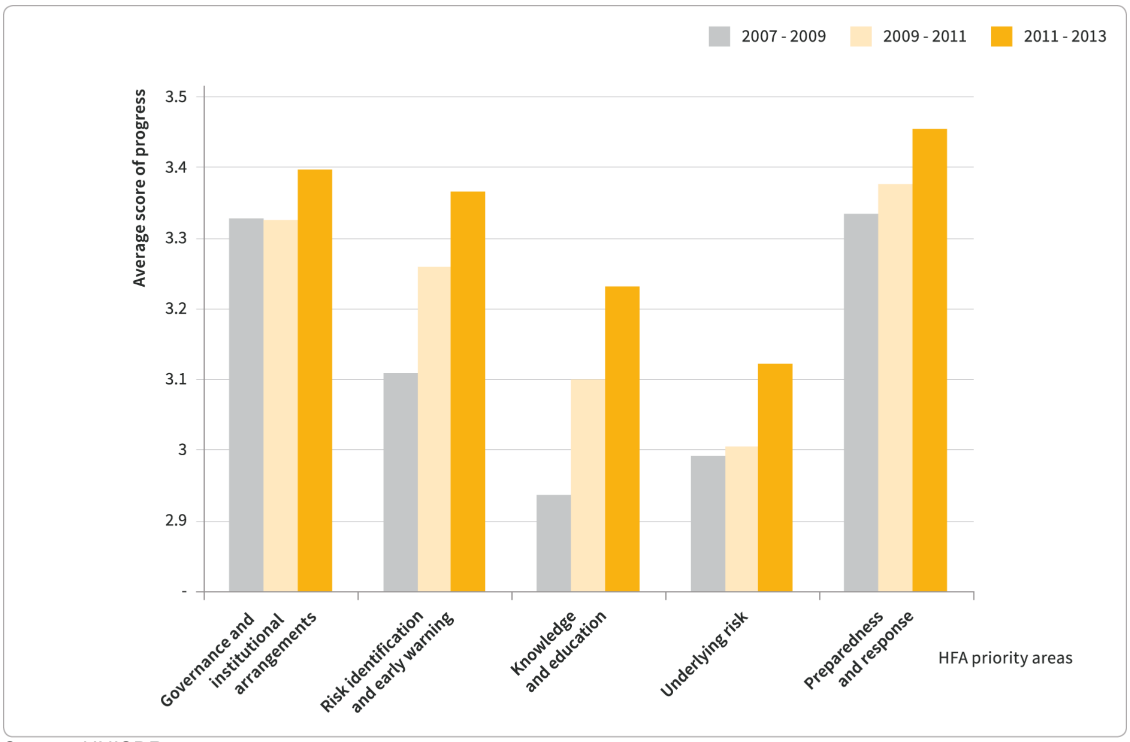
Why do we need to promote risk-sensitive public investment? First of all, economic loss due to disasters has been increasing in spite of substantial progress in DRR policies promoted by Hyogo Framework of Action (HFA) (Figure 1 and Figure 2). HFA priorities have been progressing in all areas mainly due to the effort of DRM agencies. Especially during the past decade, capacity in monitoring and risk assessment has been developed in many countries.

Figure 1: Economic loss due to natural disasters, 1980-2013



Source: EM-DAT (http://www.emdat.be/database)

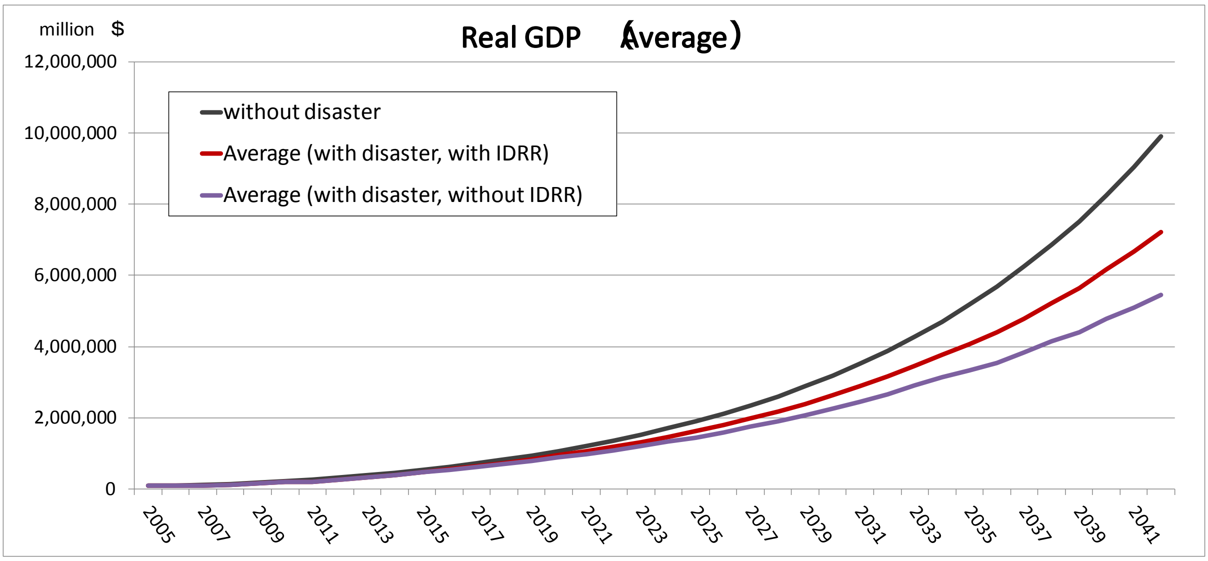
Figure 2: HFA Progress



Source: UNISDR

Disaster interrupts or slows down economic growth by damaging public and private infrastructures and negatively affecting people and economic activities. Figure 3 portrays the Pakistan GDP growth estimate calculated by JICA, clearly demonstrating that disasters will slow down economic growth and that DRR investment will mitigate the impact.

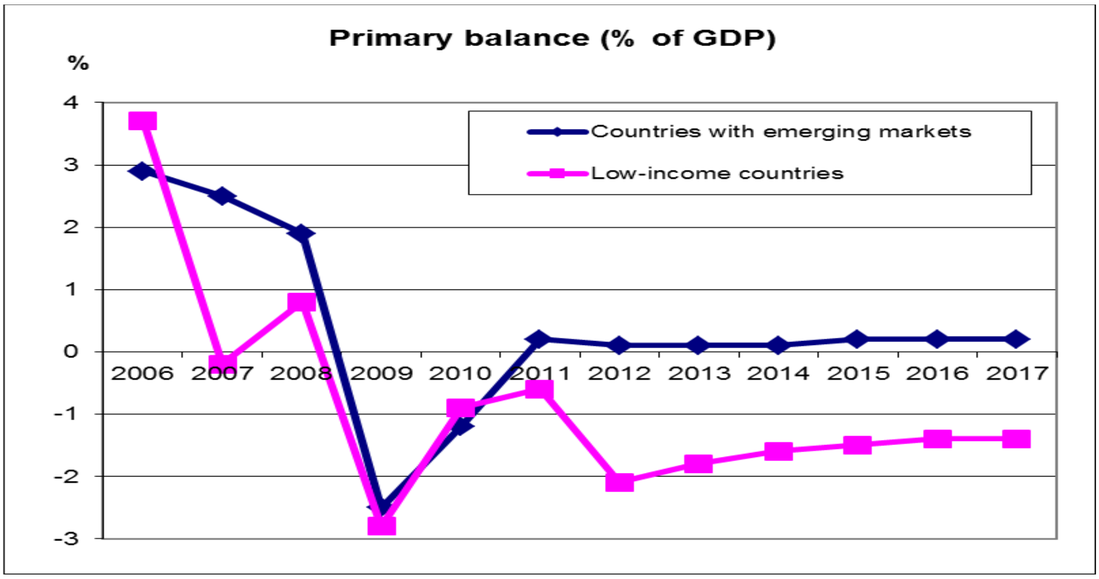
Figure 3: Pakistan GDP estimate, 2005-2041



Note: IDRR means DRR investment.
Source: Author based on the figure provided by JICA

Secondly, to reduce the impacts of disaster, governments need to invest in DRR. However, governments in most countries are suffering from tight budget constraints. Fiscal primary balance is expected to be negative in the coming years (Figure 4). The financial situations of low-income countries are especially tight. If we consider the debt and interest payment of many developing countries, the budgetary situation would be even tighter than the graph portrays.

Figure 4: Primary balance (% of GDP), 2006-2017[4]

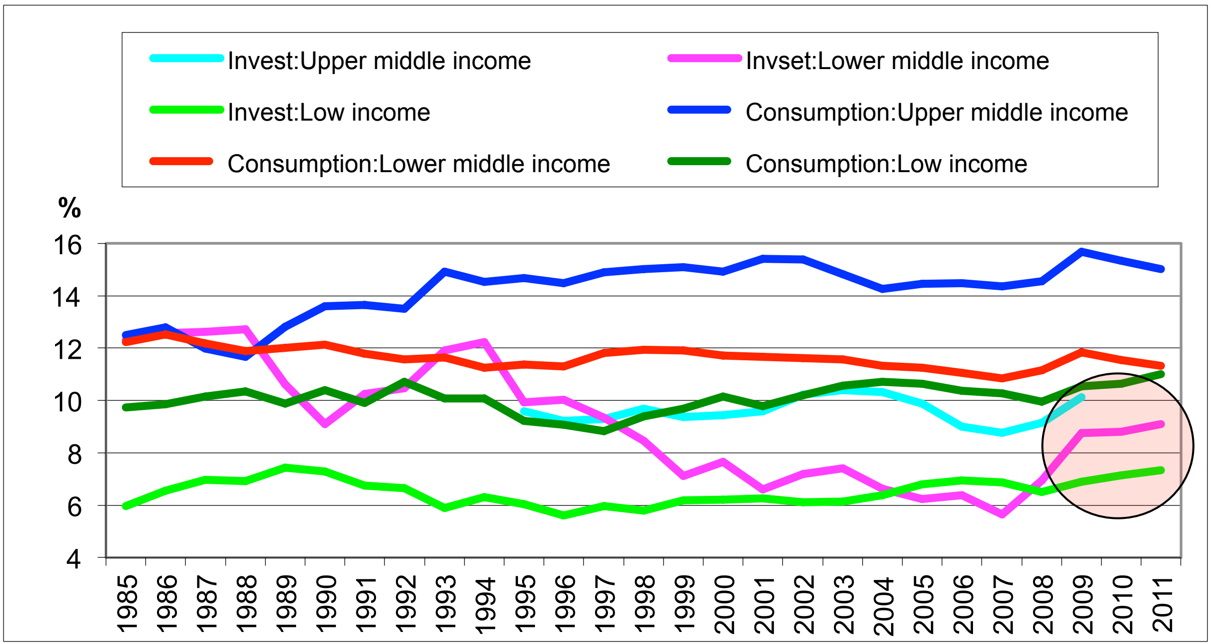


Source: Author based on IMF

4 The primary balance is the difference between a government's revenues and its non-interest expenditures; it is the most accurate reflection of government fiscal policy decisions. A country with a primary deficit, for example, spends more on roads, schools, defense, than it takes in from taxes and other revenues. Source: http://www.imf.org/external/np/fad/histdb/.

Going deeper into the details of public finance, we can see the additional influence of budget constraints. Figure 5 portrays how public investment has been under pressure due to constant or increasing financial need for government consumption. Public investment, especially in low and lower middle-income countries, is very volatile. On the other hand, in spite of these constraints, public investment is significant, recently representing 6 to 10 % of GDP in developing countries. Governments must protect the hard-won fruits of these investments.

Figure 5: Government consumption and investment (% of GDP), 1985-2011



Source: Author based on the World Bank Development Indicators

Why does disaster risk matter in public finance? Although "risk as opportunity" has become an attractive political motto, on the ground, disaster risk simply represents costs for financial planners (both public and private) and society. While we often focus on disaster loss and impacts, the overall cost of disaster risk is a summation of a) ex-ante DRR investment and risk financing mechanisms, b) post-event response, recovery and reconstruction cost and c) disaster loss and impacts. The cost of disaster risk management distracts financial resources from other priorities regardless of ex-ante or post event efforts. The impact of disaster risk on public finance should be considered based on the overview of these three categories of costs.

Recently there is increasing attention on risk-sensitive private investment (GAR2013). However, disaster risk management mechanisms should be first considered as an issue of public finance because national governments assume primary responsibility to protect people and assets from disasters, and the risk preventive infrastructure represents public goods to remedy the problem due to market failure.

In economics, **public goods** are characterized both as non-excludable and non-rivalrous in that individuals cannot be effectively excluded from use and use by one individual does not reduce availability to others. Classic examples of public goods include street lighting, police service, and fresh air and water. Paul A. Samuelson, in his seminal paper of 1954 entitled *The Pure Theory of Public Expenditure*, defined a public good (what he called "collective consumption good") as follows: "[goods] which all enjoy in common in the sense that each individual's consumption of such a good leads to no subtractions from any other individual's consumption of that good."

Disaster risk reduction mechanisms are also public goods satisfying conditions of non-excludability and no-rivalry. Sea walls and early warning system protect many people and assets at once and do not exclude anyone. The problem of public goods is that no one wants to pay for the service and the goods are likely to be under-produced (*i.e.* free-rider problem[5]).

[5] Typical examples of free rider problem include congestion in public roads and pollution of air and water.

The argument of public goods is closely related to **market failure** in economic theory. Market failure is a situation in which the allocation of goods and services by free market is not efficient. Market failures are scenarios in which the individual pursuit of pure self-interest leads to results that are not efficient – that can be improved upon from the societal point of view[6]. The typical causes that lead to market failures include lack of information, externalities, or public goods.

When private sector does not properly assess the disaster risk, it tends to over-invest. While it is important for all members of society to properly recognize disaster risk, risk assessment is often costly and beyond the capacity of small and medium enterprises.

Furthermore, the impact of disasters can be felt beyond private sector investment and spill over to society (*e.g.* damaged factory interrupts traffic and prevents response activity or interrupts production causing income decrease of the employee). In this case, portions of disaster costs are transferred to others in society. This phenomenon is called negative **externality** in economics. When externality exists, private sector does not have incentives to decrease investment in hazard prone areas even if they properly understand the risk. Government needs to commit to disaster risk management mechanisms precisely to provide sufficient risk information to society and thereby remedy the lack of information and externality problem.

Assuring sufficient disaster risk management mechanisms reduces exposed and/or vulnerable areas and facilitates private investment in such areas. In this sense, disaster risk management mechanisms constitute important infrastructure supporting economic development of society. That is also a reason why government needs to commit to integrating disaster risk in public investment planning.

In spite of **decentralization** trends, the role of national government does not diminish. Disaster risk management infrastructure, such as sea walls, are often very costly and beyond the financial ability of local governments. Given the positive externality of such infrastructure, national governments are justified to financially commit in the investment. Catastrophes such as Indian Ocean tsunami in 2004 (just before HFA adoption) and Great East Japan Earthquake in 2011 (whose experience will influence post-2015 Framework for DRR informally called HFA-2) refocused the role of national government on their capability to prepare for and respond to intensive disaster risk. In the context of developing countries, accumulated impacts of low-to-mid scale disasters damage local level capacity and need support from national governments.

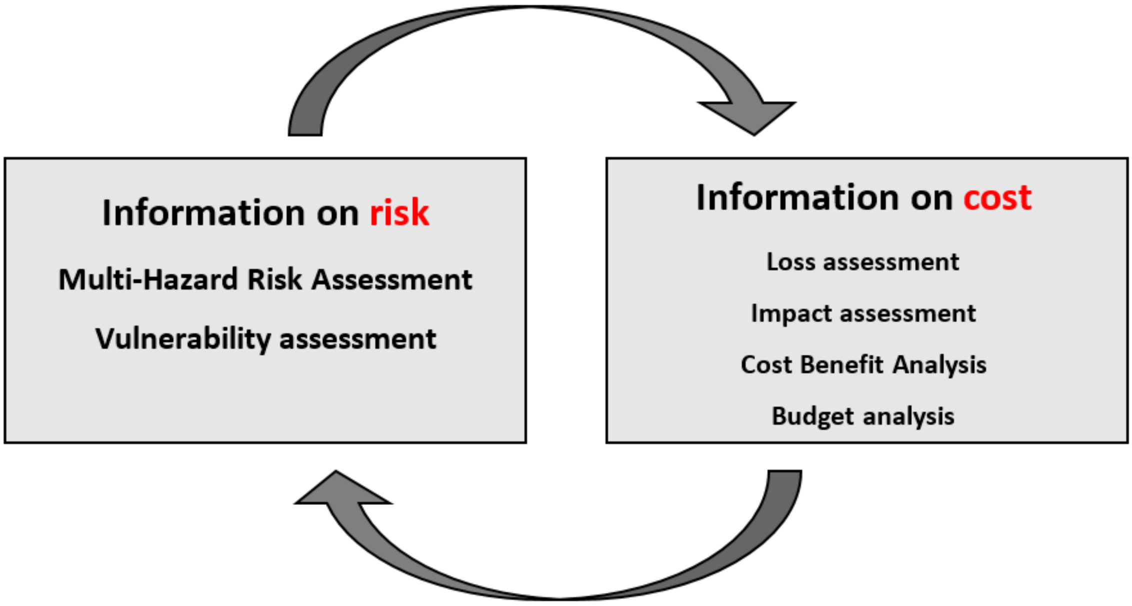
In case of catastrophe, horizontal risk transfer mechanisms such as insurance may often not be sufficient. DRR investment is, unlike risk transfer mechanism, considered inter-generational risk sharing. Following the definition of sustainable development by the Bruntland Committee, only development that addresses the existing risks without compromising the ability of future generations to address them should be promoted.

In summary, public investment in disaster risk management is theoretically justified and commitment of national level government is critical in spite of decentralization trends.

What are the gaps to be filled? It is important to focus on the lack of linkages between natural science and social science, especially in economics. Risk information produced by natural science is not well connected to cost information examined by social science. Even when risk information exists, if it is not linked to cost information, it is difficult to promote DRR Investment (Figure 6). For example, Solomon Islands states "*If policies based on risk information would lead to increased project costs, budget constraints may limit utilization of the risk information. Promoting cost benefit analysis is necessary in order to counteract this "*[7].

[6] A socially desirable state is called Paleto Optimum in economic terms.
[7] HFA Report of Solomon Islands, 2009-2011 Reporting Cycle

Figure 6: Required linkages between risk information and cost information



Source: Author

Related to the lack of cost information is an opportunity cost issue. Ministries of Finance are not concerned only about disaster risk. They need to respond to other competing country priorities. In many countries DRR is not a high priority and policymakers tend to allocate limited financial resources to other urgent needs such as poverty reduction, education and public health. It is also difficult to explain why there is *a sense of urgency surrounding DRR*, a challenge that often leads to problems securing financial resources. A classic dilemma for policy makers is whether they can justify giving up investment in growth and in order to invest in DRR? In other words, risk needs to be examined through a socio-economic lens in each country.

In the DRM cycle, response, recovery and reconstruction also place pressure on the allocation of DRR budgets. Reconstruction and compensation for those affected is imminently needed in the majority of cases. In such situations, budget restructuring following a disaster often takes money away from DRR for use in reconstruction. To assure sufficient money for DRR investment, it is necessary to be able to justify the cost effectiveness of that DRR investment –as compared to expenditure in response and reconstruction.

What exacerbates this difficult situation even more is that most countries do not have DRM labelling or dedicated budget lines for DRM in their public accounting system. So they don't know how much they spend on DRR, response and reconstruction. Sectorial DRR is especially hard to label, as it is often embedded in larger projects. For example, earthquake proof school building is included under the larger category of school building so that the part of budget dedicated to strengthen the facility is not visible, making investment tracking almost impossible. Not having a DRM budget monitoring system results in the inefficient use of resources and an insufficiency of funds. Without knowing their current budget status, countries cannot properly evaluate the current level of DRM and estimate how much funding is required for further promoting DRM activities. Nepal claims "*The budget allocated for disaster preparedness and mitigation is spread among different projects which render it ineffective. There is a need to develop and implement a financial tracking system to monitor all DRR related expenditures for mitigation, preparedness and emergency response*"[8].

Considering all, the key questions that governments must tackle would be, "how much money should be allocated to DRM in total?" and "how to decide the most efficient and effective allocation of money between risk reduction and risk financing?" (Table 1). Subsequently, more specific issues need to be examined: the design of risk sensitive investment mechanisms and risk financing mechanisms (*i.e.* appropriate combination of contingency funds, insurance and other tools).

[8] HFA Report of Nepal, 20xx

Table 1: DRM structure

Risk reduction			Risk financing		Disaster management	
Prevention	**Mitigation**	**Preparedness**	**Transfer**	**Proactive retention**	**Response**	**Reconstruction**
e.g. **land use planning**	***e.g.*** **housing retrofitting**	***e.g.*** **contingency planning**	***e.g.*** **insurance**	***e.g.*** **contingency fund**	**Emergency management**	**Build back better**

B. Streamlined process for evidence based decision making

Given challenges identified in Section B, **how to combine risk and cost information?** The initiative introduced a five-step process (Figure 7). The first step was to identify loss trends and produce risk profile (mainly activity of Components 1 and 2). Subsequently, the current state of DRR policy, public investment policy and budget was examined to verify the gap between risk and DRR efforts. Expected impact on public finance was examined with more detail using the CATSIM model. Lastly, to examine the degree a DRR policy could mitigate the negative impact of a hazard, probabilistic cost benefit analysis was conducted. It is of note that there should be a cost benefit analysis for all kinds of DRR policies and this initiative presented a methodology using only one example. These analyses, combined, are expected to provide insights on and facilitate evidence-based decision making for risk-sensitive public investment planning.

Figure 7: Overall design to support evidence based decision making

STEP 1: Identify loss trend and produce risk profile

(Loss analysis, risk assessment)

STEP 2: Check the gap between the risk and current levels of DRR policy

(Policy review, budget review)

STEP 3: Measure the impact of disaster on economy and public finance

(Macro-economic analysis)

STEP 4: Measure the impact of investment on DRR

(Probabilistic Cost Benefit Analysis)

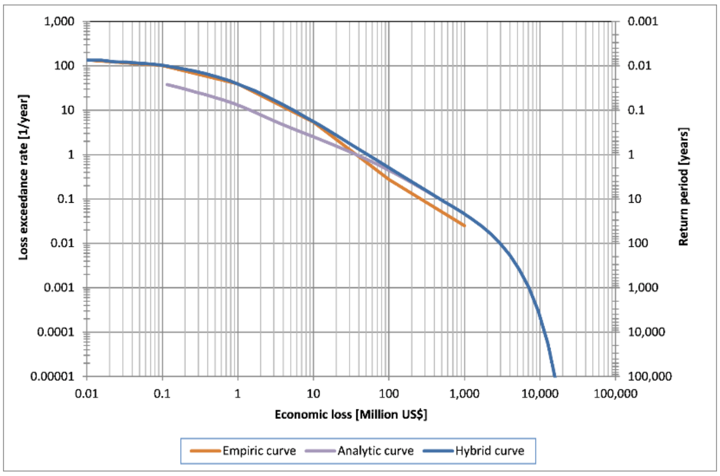
STEP 5: Political discussion based on evidence

(What to do with the gap between risk and current DRR?)

Source: Author

Understanding loss and risk in a country is the **first step** to evidence-based decision making. Loss and risk data present what has historically been lost and what is likely to be lost in future. Both loss and risk information contribute to produce hybrid curves portraying all possible combinations of probability of an event happening and the expected loss (**Figure *8***) in all risk layers including intensive (low frequency and high loss) and extensive (high frequency and small loss) (See Chapters 2 and 3). However, as outlined above, this information alone cannot determine how much should be invested in DRR.

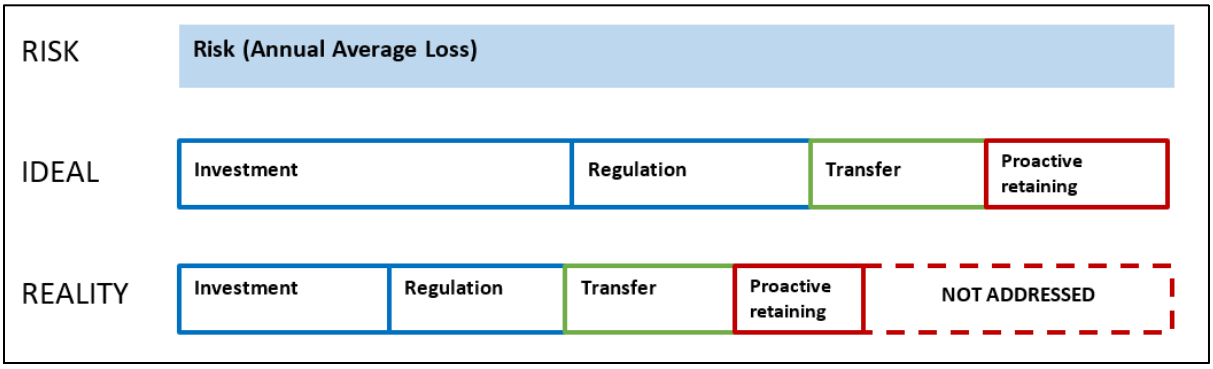
Figure 8: Hybrid loss exceedance curve



Source: UNISDR

Step 2 aims to determine the gap between risk and current levels of DRR policy. An examination of current DRR and investment policies and a comparison between risk levels and DRR investment will provide insights on how much investment in DRR is needed to fill the gap (Figure 9). (See Chapters 4, 5 and Annex A).

Figure 9: Gap identification, drawn from budget and policy analysis

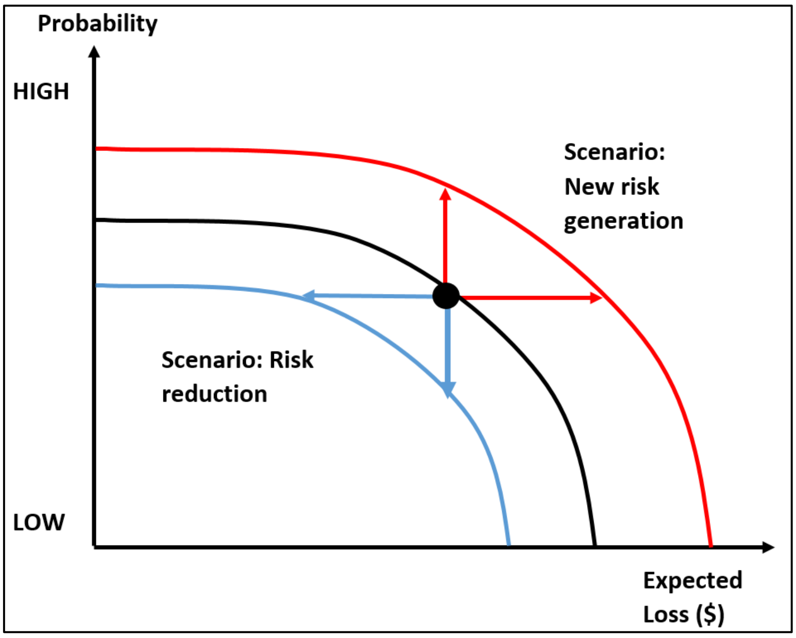


Source: Author

Step 3 measures the impact of disaster on economy and public finance, to further verify the expected impact of disasters on a country. The focus is not necessarily limited to direct loss and indirect loss, and macro-economic impacts are considered to a certain extent depending on the model. In the Indian Ocean Commission (IOC) region, the CATSIM model developed by IIASA and taking indirect loss to a certain degree was used to measure the impact of disasters on public finance. (See Chapters 5 and Annex B)

Step 4 aims to measure the impact of policy on DRR. Some policies are more cost efficient than others, meaning that such policies reduce risk more with less investment. Cost benefit analysis is implemented in this step. (See Chapter 5 and Annex C). DRR policy can shift the risk curve inward (*i.e.* lower frequency of event happening and/or decrease of expected loss) (Figure 10)

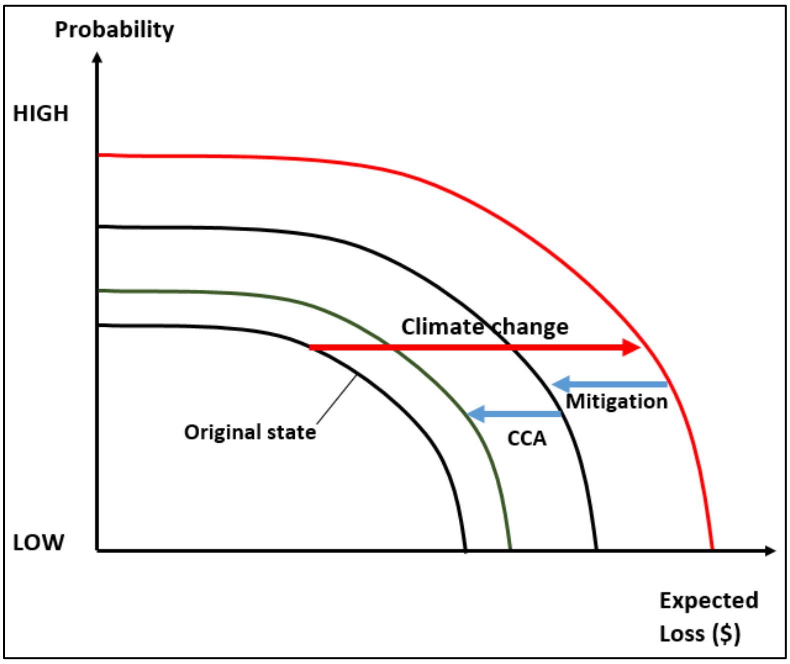
Figure 10: Shift of loss exceedance curve by DRR investment (blue) and new risk generation (red)



Source: Author

Climate change will also influence loss exceedance curve. However, investment in mitigation and adaptation can reduce the total cost. This is graphically expressed in Figure 11. Climate change will shift the curve upward while mitigation and CCA will work to shift the curve to original position. Climate change impact can be integrated into economic analysis of disaster risk applying the same methodological concept when disaster and climate change risk assessment are integrated.

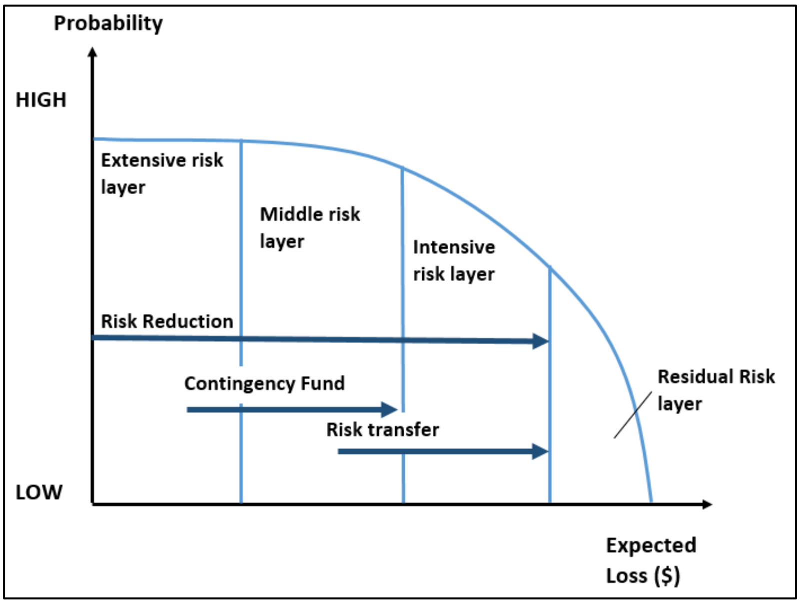
Figure 11: Climate change impact



Source: Author

These analyses, in combination, suggest that a risk-layered approach is crucial to manage disaster risk (Figure 12). In the extensive risk layer (high probability and low expected loss), investment for risk reduction is basically the most cost-efficient. However, some measures for risk reduction (*e.g.* emergency drills as preparedness) can be cost-efficient (and efforts should be devoted to) all risk layers. However, in the intensive layer (low probability and high expected loss), risk reduction is often an unaffordable and prohibitive option. Regarding risk financing, contingency funds will be effective in middle risk layers. However, to prepare for intensive risk, risk transfer schemes, such as insurance, would be more cost-efficient. It is important to note that DRR efforts decrease the scope for risk financing mechanisms, bringing risk premiums down and making insurance more affordable. DRR investment and risk financing mechanisms, therefore, should be considered in synergy to identify the optimum mix in public finance policy.

Figure 12: Risk layered approach

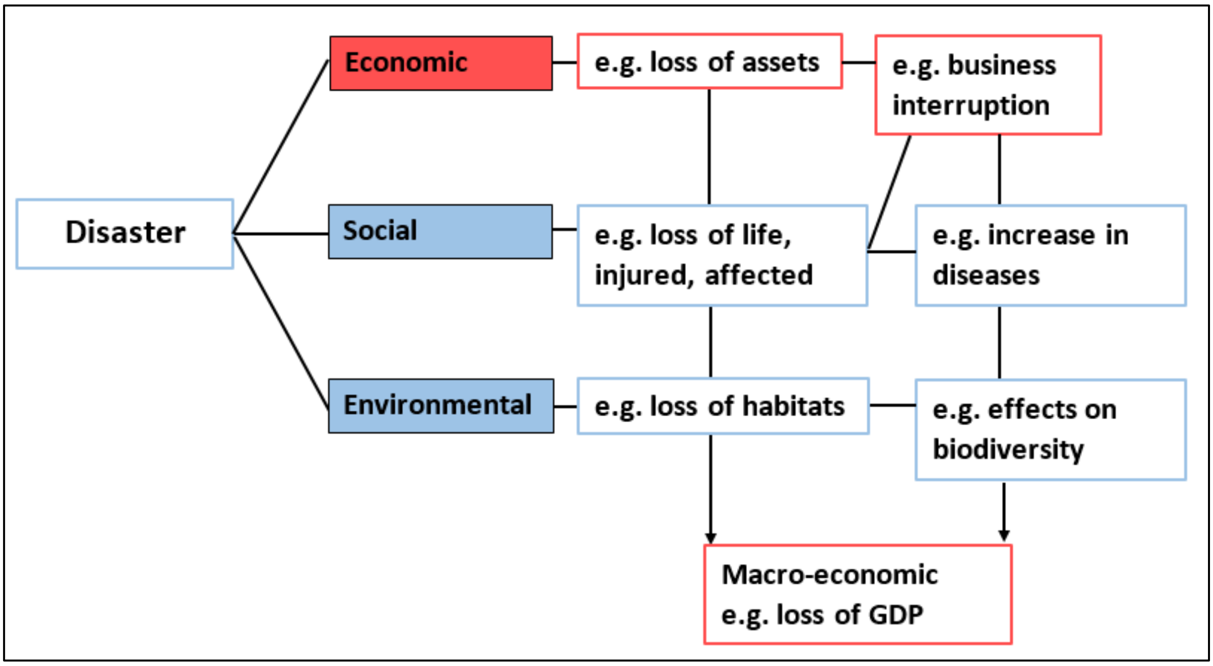


Source: Author

C. Basic concept of economic loss: direct loss, indirect loss and macro-economic impact

Disasters have diverse impacts on society; they are often categorized into economic, social and environmental impacts (Figure 13). Economic impacts include, for example, loss of assets and business interruptions. Social impacts include death, injury and changes to the functioning of communities, to name a few. Some impacts are both economic and social. For example, increased poverty and unemployment would be interpreted from both perspectives. Environmental impacts are for example, loss of habitats for animals and deforestation due to natural fire. When these are all combined, disaster can have a macro-economic impact, for example, the reduction of GDP and trade balances. Economic analysis only focuses on the economic impacts of disaster.

Figure 13: Impact of Disaster

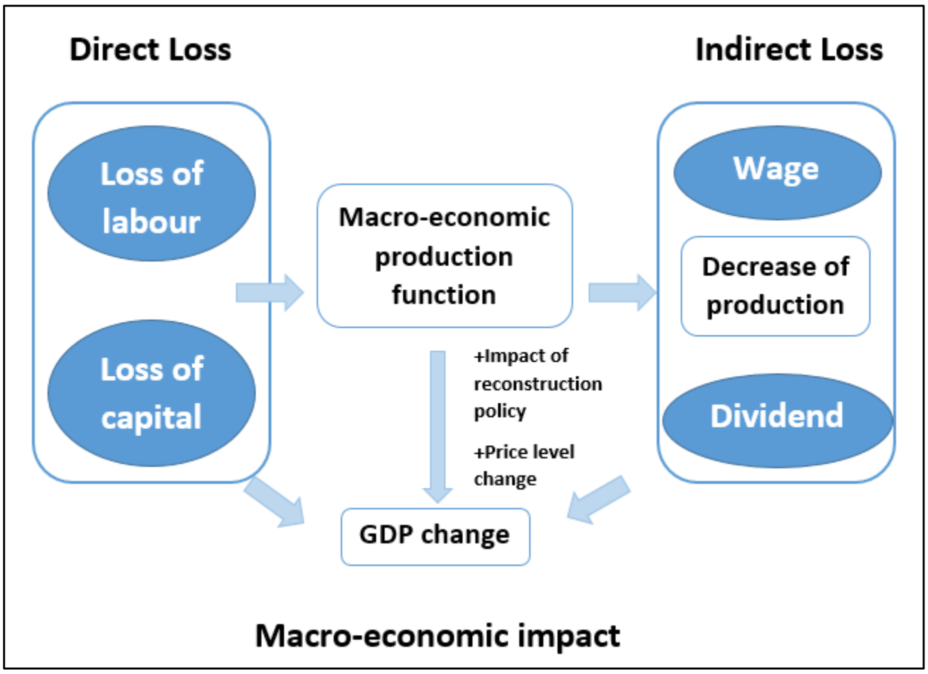


Source: Author

It is important to clarify the difference between direct loss (physical loss centred), indirect loss and macro-economic impact at the start of analysis (Figure 14, Table 2). National disaster loss databases often focus only on direct loss. Probabilistic risk assessment is also often limited to physical impacts of disasters. In these cases, economic analysis based on available loss and risk data will also be limited to direct loss only. The initiative underway in this project is not an exception. Our focus in the cost benefit and CATSIM analyses is on direct physical loss and does not include indirect loss and macro-economic impact[9].

[9] CATSIM analysis includes indirect loss to certain extent because it considers "implicit liability" of government, which means compensation to the affected. For Madagascar, the impact of public finance on macro-economy was also estimated.

Figure 14: Direct loss, indirect loss and macro-economic impact



Source: Author

Table 2: Direct loss, indirect loss and macro-economic impact

	Direct loss	Indirect loss	Macroeconomic impact
Typical examples	Loss of capital stock	Loss of economic activities (e.g. Business interruption) after the event	GDP Inflation trade balance
Time frame	Within the first few hours	Up to multiple years	Up to multiple years
Concept	stock	flow	flow

Source: Author

B.1. Direct loss

Direct loss is nearly equivalent to physical damage. Examples include death and loss to physical assets such as damaged housings, factories and infrastructure. Direct losses usually happen within the first few hours after the event and are often assessed immediately after the event to estimate recovery cost and claim insurance payment. These are tangible and can be relatively easily measured. However, there are still technical challenges, for example, how to assign monetary value to such damage. Or, should direct losses should be estimated as purchased value, book value[10] or replacement cost[11][12]?

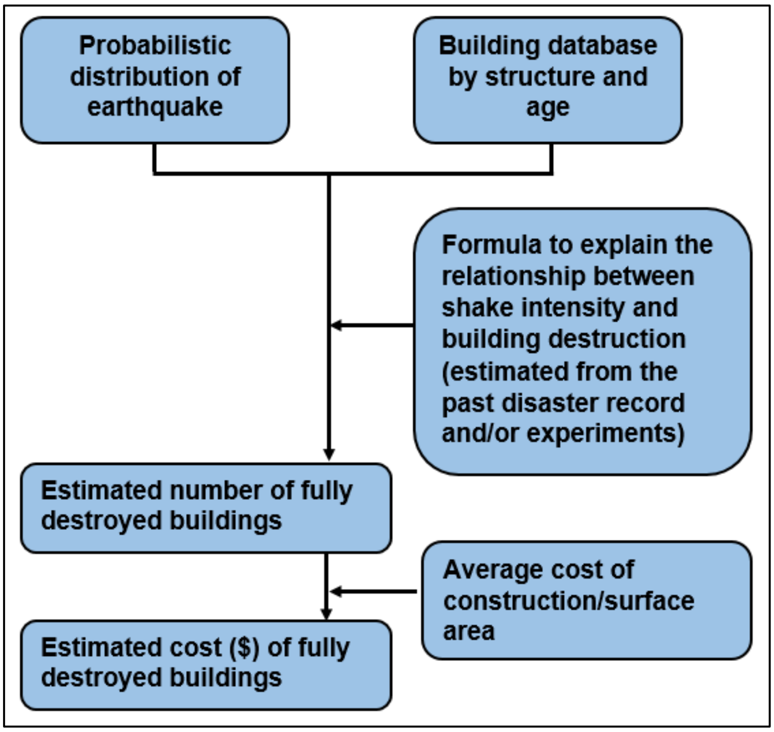
There is another important issue in measuring direct loss; "How to evaluate human loss?" There are some methodologies, for example, that evaluate human loss as lost income. However, this remains an on-going debate among economists because assigning monetary value to human life is an ethical issue, considered morally

[10] Book value means the current value of the asset on accounting book taking depreciation into consideration.
[11] Replacement cost can be cheaper than the price at which the asset was purchased. For example IT machines usually have become much cheaper during this decade. In this case, loss reported using purchased price means overestimation of the loss.
[12] Due to lack of data availability and urgent need to identify the recovery costs, replacement costs are often used in the world as a practical solution.

wrong. If we use the lost income approach, the life of a rich person is more valuable than a poor person. But sometimes, monetary value is assigned to human loss. For example, after 911, NY City estimated the monetary value of human loss in the World Trade Center, Many were high income, young to middle-aged people who pay high taxes and consume and invest heavily in the NY economy. The economic planner of city government practically would have needed the economic and financial impact of loss of such people, but this is a very rare case. It is not common to monetize human loss[13].

In the case of earthquake impacts on building assets, if data on probabilistic distribution of earthquake hazards, building by structure and age, and the past disaster record are availabe, we can estimate the value of expected building damage. If we multiply the number of houses destroyed by average cost of construction, then we can estimate monetary value of such building loss (Figure 15[14]).

Figure 15: Impact of earthquake on building

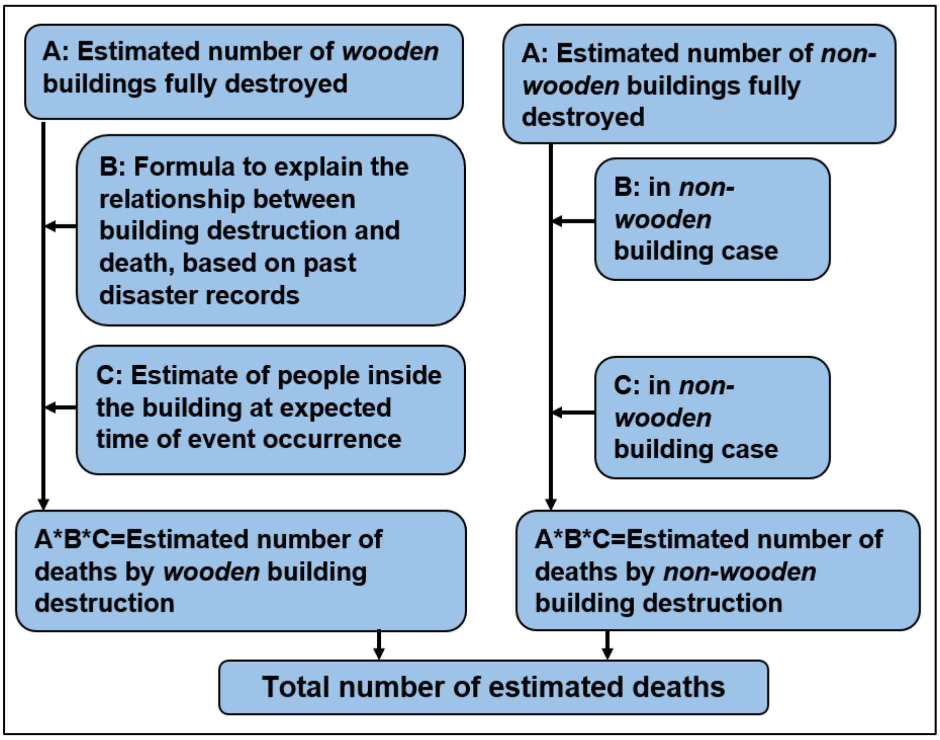


Source: Author

Regarding human loss due to earthquakes, if similar data such as probability, building structure and age, and past disaster records are available, then we can also estimate mortality (Figure 16).

[13] This does not necessarily mean policy makers should not evaluate human loss at all. Most economists simply claim that human loss should not be evaluated at monetary value. Human loss should be counted as number of person killed, injured etc. Cost-effectiveness approach is developed for economic evaluation to determine options, for example, to reduce mortality. In a similar way to cost-benefit analysis explained in Annex C, this approach compares several options and evaluates cost-efficiency given certain objective such as x % reduction of mortality.
[14] The formula in the figure is often called “vulnerability function” in probabilistic risk assessment.

Figure 16: Mortality estimate process



Source: Author

It is clear from the examples that we need to have risk profiles, past loss data and baseline data, for example number of buildings by structure and age to estimate the loss.

B.2. Indirect loss and macro-economic impact

Indirect loss is more complicated. For example, a reduction in labour force and physical capital will cause business interruption and therefore a decrease in production. The reduction of production might be instantly recovered but most often it lasts several years. Damage to economic activity, therefore, should be monitored over a longer period. Indirect losses are conventionally estimated within maximum of five years; it is reported that most loss occurs in the first two years after the disaster. Measurable impacts are often loss to production and income due to destruction of physical assets[15]. Though these indirect losses might be seemingly measurable, it is difficult to isolate the impact of disaster from others, for example, global financial crisis[16]. Technically speaking, to estimate indirect loss, it is necessary to have a "production function" linking labour and capital with production.

There are immeasurable indirect losses, which can be positive or negative, for example, human suffering (negative) or increased sense of mutual help (positive). Though they are not easily measurable, it is important to recognize such issues.

Macro-economic impact is much more complicated, because economic activity is interlinked. For example, production decreases are likely to push prices upward, if demand level remains stable. The rise of price level will increase interest rates[17]. High interest rates will bring private investment demand down. Reconstruction activity through public spending might produce effective demand for depressed economy but might crowd out private investment in growing economy. To estimate macro-economic impact, it is important to model the causal relationship of all these factors. Macro-economic impacts such as GDP, inflation and trade balances will often

[15] Decrease of production will impact the wage level and dividend level.

[16] Another difficult issue would be for example, that lost product has two prices, which are producer price and consumer price. When measuring production sector's loss, then producer price would be more appropriate. On the other hand, if it is desirable to measure the loss from the interrupted service, consumer price would be better.

[17] The reason for this increase is because people want to withdraw money from the bank, and banks need to set high interest rates, as incentives to maintain deposit levels.

persist for several years and should also be monitored over time. They are conventionally estimated within maximum of five years after disaster events.

Indirect loss and macro-economic impacts are highly analytical and the results change depending on many factors. First, the result depends on geographic scale, for example, municipality, region, or nation. For example, the impact of the Great East Japan Earthquake on the national economy is estimated to be negative (*i.e.* a loss in production). But if we look at the regional scale, while Miyagi prefecture including Sendai City-- severely affected by the tsunami-- had a negative impact, Tokyo had a positive impact --an increase in production to cover the loss in Miyagi prefecture.

Second, the result depends on the time an impact is estimated. As time passes, more information is gathered but some information will also be lost. For example, the estimate of one month after the event usually cannot integrate the impact of reconstruction activity on macro economy. In the case of intensive disasters, even after one year, the impact of reconstruction activity cannot be fully evaluated.

Third, the result also depends on the availability of baseline economic scenarios. The impact of a disaster on the macro economy should exclude other factors. For example, if the economy has been declining for the past decade and is likely to decline in coming five years, even if the GDP decreases after the disaster, that might be reflecting the general economic trend more than the event itself.

Forth, the results depend on the definition of impact, which is likely to be politically influenced by main concern for society and its policy makers. In case of 911, the Asia-Pacific Economic Cooperation (APEC) estimates included the increase of security costs. After Niigata earthquake of Japan --which also caused nuclear power plant problems, though much smaller scale than Fukushima, Niigata prefecture included an estimate of the impact of “reputation loss” due to the nuclear problem.

B.3. Macro-economic impact

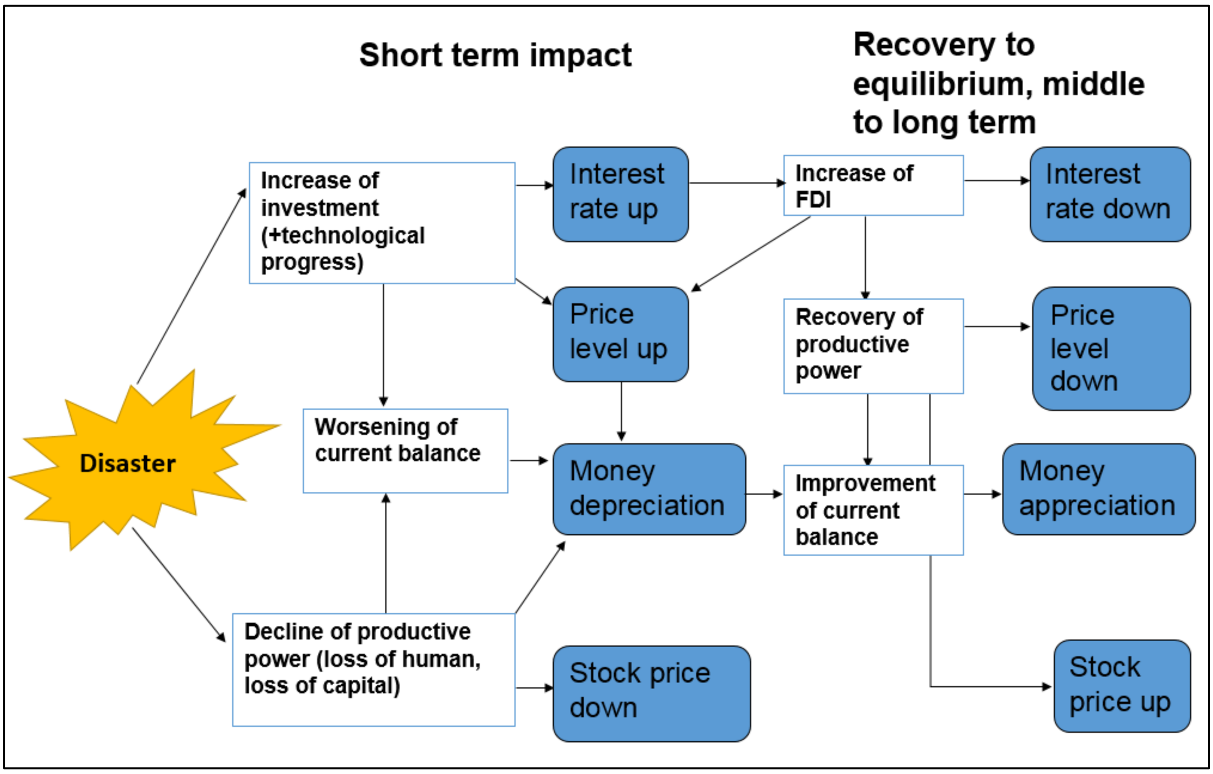
In analysing macro-economic impact, it is very important to analyse the impact from supply and demand sides and short and long-term perspective (Table 3). From supply side, decrease of production due to capital loss can be observed as a negative impact in the short term. However, in the long term, replaced new and more productive factories can improve efficiency and produce positive impact. From the demand side, decline of income, asset value, and population can be all observed as negative impacts in the short term. However, reconstruction demand can have a positive impact, especially for depressed economies that lack effective demand. The total impacts can be evaluated as the balance of supply and demand side impacts. A macro-economic model is constructed based on many assumptions reflecting causal relationships that impact both the demand and supply sides (Figure 17 and Figure 18).

Table 3: Macro-economic impact

		Short Term Impact	Long Term Impact
Supply	Decline of production capacity due to capital loss	Negative	
	Technological progress (e.g. replacement of factory)		Positive
Demand	Decline of income	Negative	
	Decline of asset value	Negative	
	Population decrease	Negative	Negative
	Reconstruction demand	Positive	Positive

Source: Author

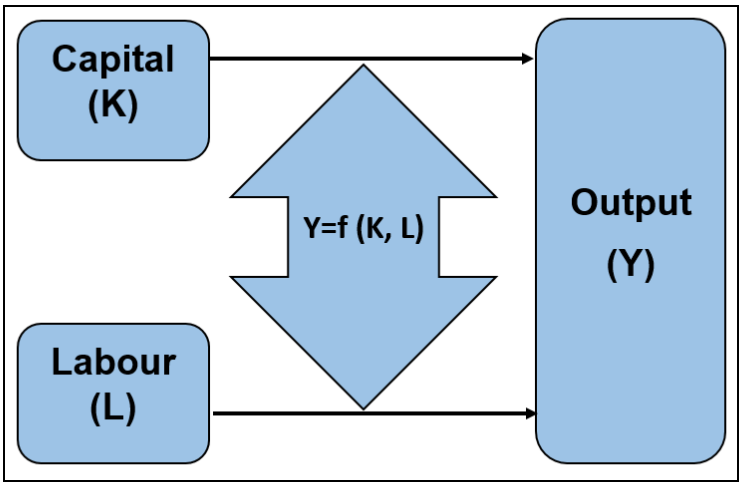
Figure 17: Example of economic modelling



Source: Author

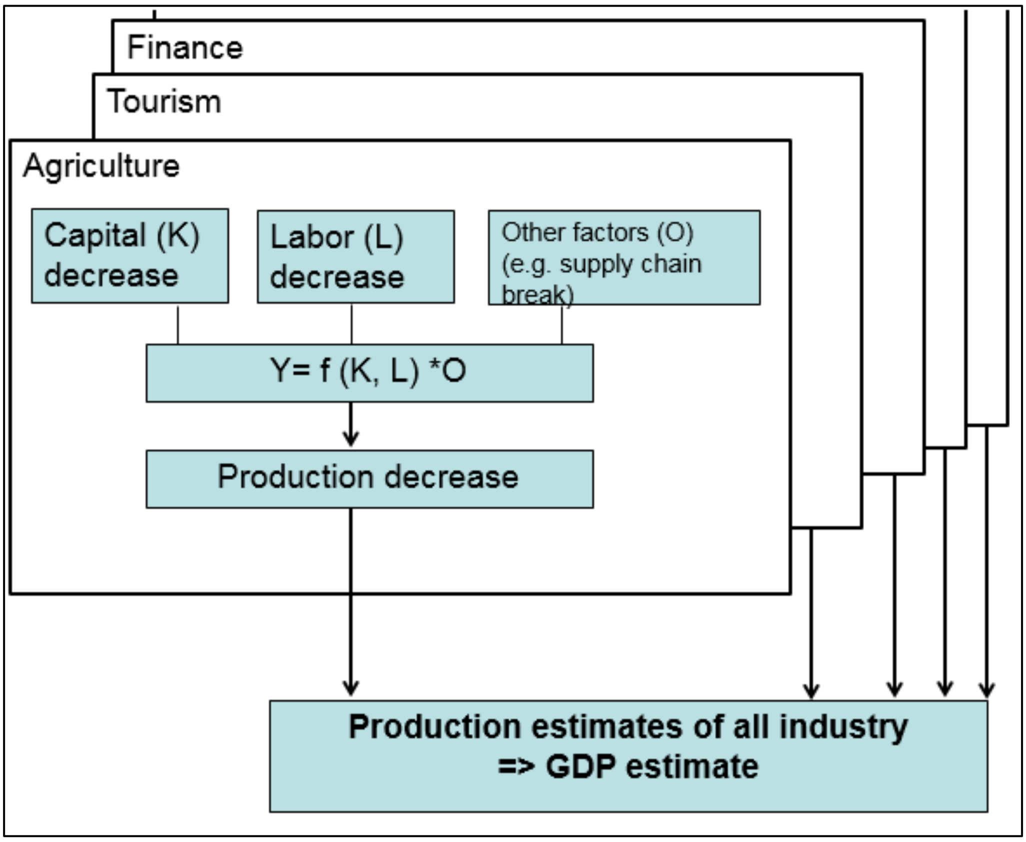
When macro-economic modelling is not available or a more micro-level approach is more practical, a sectoral-based approach might be preferable. The essence of estimating economic impact is in how disasters impact labour and capital --the two most important factors for economic growth (Figure 18). If capital and/or labour decrease, production will decrease based on the production function. Each sector, or even each company, has a different production function. Those results will constitute GDP estimates (Figure 19). Sectors often assessed are infrastructure, schools, hospitals, energy etc. However, when summarizing them, we need to be careful about double-counting and the inter-relationship between sectors. When each sector is not well coordinated, double-counting often occurs. Inter-relationships between sectors also should be checked using an input-output table, if possible.

Figure 18: Production function



Source: Author

Figure 19: Production function by sector

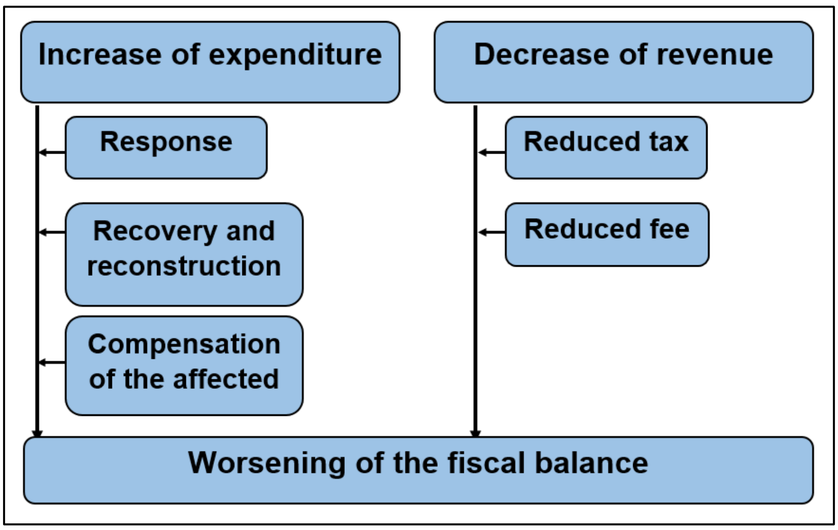


Source: Author

B.4. Impact on public finance

When considering the impact of disasters on public finance, similarly we need to explore the demand and supply sides of public finance. On the demand side, increased need for expenditure in response, recovery and reconstruction are always observed. On the supply side, decrease of financial resources by reduced tax and fees can be also noted. Therefore, fiscal balances almost always worsen (Figure 20).

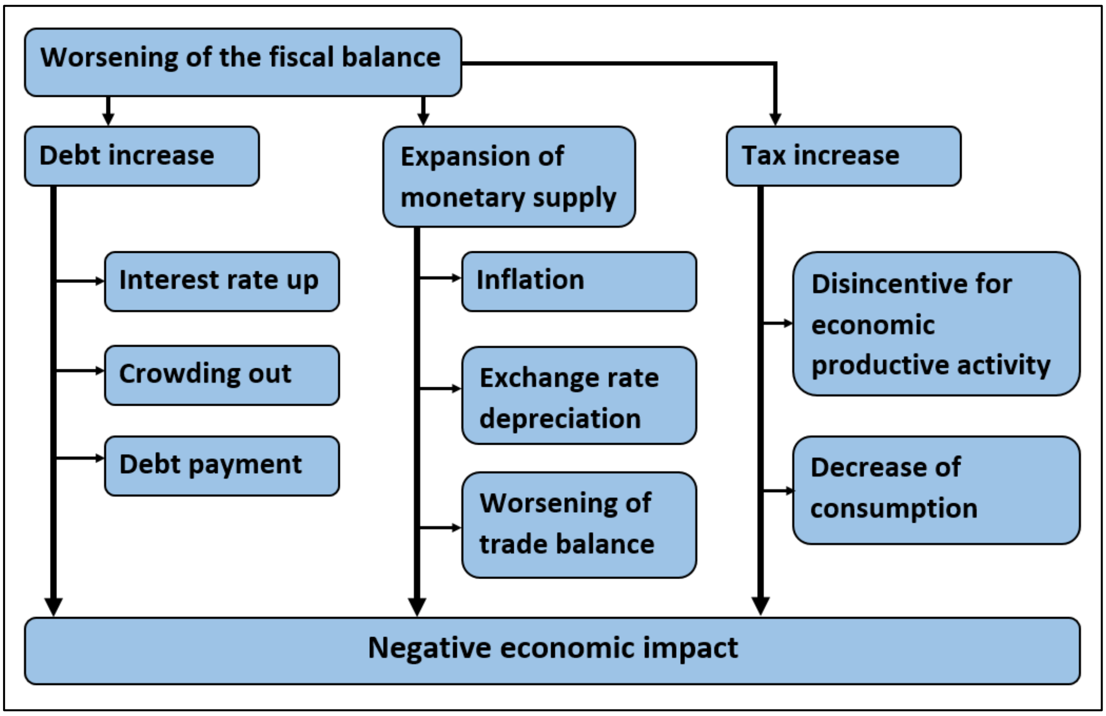
Figure 20: Fiscal impact of disasters



Source: Author

A worsened fiscal balance often has a negative impact on the macro economy. Figure 21 below presents three cases of a negative chain of fiscal impact: debt increase, expansion of monetary supply, tax increase. Whichever option a government takes, it will have a negative impact on macro-economy. IIASA's CATSIM model estimates the impact of public finance on macro-economy.

Figure 21: Relationship between fiscal impact and economic impact



Source: Author

Reference

HFA Report of Nepal, 2009-2011 Reporting Cycle

HFA Report of Solomon Islands, 2009-2011 Reporting Cycle

IMF

2. Disaster Loss[18]

A. Overview

Component 1 of this initiative was to build a disaster loss database that registers not only large-scale but also small-to-medium scale disasters. The small-to-medium scale disasters are rarely registered in the international disaster databases, because their effects are considered to be less relevant from a macroeconomic perspective. However, such disasters usually impact the livelihoods of poor people, perpetuating their level of poverty and human insecurity, and eroding government budgets. They exacerbate local level sustainability and pose serious problems for the development of a country as a whole. The analysis of disasters at all scales allows the identification of aggregated effects over time, regional areas and hazards targeted as high priority, and impacts on housing and livelihoods of local communities.

Loss information contributes to comprehensive risk assessment by providing an estimate of the risk of high frequency but small-scale risk. It also gives information on non-modelled hazards. Furthermore, it can be utilized as an input to economic analysis, for example cost benefit and economic impact analysis. The key concepts introduced in the loss data analysis are:

Intensive disasters: high-severity, mid to low frequency disasters, mainly but not exclusively associated with high profile fast-onset hazards. UNISDR classifies disasters as intensive when at least 30 people are killed, and/or a minimum of 600 houses are destroyed.

Extensive disasters: low severity, high frequency disasters, mainly but not exclusively associated with highly localized and often slower-onset hazards. All disasters with less than 30 people killed, and/or less than 600 houses destroyed, are classified as “extensive”. There is no minimum number of deaths or damaged houses to be considered extensive[19].

During the project, data on extensive and intensive disasters that occurred from 1980 to 2014 were collected. The data were registered by district, which allows more detailed examination of loss distribution in the country. The current loss database basically registers direct physical loss data only. Indirect and socio-economic loss data are not registered in principle. Even if registered, it needs to be analysed with caution due to ambiguity of definitions. The disaster data not directly associated with natural hazards (*e.g.* traffic accident, marine accident, epidemic, shark attack) were registered in the database but excluded for analysis in this report[20].

The disaster loss database takes into account the different disaster types and registers a series of indicators to classify impact such as:

- Damaged houses

- Destroyed houses

- Basic human loss (mortality, injured, affected).

The loss data were assigned monetary value by applying the methodology developed by UNISDR, which allows comparison across countries[21].

Civil Protection authority in Comoros hosted Component 1 with cooperation from the Ministry of Environment.

The data is open to public in the following site:http://www.desinventar.net/DesInventar/profiletab.jsp?countrycode=com

[18] This chapter was drafted by Sylvain Ponsere (UNISDR)
[19] The most well-known international disaster loss database called EM-DAT registers disasters for a minimum of 10 deaths (see http://www.emdat.be/criteria-and-definition).
[20] Fire is included in the analysis, though.
[21] For methodology of assigning monetary value to loss, see http://www.preventionweb.net/english/hyogo/gar/2013/en/gar-pdf/Annex_2.pdf

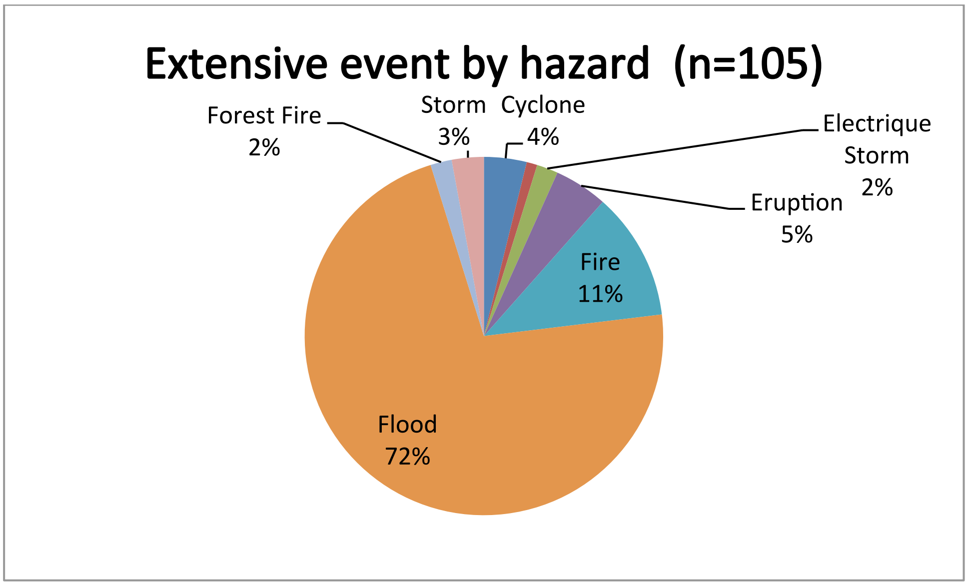
B. Disaster loss in Comoros[22]

Comoros is generally prone to a wide range of natural hazards including Volcanic eruptions, cyclones, flash floods, torrential rains, landslides, drought, pest, epidemics, tsunamis and tidal waves. Coastal erosion arising from climate change can also be added to this list.

A total of 105 data cards were registered for natural hazards: 104 cards were categorized as extensive disasters while only one card was categorized as an intensive disaster. Intensive loss was due to Tropical Storm Doloresse in 1996, which resulted in 67 deaths.

Out of 105 extensive disasters, flood is the most frequent/prevalent (72%), followed by, fire (11%), volcanic eruption (5%) and cyclone (4%) (Figure 22).

Figure 22: Extensive event by hazard



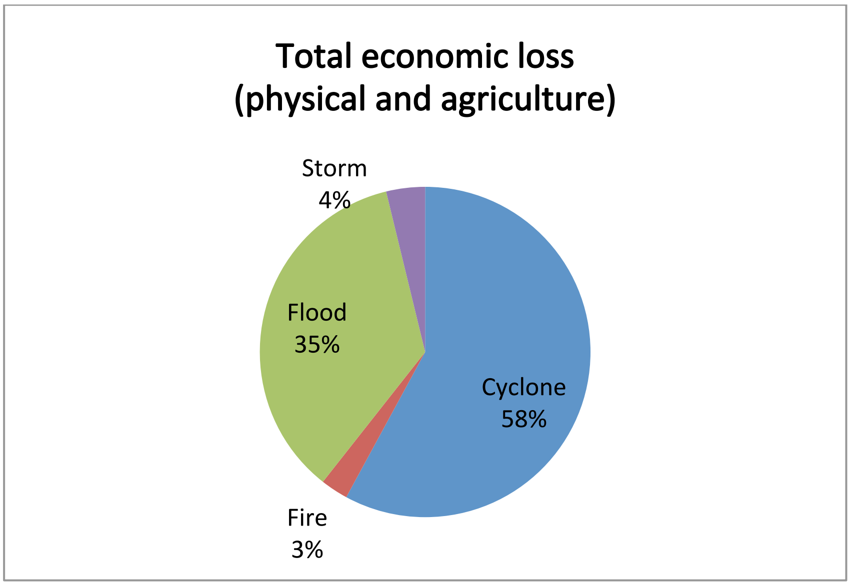
Source: Author based on Comoros National Loss Database

Total mortality to the 105 disaster events is 34, mainly due to flood and cyclone.

Economic loss (physical and agriculture) is estimated at USD 9.8 million at 2012 prices. When intensive and extensive losses combined, cyclone caused 58% of total losses, followed by flood (35%) and storm (4%) (Figure 23).

[22] For detailed methodology, see UNISDR/IOC (2014) and http://www.desinventar.net/methodology.html

Figure 23: Total economic loss (physical and agriculture)



Source: Author based on Comoros National Loss Database

The island of Ngazidja is impacted more than other islands in term of mortality and economic losses.

Though not having registered much economic losses and mortality, the eruption of Mount Karthala in 2005 affected 2,000 people. The Karthala volcano is very active, having erupted more than 20 times since the 19th century.

3. Disaster Risk[23]

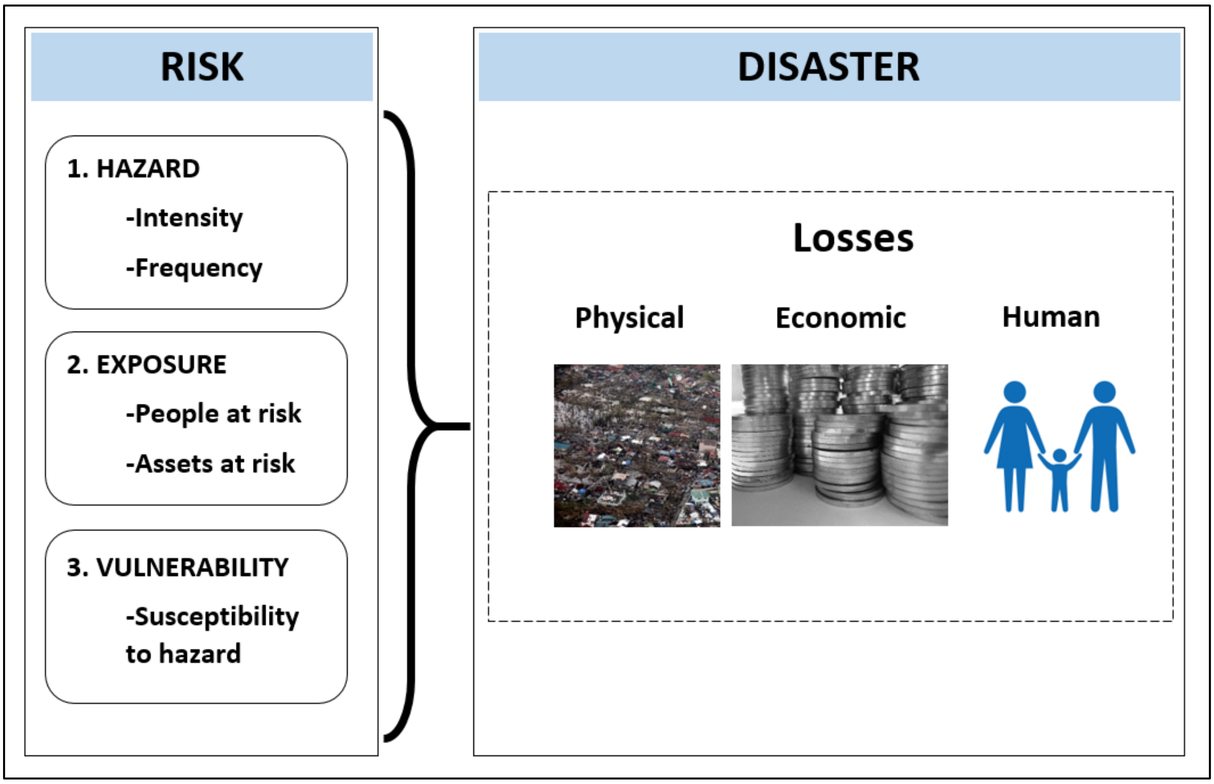
A. Overview

Component 2 of this initiative aimed to build a database for probabilistic risk assessment. UNISDR facilitated the identification and consolidation of a national focal point for disaster risk information and enhanced the understanding of risk concepts and risk assessing methodologies through capacity building workshops

Probabilistic risk assessment differs from a "deterministic" risk assessment in that it attributes a probability to hazardous events. Probability indicates the likelihood of the event to occur during a given year; it is estimated using frequency and is expressed in terms of "return period" or "loss exceedance rate". Risk is expressed as a combination of the probability of the event occurring and the expected loss when such an event occurs.

In probabilistic risk assessment, risk is composed of three factors: hazard, exposure and vulnerability (Figure 24). **Hazard** data are basically calculated from a set of stochastic scenarios and in this initiative the data were extracted from global datasets[24]. **Exposure** data measures the degree at which people and assets will be at risk when a hazard hits, and often consists of inventories of buildings, population and infrastructure. In this initiative, we used a combination of global exposure databases and data compiled by national experts (processed to construct a proxy). **Vulnerability** indicates the susceptibility of exposed population or assets to suffer damages and loss. This is important because hazard affects exposed element in different ways. For example, a certain wind speed affects a wooden house more heavily than a concrete building. In other words, vulnerability data show the relationship between hazard intensity and the expected values of damage. In this initiative, vulnerability data were also taken from global data sets.

Figure 24: Key concepts of probabilistic risk assessment

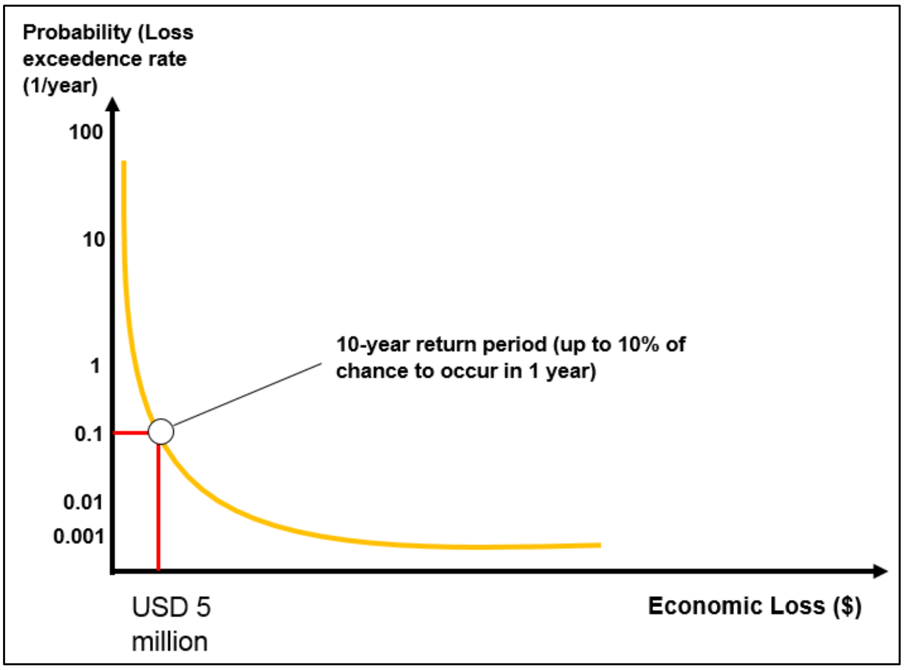


Source: Author

[23] This chapter was drafted by Kazuko Ishigaki (UNISDR).
[24] Hazard, exposure and vulnerability data used for the risk assessment in Comoros is outlined in INGENIAR (2014) and UNISDR/IOC (2014).

Based on probabilistic risk assessment, a loss exceedance curve for each hazard is produced (Figure 25). The curve shows the relationship between each value of the losses and the likelihood (probability) of having such loss during one year.

Figure 25: Loss exceedance curve



Source: Author

This curve enables the calculation of important national risk metrics called Annual Average Loss (AAL) and Probable Maximum Loss (PML). The AAL is basically the combination of all the potential losses that can occur every year due to a particular hazard, weighted according to their likelihood of occurrence. Simply said, the AAL is the loss that can be expected every year, regardless of whether it actually occurs or not. It gives insights into investment planning because the value shows how much risk should be reduced or transferred annually to prepare for all layers of risk. The PML is the loss associated to a specific, usually long return period. PML is a loss that is not frequent, therefore usually high, but still plausible. PML is a useful reference value to draft a worst-case scenario and prepare for intensive events.

Probabilistic risk assessment can be utilized for diverse policy areas, from emergency management planning to land use planning and financial and investment planning. However, caution should be given to the limitation caused by scarce data that feed into probabilistic risk assessment, and simplified modelling of complex phenomena.

In the IOC region, UNISDR supported probabilistic risk assessment for tropical cyclone (wind) and earthquake hazards. Tropical cyclone was selected because it was clear from the disaster loss data outlined in Chapter 2, that the region (especially Madagascar and Mauritius) has been hit by cyclone very often causing much loss. Earthquake was selected due to data availability given the short time frame of the initiative, even though it is not a major hazard for the region.

UNISDR and the national team collaborated to produce hybrid loss exceedance curves that combine probabilistic risk curves based on data collected in Component 2 with empirical risk curves based on historic loss data registered in Component 1 (see Chapter 2). Probabilistic risk assessment tends to underestimate the extensive risk and historic loss data is used to remedy this problem.

The challenge is that the current historic loss databases have time series that are too short to produce high quality risk assessments. Achieving more detailed risk assessments requires continuity on capacity building processes, improvement of data/information and commitment of institutions, technical personnel and decision makers.

As described above, the probabilistic risk assessment implemented in this initiative is very often based on global data and does not have high resolution. Therefore it cannot be utilized for detailed cost benefit analysis, local planning and insurance premium calculation. The result is currently also limited to the assessment of physical assets due to data availability. However, the result can be very useful to raise awareness of disaster risk and initiate dialogues on incorporating DRM into the country's public investment planning.

In Comoros, Director General of Meteorology in Ministry of Interior, ANACEM in Ministry of Finance and Budget, Union of Chamber of Commerce, Industry and Agriculture of Comoros (UCCIA), and Consular of Legal Affairs participated in the disaster risk assessment activities for Component 2.

B. Probabilistic Risk Assessment in Comoros[25]

In Comoros, UNISDR and the national team conducted probabilistic risk assessments for tropical cyclonic wind and earthquake risk; both are described below.

B.1. Cyclone wind risk assessment

Table 4 presents the AAL and PML in absolute and relative values to exposed assets, gross fixed capital formation (GFCF) and GDP. AAL is USD 0.16 million and constitutes 1.9‰ of GFCF. PML is USD 2.61 million for a 50-year return period and it increases with longer return periods. Compared to the earthquake risk, tropical cyclonic winds represent a less important hazard, since the associated losses for the same return periods are much lower than those for earthquakes.

Table 4: AAL and PML for tropical cyclonic wind in Comoros

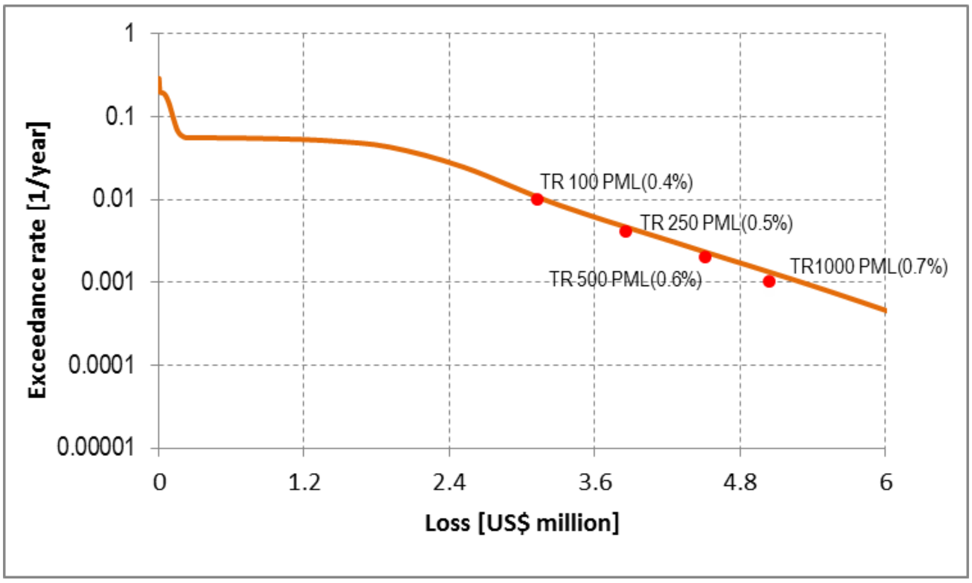
	USD million	**Exposed Assets (2014)**	**GFCF (2013)**	**GDP (2013)**
		808.1	**85.99**	**450.11**
	Absolute	*Relative*		
Annual Average Loss (AAL)	**0.16**	0.20‰[26]	1.9‰	0.4‰
Probable Maximum Loss (PML)				
Return Period (years) 50	**2.61**	0.3%	3.0%	0.6%
100	**3.13**	0.4%	3.6%	0.7%
250	**3.87**	0.5%	4.5%	0.9%
500	**4.52**	0.6%	5.3%	1.0%
1000	**5.05**	0.6%	5.9%	1.1%

Sources: Exposed Assets AAL, PML: UNISDR/IOC (2014), GFCF and GDP: World Bank development indicator

Figure 26 shows the loss exceedance curve while Figure 27 shows the PML curve. In addition, the loss exceedance curves for given different periods, specifically 50, 100 and 200 years, are presented in Figure 28. These plots show the probability of exceeding a certain value of loss in a given time frame; for example, the probability of exceeding loss of USD 2.61 million (PML for a 50-year return period) in the next 50 years is approximately 63 %.

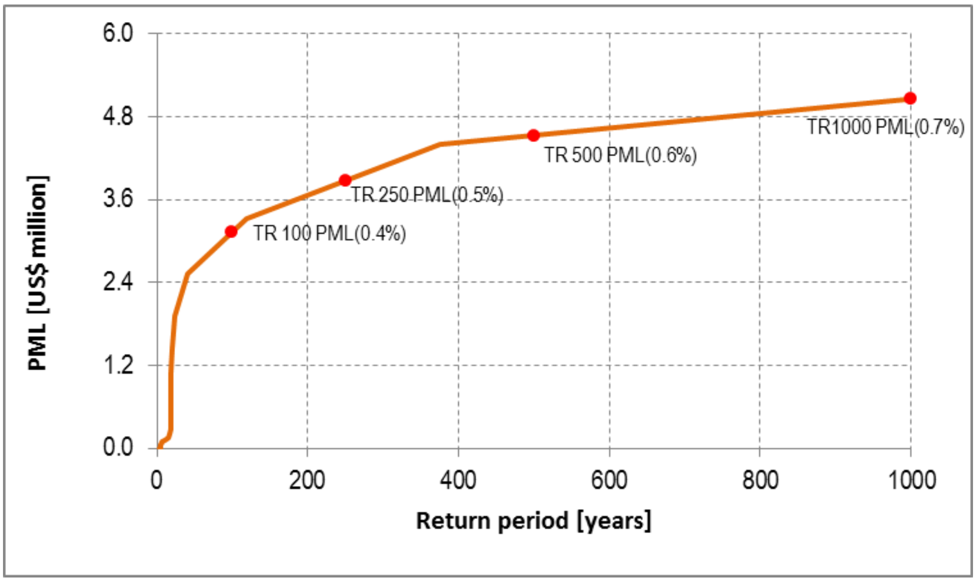
[25] For detailed data source and methodology, see UNISDR/IOC (2014)
[26] Mille is a mathematical term that means per thousand, as its name in French suggests. It is represented by the symbol ‰.

Figure 26: Loss exceedance curve for tropical cyclonic wind



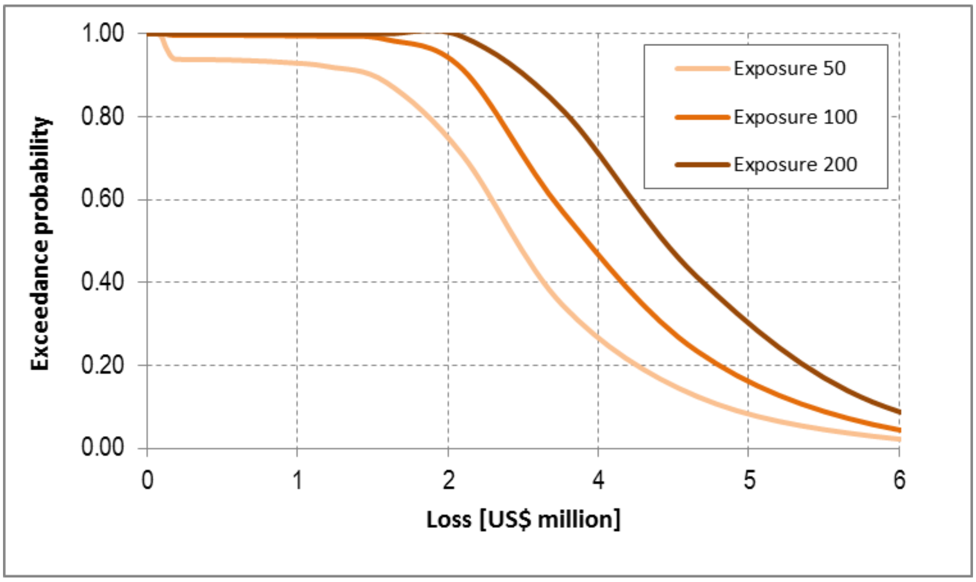
Source: UNISDR/IOC (2014)

Figure 27: PML curve for tropical cyclonic wind



Source: UNISDR/IOC (2014)

Figure 28: Exceedance probability curves given different times

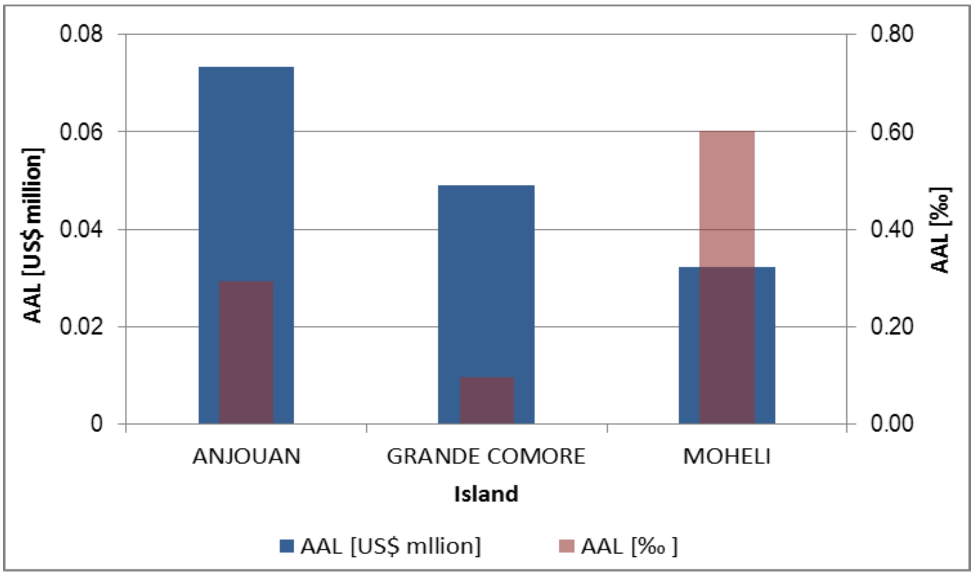


Source: UNISDR/IOC (2014)

The analysis of risk concentration is first carried out for the different islands, and then for the different sectors (for both the public and private sectors, and for the main components of infrastructure at national level).

Figure 29 and Figure 30 show the AAL (absolute and relative to the exposed value) by islands. The risk in absolute and relative terms is concentrated in Anjouan while in relative terms the risk is also concentrated in Moheli. The geographical location of both islands makes them more susceptible to tropical cyclones. The higher absolute AAL of Anjouan compared to Moheli is due to the higher exposed value. In spite of lower exposed value in Moheli, the assets in Moheli are more vulnerable to strong winds than the ones in Anjouan, which explains high relative risk in the Island.

Figure 29: AAL (absolute and relative) by island for tropical cyclonic winds



Source: UNISDR/IOC (2014)

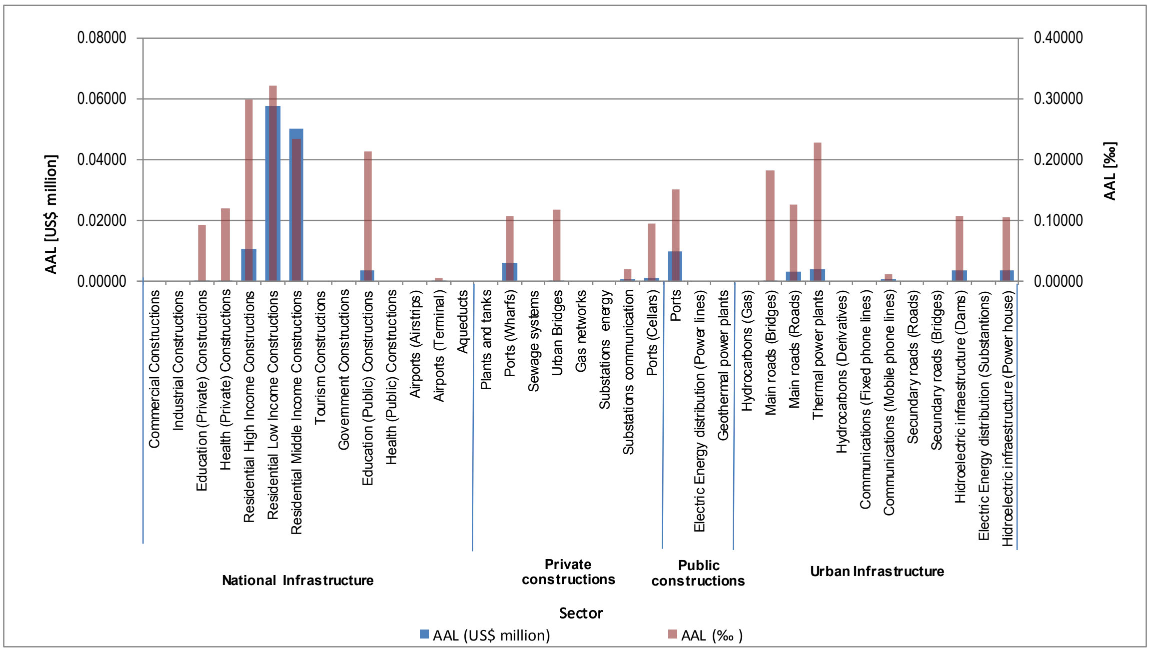
Figure 30: AAL (absolute and relative) by island for tropical cyclonic winds

Absolute AAL | Relative AAL

Figure 31 summarizes the AAL (absolute and relative to the exposed assets) for for each sector. In absolute terms, the Residential Low-Income and Middle-Income constructions among the built environment assets database have the highest risk level to tropical cyclonic wind in Comoros. In relative terms, both, the Residential Low-Income and the High-Income constructions are the assets that have the highest relative risk level to tropical cyclonic wind. The residential sector (high, middle and low income) are the constructions with the highest relative AAL. Public and private education present also a high relative AAL due to tropical cyclonic wind but a very low absolute AAL if compared to the residential sector.

Source: UNISDR/IOC (2014)

Figure 31: AAL by sectors for tropical cyclonic winds



Source: UNISDR/IOC (2014)

B.2. Earthquake risk assessment

Table 5 presents the AAL and PML in absolute and relative values to exposed assets, GFCF and GDP. AAL is USD 0.21 million and constitutes 2.44‰ of GFCF. PML is USD 0.49 million for 50 years of return period and it increases when return periods get longer. Given the proximity of the islands to the continental Africa, strong earthquakes are more likely to occur in Comoros compared to other countries. However, the seismic risk in Comoros can be considered low; even though a loss of USD 42 million may seem high, it only occurs, on average, every 1,000 years. Despite the fact that the risk is low, they should not be considered negligible because an extreme event can generate high disruptions, damages and causalities.

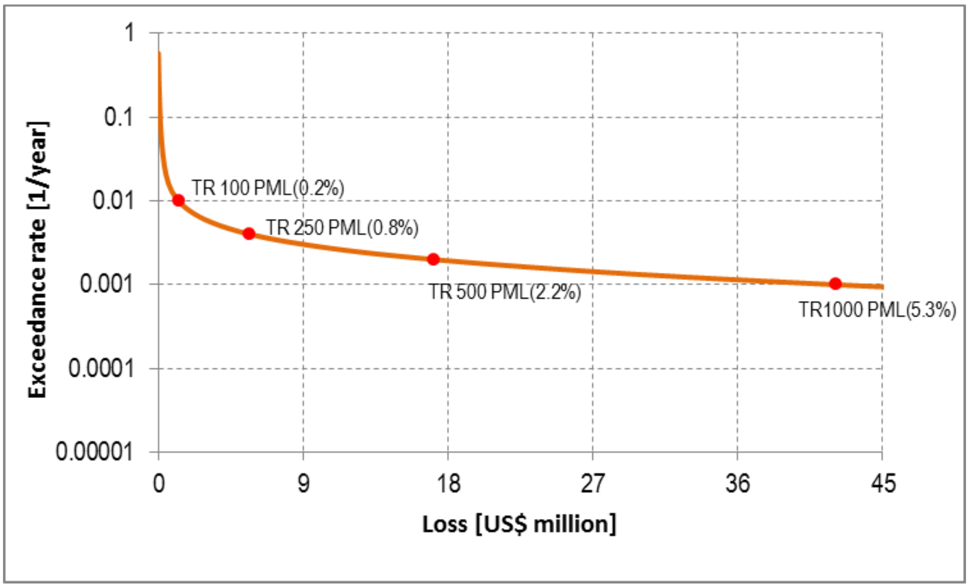
Table 5: AAL and PML for earthquakes

	USD million	**Value of Exposed Assets (2014)**	**GFCF (2013)**	**GDP (2013)**
		808.1	**85.99**	**450.11**
	Absolute	Relative		
Annual Average Loss (AAL)	0.21	0.03‰	2.44‰	0.47‰
Probable Maximum Loss (PML)		%		
Return Period (years) 50	0.49	0.06%	0.57%	0.11%
100	1.25	0.15%	1.45%	0.28%
250	5.70	0.71%	6.63%	1.27%
500	17.09	2.12%	19.87%	3.80%
1000	42.07	5.21%	48.92%	9.35%

Sources: Exposed Assets, AAL, PML: UNISDR/IOC (2014), GFCF and GDP: World Bank Development Indicators

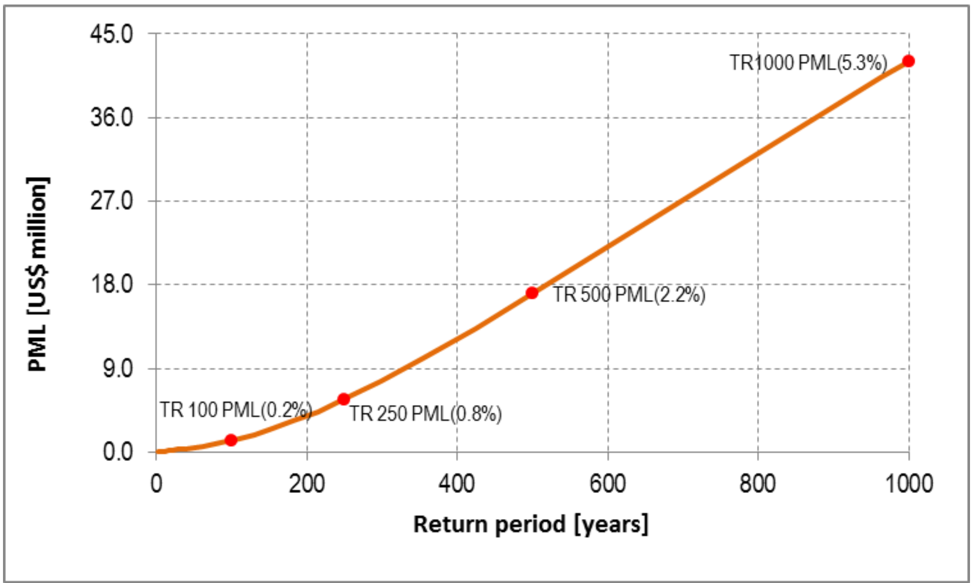
Figure 32 presents the loss exceedance curve and Figure 33 presents the PML curve. In addition, the loss exceedance curves given different exposure periods, specifically 50, 100 and 200 years, are presented in Figure 34; these plots show the probability of exceeding a certain value of loss in a given exposure time frame; for example, the probability of exceeding a USD 17 Million of loss value (PML for 500 years return period) in the next 50 years is approximately 10%.

Figure 32: Loss exceedance curve for earthquakes



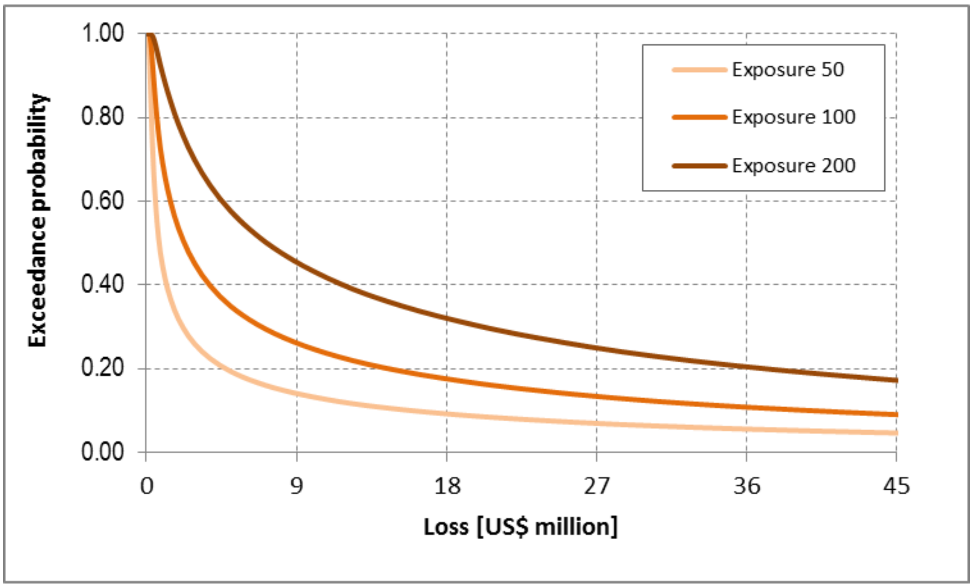
Source: UNISDR/IOC (2014)

Figure 33: PML curve for earthquakes



Source: UNISDR/IOC (2014)

Figure 34: Exceedance curves given different periods

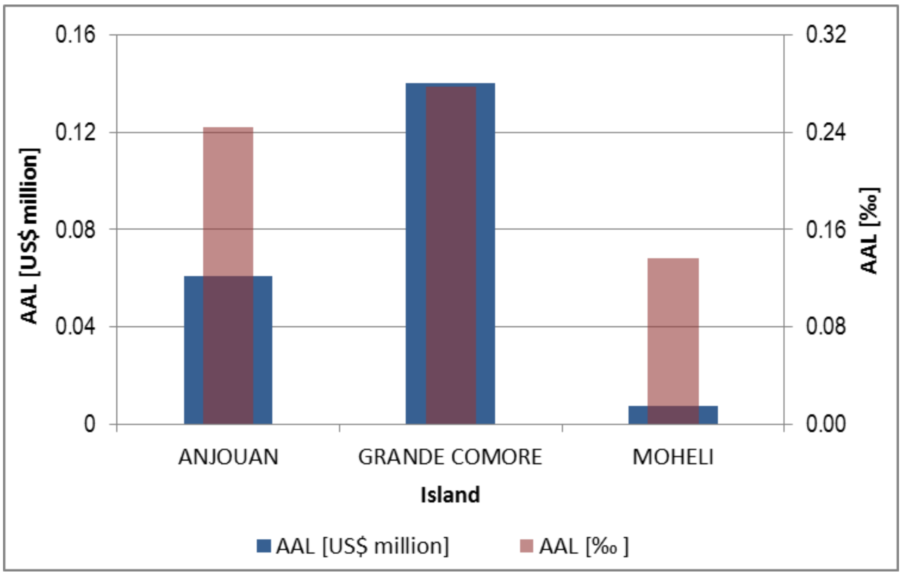


Source: UNISDR/IOC (2014)

The analysis of risk concentration is first carried out for the different islands, and then for the different sectors (for both the public and private sectors, and for the main components of infrastructure at national level).

Figure 35 and Figure 36 show the AAL (absolute and relative to the exposed value) by island. The regional distribution of risk is totally different from the one for tropical cyclonic wind risk. The risk in absolute and relative terms is concentrated in Grande Comore while in relative terms the risk is also concentrated in Anjouan Island. Risk concentration in Grande Comore is related to the fact that the total exposed value is concentrated the most. A relative AAL of 0.28 ‰ means in general terms that the total value of Grade Comores can be lost every 3,500 years. Although it may seem a very long period of time, it is important to recognize that it corresponds to a mean estimate and a worse scenario can happen. Therefore it should not be neglected. Anjouan Island has around half the exposed value of Grande Comore, however, relative AAL is very similar to the one in Grande Comore. This situation should be assessed with more detail.

Figure 35: AAL (absolute and relative) by island for earthquakes

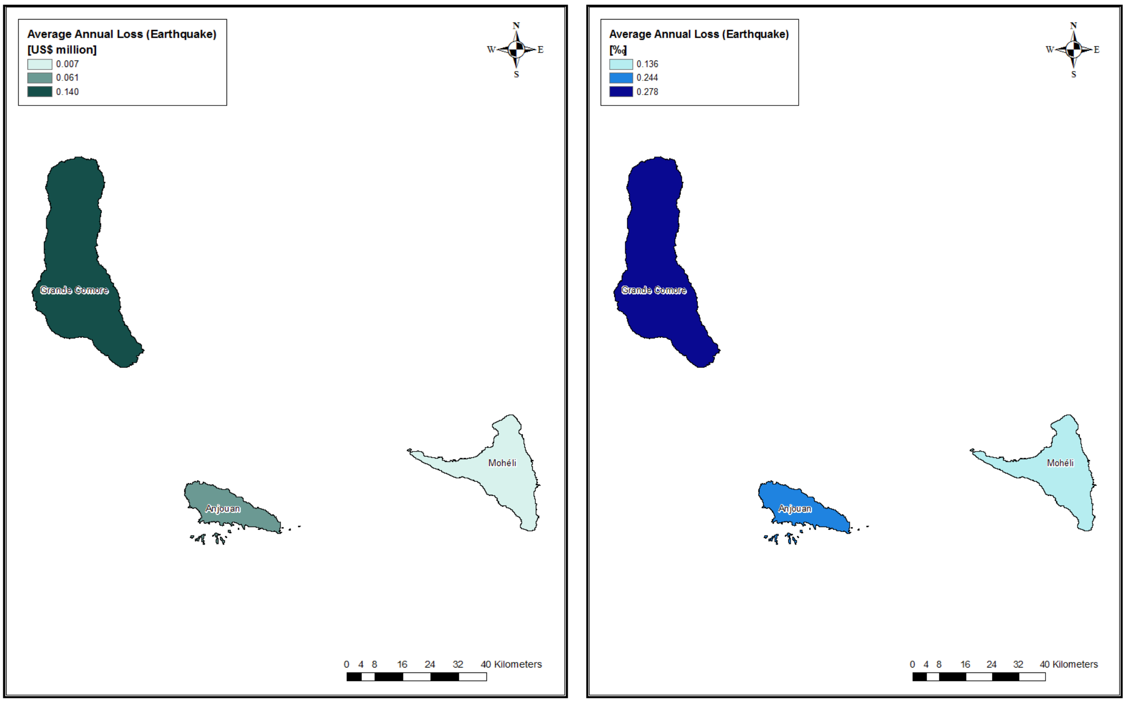


Source: UNISDR/IOC (2014)

Figure 36: AAL (absolute and relative) by island for earthquakes

Absolute AAL

Relative AAL



Source: UNISDR/IOC (2014)

Figure 37 summarizes the AAL (absolute and relative to the exposed assets) for each sector. In the case of earthquakes, the residential sector (low income and middle income constructions) are the assets that present the highest values while regarding the AAL in relative terms the sectors of education, both, public and private, and health public and private present the highest values even their absolute value is very low.

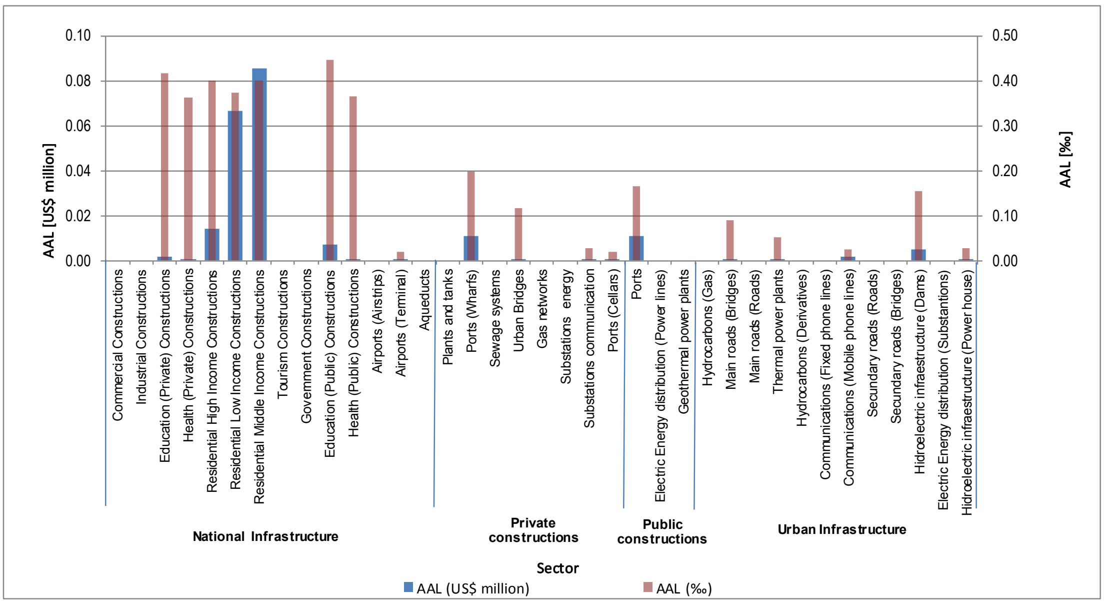


Figure 37: AAL by sector for earthquakes

Source: UNISDR/IOC (2014)

Due to the limited data in disaster loss database outlined in Chapter 2, we could not produce hybrid curves.

Reference

UNISDR /IOC (2014). Component 1 and 2: Comoros, Madagascar, Mauritius, Seychelles and Zanzíbar. Building capacities for increased public investment in integrated climate change adaptation and disaster risk reduction: 2012-2015. European Commission - Directorate General for Development and Cooperation. Geneva, Switzerland.

4. National DRM/DRR/CCA Framework[27]

A. Institutional Structures

To date in Comoros DRM efforts consist of rebuilding after extreme events rather than trying to reduce risks or build resistant structures. Comoros is just starting to establish institutional entities explicitly mandated to manage risk. Among the prominent stations in government, a National Platform for DRR (PNRRC in French) was created in 2010. A ministerial committee and executive body, the Directorate General of Civil Defense (*Direction Générale de la Sécurité Civile* or DGSC in French), coordinates this platform.

The DGSC, also in its capacity as the focal point of the Hyogo Framework for Action (HFA), is the leading national partner of the project "Mainstreaming Disaster Risk Reduction into policies to reduce the poverty of Comoros" supported by UNDP-Comoros. This project focuses on the establishment of structures and foundations, agents and guidelines for risk reduction. It is in this context that the country is trying to articulate appropriate measures to reduce disaster risk and to develop the National Strategy for Disaster Risk Reduction (SNRRC in French).

The state entities and organizations primarily involved in disaster risk management to date are detailed below. Activities such as prevention, preparedness and reconstruction are not addressed systematically. Overall the entities include:

- Ministry of the Interior (MoI)
- Ministry of Foreign Affairs (MFA)
- Directorate General of Civil Protection (DGSC)
- Technical Directorate of Meteorology (DTM and ANACM)
- Volcanological Observatory of Karthala (OVK)
- Regional Directorates of Civil Defense (Grand Comore - Anjouan and Moheli)
- National Directorate of Health (DNS)
- Directorate for Land and Infrastructure
- Directorate General of Environment and Forest (DGEF)
- Directorate General of Budget (DBN)
- General Planning Commission (CGP)
- Production Station - Anjouan
- Production Station – Moheli
- Union of Chambres of Commerce, Industry and Agriculture (UCCIA)
- Comoros Red Crescent (CRCo)
- University of Comoros

A few details are provided below for the main institutions.

The Directorate General of Civil Protection (DGSC): Governmental structure created in 2012 by Decree No. 12-054 / PR, is mandated to protect population, property and the environment, and to coordinate the development of a national DRM strategy and ensure its implementation. Theoretically it also has a role in risk reduction. The DGSC ensures the Permanent Secretariat of the National Platform for DRR (PNRRC). In spite of its mandate, it is in an embryonic stage. Prior to its creation, it was serving since 2007 as COSEP (Centre des opérations de secours et de la protection civile).

From the perspective of human resources and professional skills, DGSC does not have qualified staff in the field. A strengthening of expertise, human capacity and technical skills is necessary for proper prevention and preparedness for different hazards. The DGSC has a Center for Information Processing Analysis (CATI) responsible for collecting, analyzing and processing geo-referenced data. However, the center lacks qualified technical and human resources to carry out the tasks entrusted to them.

The **Technical Directorate of Meteorology (DTM and ANACM):** Given the lack of financial resources and the necessary equipment, ANACM lacks expertise and professional skills in all services. Despite involvement in DRM from the institutional point of view, it keeps few data cards for hydro-meteorological hazards. Its surveillance system is primarily based on information generated outside the country. Thus, in practice, the management does not play its role in the prevention or monitoring extreme weather events responsible for major disasters and risks.

Volcano Observatory of Khartala (OVK): Opened in 1986, the OVK has a dual mission; the first is to ensure continuous monitoring of the activity of the Karthala volcano and the second is to conduct scientific research to

[27] This chapter was drafted by Lezlie Moriniere with inputs from the National ISLANDS team in Comoros.

better understand the internal structure of the volcano, geology and especially understand the mechanisms of its activity. Despite long experience and networking with DGSC and the University, the OVK continues to suffer from inadequate supervision; with a very small staff (two technicians), this does not allow it to conduct strong research, including the history of eruptions.

The future institutional framework is being redesigned under the imminent National Strategy for the Reduction of Risk and Disasters (SNRRC).

B. Legal Structures

At present, the Comoros has developed eight national-level plans that are related to DRM. They include:

- National Plan for Preparedness and Response in Emergency
- Plan for Organizing Relief (ORSEC)
- Response Plan for Karthala volcano eruptions
- National Contingency Plan
- Specialized Cyclone Relief Plan
- Contingency Plan Cyclones / Flood in the health sector
- Specialized Tsunami emergency plan
- Plan for Marine Pollution (MARPOL)

Other legislative and regulatory texts have been developed to strengthen the legal framework for managing disaster risks. They include:

- Environmental Law Decree No. 94-100 / PR on Article 70 that there is a commitment to the contingency plans (response in crisis situations);
- Decree of Health Law No. 95-013 / PR in Chapter VI on the fight against disasters, stipulated in Articles 179, 180 and 181.

Yet other decrees such as laws on the code of urbanism and habitat, forestry law etc. do not yet take into account major risks.

The recent mainstreaming DRR into the National Sustainable Development Strategy 2015-19 (known by the name of *Stratégie de Croissance Accélérée et de Développement Durable, or* SCA2D), demonstrates a serious political and strategic commitment by the Government of Comores. The SCA2D has established the following DRM related specific objectives:

- To strengthen the scientific knowledge and information systems to predict disasters
- To strengthen institutional preparedness and capacity of the population to disasters and their consequences
- To strengthen the response capacity of the population and organized government upon the occurrence of disasters
- To improve reconstruction capacity and resilience of communities after disasters.

This document constitutes the national framework for monitoring and implementation of policies, strategies and Comorian sustainability programs as well as programmes by its development partners.

The National Strategy for the Reduction of Risk and Disasters (SNRRC) is still in draft form at the time of this project. The SNRRC action plan will be aligned with that of the SCA2D and its measures are organized according to the different phases of DRR. They were identified during a consultation workshop using a participatory approach. There are six strategic objectives defined, and 27 program components proposed therein to substantially reduce disaster risks. Each component includes a series of activities to reduce disaster risks, planned for five years following the implementation of the priority action plan. The SNDRR aims to align to the following strategies:

- The Hyogo Framework for Action, 2005 - 2015
- The International Strategy for Disaster Reduction (ISDR)
- The Arab Strategy for Disaster Risk Reduction
- African Strategy for Disaster Risk Reduction

5. DRR/DRM/CCA in Public Investment Planning[28]

This chapter provides an overview of the current status of public investment planning related to disaster risk reduction/management and climate change adaptation in Mauritius. It moreover contains a summary of the findings of the three types of analyses conducted under the initiative; namely the Risk Sensitive Budget Review (RSBR), CATSIM analysis and the Cost Benefit Analysis.

A. Current Status of DRR/DRM/CCA Public Investment Planning

No special measure for public investment has been set up to address DRR/CCA in Comoros. Laws and guidelines do not exist yet to deal with these issues. A disaster risk assessment has not been required for public investment projects because there are not yet guidelines to support such efforts. Disaster risk is also not yet integrated into environment impact assessment for public investment because of lack of guidelines.

Some government entities and Ministries have implicitly achieved DRR investment (National Assembly, President's Office, Ministries of Health, Production and Education, etc.) but those initiatives are not coordinated and harmonized. Each agency plans their DRR/DRM activities independently. Moreover, Comoros does not have a critical infrastructure protection plan.

Ministry of Finance leads the budgetary planning processes of each Ministry but does not require, to date, cost benefit analysis in the budget request process.

B. Contingency Finance Mechanisms

Government will take not only the legal and explicit liability but also the implicit liability where government is expected to intervene promptly to provide relief and recovery to the affected (damaged and destroyed housing, loss of property). There are a few finance mechanisms to manage disasters, summarized in Table 6. These mechanisms mainly address recovery and reconstruction costs.

Table 6: Finance mechanisms for disaster management

EX-ANTE MECANISMS	
Contingency budget line	There wasn't a specific budget line before the Finance Law of 2015. It represents 5% of the 2015 National Budget.
Contingency funds	An emergency fund was created after the 2012 floods and was approved by the Ministries Council and managed by a special commission created and managed by the Prsidents Office and followed by the Ministry of Finance. Contributions by the State and the Private Sector, the sum is not totally utilized. It is in a special account in case of emergency, but hasn't been updated.
Insurance	The private sector and public infrastructure are not covered by insurance. Some enterprises are covered by insurance, but the Government has not a strategy for encouraging insurance subscriptions.
Others	No
EX-POST MECANISMS	
Diverting funds from other budget items	Fonts are not diverted from other budgetary linesOn peut pas affirmer des détournements des postes budgétaires especially since there was no specific budget lines before the 2015 Finance Act.
Imposing or raising taxes	Never used Comoros; it is unlikely to come true in light of financial position of Comoros.
Taking a credit from the Central Bank (either prints money or depletes foreign currency reserves)	It is quite possible, and the practice is used frequently in the past. In case of natural disasters including all possible to print money or deplete but in the context of the implementation of the overall budget.
Borrowing by issuing domestic bonds	Never used Comoros
Accessing international assistance	The government generally expected international and national support when catastrophic events occur. It must be said that the major natural disasters

[28] This chapter was drafted by Lezlie Moriniere, based on inputs supplied by Comoros ISLAND project team.

	appear as new phenomena in the Comoros. This explains why public financial strategies did not exist to deal with DRR / DRM (or were not actually implemented)
Borrowing from multilateral institutions	Never used Comoros
Issuing bonds on the international market	Not used until now.

Source: Comoros, Ministry of Finance

C. Economic analysis to support risk sensitive pubic investment planning

Based on the philosophy explained in the introduction chapter, three types of economic analysis were conducted. A summary of analysis follows for the Risk-Sensitive Budget Review, the Macro/CATSIM assessment and the Micro/Cost Benefit Analysis. Each of the theoretical and technical elements is also described in greater detail in corresponding Annexes A, B and C.

C.1. Summary of the Risk-Sensitive Budget Review

(See also Annex A for theoretical and technical background)

Overview: The Risk-Sensitive Budget Review (RSBR) aims to apply the DRM Marker method to identify the degree to which government has budgeted or/and invested in DRR/DRM/CCA. To that effect, the budgets of key Ministries and Departments have been analysed to mark those projects whose "significant" (but not main) objective is DRR and those projects specifically addressing DRR, which would not have been undertaken without the "principal" DRM objective.

In addition to categorizing the budget/expenditure for different projects, functions and administration activities as Significant or Principal, they were classified into four distinct categories of disaster risk management, namely, Risk Prevention/mitigation, Preparedness, Response/Relief and Reconstruction.

The resources of the Comorian State allow it mainly to cover its operating expenses, including paying pensions, salaries and wages of personnel, insuring the external debt service and paying contributions to international organizations. Once these expenses are incurred, the balance is normally distributed among four units: the Union itself, and the autonomous islands. To this end, the Comoros has only four budgets and one finance law. Due to limited internal resources, public investment needs are generally covered by economic and financial partners, mainly represented by multilateral aid (EU, UNDP, WB) and bilateral (China, France, Japan, etc.), but also by the support of the emirates of the Persian Golf (Qatar, Kuwait, Dubai, Saudi Arabia, Oman, etc.

In this risk-sensitive budget review, we examined data of the central government (but not the island budgets) from 2011 to 2014, we have broken down into three sections (operating, investment and debt), distributed in ten ministries, a presidency, a national assembly, two houses (Supreme and Constitutional) and the common expenses managed by the Ministry of Finance.

Scope: Table 7 below summarizes the scope of the budget review.

Table 7: Scope of the risk sensitive budget review

Year	2011 to 2014 (4 years)
Coverage	National Assembly, Office of the President, Ministry of Health, Solidarity, Social Cohesion and Gender; Ministry of Production, Environment, Energy and Industry; Ministry of National Education, Research, Culture, and the Arts; Authority for Youth and Sports; Finances and budget – Communal Spending
Budget or expenditure	Budget
Current or Capital	Current and Capital
Targeted hazards	Uncertain

Results: The overall estimated investment in DRM identified in this review is on average 1.4 billion (USD 3.7 million), which is approximately 7% of the total budget of 21 billion (USD 52 million) during the period 2011-2014 (see Table 8) and has been regularly increasing since 2011.

Table 8: DRR/CCA Investment"

Ministères	Désignation	2011 MARKED	2012 MARKED	2013 MARKED	2014 MARKED	AVERAGE MARKED AVERAGE
Assemblée National de l'Union	Aides et Secours médicaux	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000
Présidence de l'union	Aides et Secours médicaux	10,939,912	12,033,903	12,033,903	11,721,022	11,682,185
	Evacuation sanitaire	69,399,120	75,339,032	75,339,032	73,380,217	73,364,350
Ministère de la santé, de la solidarité, de la cohésion sociale, et de la promotion du genre	Projet SIDA	20,000,000	18,800,000	20,116,000	20,000,000	19,729,000
	Programme Elargie de Vaccination	20,000,000	18,800,000	20,116,000	20,000,000	19,729,000
	Lutte Contre les Epidémies	5,800,000	5,452,000	5,833,640	5,833,640	5,729,820
	Lutte Contre le Paludisme	20,000,000	18,800,000	20,116,000	20,000,000	19,729,000
	Evacuation sanitaire	20,000,000	18,000,000	18,000,000	18,000,000	18,500,000
	Total Ministère	**186,139,032**	**187,224,935**	**191,554,575**	**188,934,879**	**188,463,355**
Ministère de la production, de l'environnement, de l'énergie, de l'industrie et de l'artisanat	Bureau Géologique	-	-	90,000,000	80,660,000	85,330,000
	Parc Marine de Mohéli	-	-	5,000,000	4,905,000	4,952,500
	Direction Nationale des ressources Halieutiques	-	58,525,376	58,525,376	57,003,716	58,018,156
	Total Ministère	**-**	**58,525,376**	**153,525,376**	**142,568,716**	**148,300,656**
Ministère de l'éducation nationale, de la recherche, de la culture, des arts, chargés de la jeunesse et des sports	Centre Nationale d'Horticole	5,400,000	4,050,000	4,050,000	4,050,000	4,387,500
	Centre National de Recherche Scientifique	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000
	Ecole Nationale des Travaux Publics	50,175,000	50,175,000	80,175,000	80,175,000	65,175,000
	Ecole Nationale de la Pêche	39,549,700	39,549,700	37,549,786	37,549,786	38,549,743
	Total Ministère	**100,124,700**	**98,774,700**	**126,774,786**	**126,774,786**	**113,112,243**
Finances et budget - dépenses communes	Imprévues	597,680,750	631,429,833	930,653,466	839,066,527	749,707,644
	Aides et Secours médicaux	93,437,993	91,505,713	91,505,713	91,505,713	91,988,783
	Projet habitat	122,000,000	127,072,000	190,274,840	540,274,840	244,905,420
	Total Ministère	**813,118,743**	**850,007,546**	**1,212,434,019**	**1,470,847,080**	**1,086,601,847**
	TOTAL	**1,099,382,475**	**1,194,532,557**	**1,684,288,756**	**1,929,125,461**	**1,476,832,312**
	TOTAL STUDIED BUDGETS	**20,021,374,249**	**21,012,270,829**	**21,012,270,829**	**22,193,798,350**	**21,059,928,564**
	SHARE OF TOTAL BUDGET	5%	6%	8%	9%	7%

These sums, recalculated as USD, are featured in Table 9. Most of the budget is identified as "Principle". This may indicate that there is little mainstreaming across ministries and efforts to date. The only "significant" investment was marked in prevention/mitigation (under the Ministries of Production, and Education).

The Budget Review also classified the marked investment according to the DRM process. By far the most important category that was tagged is for Response, demonstrating the need to consider DRR more explicitly. The second greatest investment is in prevention/mitigation, and it is uncertain to what extent the budget (Table 9) currently includes the Volcano Observatory.

Table 9: DRM/CCA investments across 4 components for the 4-year Average (2011-2014)

Investment per Risk Management phase/category	Significant (USD million)	Principal (USD million)	Total (USD million)	Percentage of Total Marked
Prevention/mitigation (1)	0.39	1.35	1.74	**37%**
Preparedness (2)		0.07	0.07	**2%**
Response (3)		2.39	2.39	**65%**
Reconstruction (4)	0	0	0	**0%**
Average annual budget allocations (2011-14)	**0.39**	**3.81**	**4.2**	
Share of total budget (USD 52.12 million)			**7%**	

Source: Ministry of Finance and Budget / calculated by author

Component 2 of the project determined an average annual loss of USD 0.37 million to tropical cyclonic wind and earthquakes combined. A simple comparison of estimated AAL to the most current annual investment in DRR indicates a **positive balance**: greater investment (USD 4.2 million) than expected loss in the present year. However, it is important to keep in mind that AAL is only estimated for tropical cyclonic wind and earthquake risk' it is critical to go back to the actual marked activities in the budget to determine their link to cyclonic wind or earthquake risk. If this investment could be reasonably linked to cyclone or earthquake risk reduction, it would seem to offset the AAL by many years (Table 10).

Table 10: Checking the Gap: DRR Investment, loss and risk

	DRM Investment (budget), 3-year average of 2011-2014	AAL (tropical cyclonic wind and earthquake only)	Loss, 1980-2014 (105 data cards)
Value	USD 4.2 million	USD 0.37 million	USD 9.8 million (Annual average: USD 0.29 million)
Status		NO GAP	NO GAP

As reference, loss data were also compared to the budget. Again, this comparison also shows a positive balance, as even the average registered loss over past 34 years (USD 0.29 million) is lower than the annual investment in DRR.

Although this is only a very simple and straightforward example that cannot be extrapolated to other hazards or years, it serves to underscore the utility of the AAL, Loss analysis and the budget review as a combined tool to move Comoros towards risk-sensitive public investment in light of their most important natural hazards.

C.2. Summary of Macro-Analysis / CATSIM

(See also Annex B for theoretical and technical backgrounds and a detailed case study)

Overview: CATSIM analysis evaluates the ability of governments to manage potential fiscal and economic risk arising from tropical cyclone winds and earthquakes. The Government is generally not responsible to provide all reconstruction needs because private households and businesses will assume responsibility of their own reconstruction needs. Therefore, we assume that the government will take the following responsibility in case of a disaster:

- The Comoros government will be responsible to finance reconstruction of public assets, including roads, bridges, schools and hospitals, etc. (Explicit liability)
- The Comoros government will extend partial support for private relief and recovery including provision of support to the poor (Implicit liability)

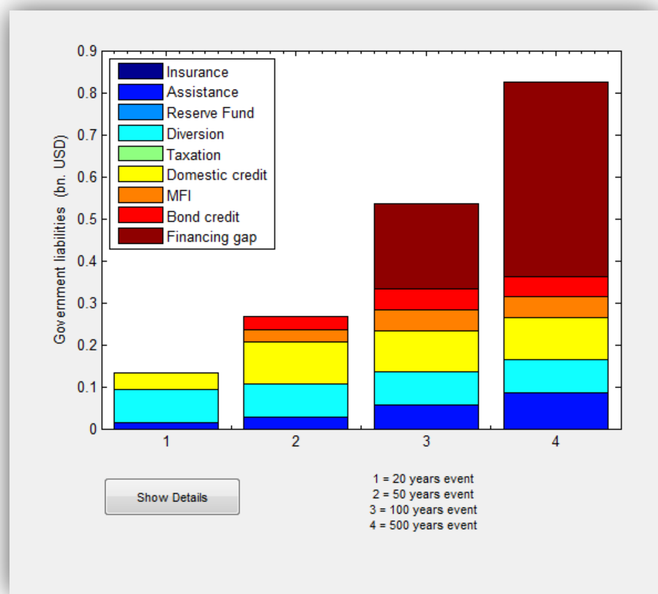
AAL was estimated to be USD 1.07 million. Total liabilities of Comoros Government were estimated as USD 1.6 billion based on capital stock data. Then, the options to finance reconstruction and recovery were examined and same assumptions across IOC countries are applied. In a conservative case, USD 10.6 million were estimated to be assured through diversion from budget, domestic bonds and credit and international market borrowing.

Combining direct risk and fiscal resource availability information compiled, we then estimated the governments' potential fiscal resources gap year—the return period at which the government will face difficulty in raising sufficient funds for reconstruction.

Combining direct risk and fiscal resource availability information obtained, it is estimated what would be the governments' potential fiscal resources gap year—the return period at which the government will face difficulty in raising sufficient funds for reconstruction.

Results: Comoros was found to face a fiscal resources gap at year 77 (CAPRA estimate) (**Figure *38***). Based on the loss distribution available from Hochrainer-Stigler (2014), a fiscal resource gap year was estimated at 56 years (Figure 45). Based on the CAPRA estimate, the reconstruction and recovery capital needs are estimated at: USD 1.85 million (20 year event), USD 6.90 million (50 year event) and USD 14.0 million (100 year event) and USD 34 million (500 year event) respectively. MFI and international borrowing constitute a larger portion of reconstruction and recovery costs as return period increases where above 70 % of the costs will be financed through these means for the 50 year and 100 year events. The financing gaps are expected to increase to USD 1.96 million in the 100-year event and USD 20 million in the 500-year event (Figure 46).

Figure 38: Resources gap year analysis for Comoros

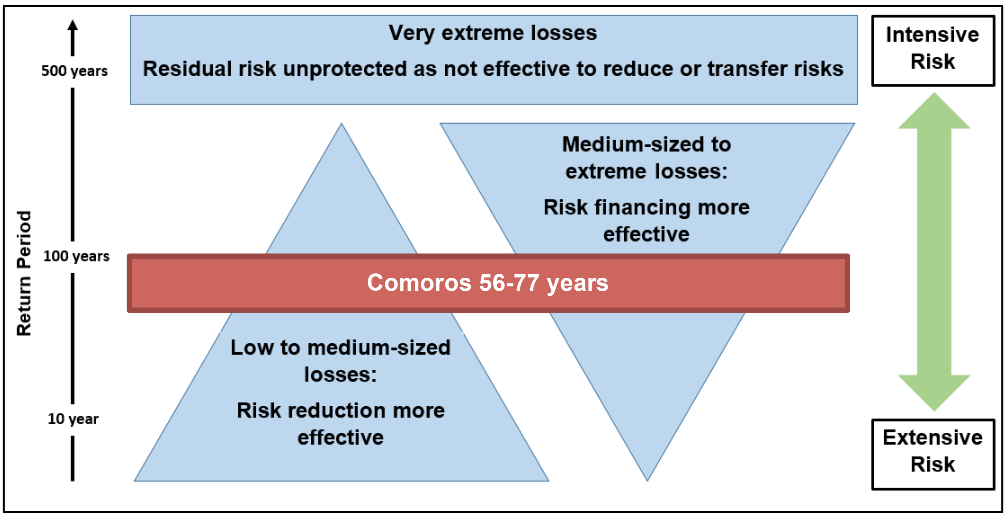


Source: IIASA

The government is encouraged to take a 'layered risk management' approach where resources are allocated based on the varying levels of risk facing the country, with a priority given to reducing existing risk and preventing the creation of new risks in the extensive risk layer (Figure 39). The CATSIM analysis conducted from Steps 1 to 3 has illustrated the need for improved management of disaster risk in Comoros.

For Comoros, the combination of risk reduction and risk financing will be most effective to manage fiscal risk from cyclone wind and earthquake risks in the country. Given that Comoros does have specific budget lines allocated for disaster risk reduction nor contingency budget that can be carried-over across fiscal years, that the establishment of a reserve fund where a certain percentage of unspent money can be used for DRR investment activities may provide good risk management strategies that can cover the mid-layer of risk.

Figure 39: Risk Layering Approach



Source: IIASA

The present study identified data gaps and sources of uncertainty regarding fiscal risk assessment. The present studies did not fully account for indirect effects of disaster damage, and further studies are needed to quantify and evaluate the indirect risks caused by disaster damage.

Risk assessments of additional hazards including cyclone (rain/storm surge), floods, volcanic eruption etc. are certainty needed to conclude on a more comprehensive assessment of fiscal risks that Mauritius faces.

Given the relatively short period of data availability, high uncertainty can be expected of catastrophic risks with return periods of above 500. It is advisable, therefore, further data collection, validation and analysis performed in an iterative fashion to reduce the range of uncertainty.

A technical and institutional support package is necessary to establish iterative risk management system in Comoros and other IOC countries (Table 11). In terms of technical needs, knowledge regarding probabilistic risk assessment and economic assessment tools (CATSIM) would be needed along with general awareness of risk related concepts and statistics. Given the limited availability of risk experts in IOC countries, a regional approach to training and capacity building (*e.g.* regional workshop for training of trainers/ regional sharing of risk knowledge experts, etc.) may be an effective way to leverage local capacity and resources. Institutional support for iterative management should be embedded in the existing DRR/CCA policy framework of Comoros.

It is important to discuss and update fiscal resilience parameter and value at critical time, for example, when administration changes or after disaster. Financing mechanism for disaster management (see Table 6 in Chapter 5) should be checked regularly. Defining government liability more concretely is also recommended.

Some of the important policy questions to ask in Comoros would be:

- What is the desirable level of fiscal preparedness in the country? What would be the policy goal in mid to long-term (maintain or reduce fiscal gap etc)?
- How can you balance the need for risk reduction and risk-transfer?
- What are the priority areas of action regarding DRR in your country?
- What are tangible milestones and goals in the DRR priority areas in your country?
- What further risk assessment is needed to achieve the goals of DRR priority areas in your country?

Table 11: Identified data gaps, technical and institutional capacity needs

Data needs:	-Risk information regarding additional hazards such as flood, cyclone (rain & storm surge), drought will improve the scope of analysis -Uncertainty regarding larger return period events is high given the relatively short period of data availability (In Component 1, loss data was collected since 1980). Further data collection will improve accuracy especially for higher return period events
Technical capacity needs:	-Technical training on risk assessment and economic modeling including CAPRA and CATSIM training. -Further sensitization of risk-based thinking. General familiarity of risk based terms such as the annual average loss, the probable maximum loss, exceedance probability must be explained to decision-makers.
Institutional capacity needs:	-Coordination, where both risk and socio-economic data are jointly collected and managed by relevant agencies (DRM agency plus Ministry of Finance). -Clarity on the specification of the role of each agency in data collection and analysis to avoid the duplication of the efforts.

Source: Author

C.3. Summary of Probabilistic CBA
(See also Annex C for theoretical and technical backgrounds and a detailed case study)

Overview: Cost benefit analysis (CBA) is an established tool in economics. This analysis can be used for both sectorial and project analysis. Many countries already adopt cost benefit analysis as a requirement of large-scale public investment projects. In this initiative, probabilistic CBA was applied to account for the benefits of risk reduction. The benefit is estimated by measuring how much annual average loss (AAL) will be reduced after the investment. As probabilistic risk assessment for flood has not been developed, historic disaster loss data was used as input (backward- looking probabilistic CBA).

Case study of housing retrofitting against flooding and cyclonic wind: Probabilistic Cost- Benefit Analysis was performed regarding flood/wind-retrofitting options in Comoros. Assuming that residential assets make up 53% of the total and that retrofitting against flood (including cyclone-induced rain) does not contribute to retrofitting against wind, and that all housings are in the category of low design quality and retrofitting would result in high design quality, it was estimated that the cost of retrofitting is 16% (11% for flood and 5% for wind). In this case, retrofitting all housings against wind and rain appears to be cost-inefficient with a net present value of USD -113 million.

However, there are a number of factors regarding the data and the assumptions that potentially limit the validity of the figures found in this report. For example, we have no concrete data on house value. The only metric provided from potential housing value comes from an exposed asset file, which shows 53% of the national assets falling into the residential sector. It is unclear if this figure is the value of the housings itself (which is the assumption used in this analysis), or if it includes all of the assets owned by households. If the latter is the case, then the estimation of the value of housings would be significantly over-estimated, resulting in an overestimation of both ALL and total retrofitting costs.

The second issue is with regards to the project retrofitting costs. With no local estimate, the cost of retrofitting for wind and flood could be significantly different than the figures taken from previous findings based in other countries. For example, in this study, we used the figures from Woodruff (2008) which estimated that cost of raising the floor heights of housings to be anywhere from 11-50% of the housing value in Samoa. We also have no information on flood exposure in the country, which significantly limits the quality of present analysis.

It is also important to keep in mind that the present assessment did not take into account many of the indirect and intangible losses, such as loss due to business interruption and any reduction in land values that may result due to frequent disasters. These are clear limitations of this current analysis and further studies are certainly needed to improve the accuracy and comprehensiveness of our analysis.

6. Policy Recommendations[29]

Regarding the analysis highlighted in chapters on disaster loss and disaster risk above, the main conclusions are as follows:

- Economic loss (physical and agriculture) totals USD 9.8 million at 2012 prices.
- Geographically, the economic risk is observed in all islands. Absolute cyclone loss was most concentrated in Anjouan and relative loss in Moheli.
- Comoros has often confronted both natural hazards such as flooding, fire, volcano, storms and cyclones, forest fires and (mainly technological) hazards like transport accidents, industrial pollution, fire, and epidemics. However, the most important direct losses that Comoros experiences from disaster events are those that occur after cyclones and flooding.

The greatest challenge to go forward in addressing DRR/CCA and in mainstreaming Risk-Sensitive Public Investment is the lack of pertinent policies in the fields of agriculture, road and public infrastructure, health and environment. Sensitization of key decision makers is crucial; short training courses on DRR concepts and its importance in poverty reduction and development are critical. Also, the challenge to mainstream DRR is budget constraints. Though some decision makers are sometimes aware of the importance of DRR, the lack of resources has resulted in a focus first on priorities and emergencies. The opportunity costs of implementing DRR measures have been considered too high.

Given these conclusions, the national risk profile and the lack of financial resources in the country, mainstreaming DRR in the budget planning process needs to be made more effective by starting with the following noteworthy priorities:

- **Awareness raising** of all stakeholder on risk reduction and risk sensitive public investment
- **Stronger collaboration** between the DRM entity, Ministry of Finance and other key sectorial ministries with the implication of civil society
- **Continuous capacity building** on risk terminology and concepts, loss and risk information management and economic analysis by all stakeholders, including Ministry of Finance

[29] This chapter was drafted by Lezlie C. Moriniere, with inputs from the ISLANDS Country team of Comoros.

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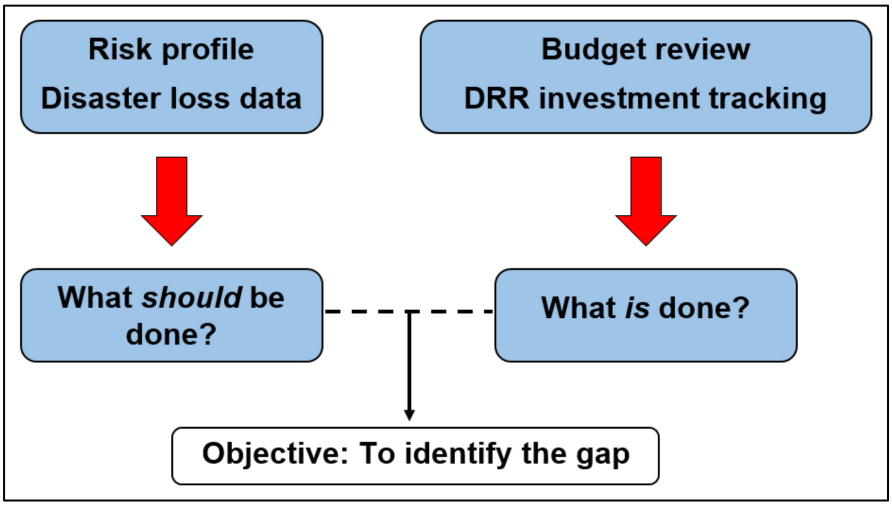
Annex A: Risk-Sensitive Budget Review (RSBR) [30]

A. Overview

The objective of the Risk-Sensitive Budget Review (hereafter called budget review) is to explore the gap between risk level and DRR investment (Figure 40). While CATSIM analysis outlined in Annex B will identify the financial gap year by comparing risk and financial capacity of the country, the budget review aims to clarify what has already been done to reduce risk. It also checks the balance between disaster risk reduction/mitigation, preparedness, response and reconstruction. Understanding the costs of response and reconstruction is an opportunity to re-consider the importance of DRR investment.

Figure 40: Objective of budget review



Source: Author

Budget review is expected to bring about improved efficiency and accountability. Systematic budget analysis requires the cooperation of all stakeholders, thereby improving budget coordination and leading to a more effective use of financial resources. Budget review clarifies the current level of DRR activities and enables a thorough analysis of the gap to explain how much funding is required for further DRR implementation.

In the HFA Monitor, Indicator 1.2 aims to monitor the DRR budget. However, not many countries report their budgets due to lack of monitoring system for their DRR budget. Table 12 below, shows the reported value in selected countries. While we need to be cautious when comparing the values across countries, due to the application of different counting methods, this table shows that out of five countries, three invested significantly more in relief and reconstruction than in DRR and prevention.

[30] This chapter were drafted by Kazuko Ishigaki (UNISDR).

Table 12: DRR Budget in selected countries (% of total budget)

Country	Year	DRR and prevention (%)	Relief and Reconstruction (%)	Total (%)
Belarus	2013	0.160	0.160	0.320
Ecuador	2013	0.300	1.600	1.900
Indonesia	2013	0.286	0.413	0.699
Mozambique	2013	4.610	0.350	4.960
Papua New Guinea	2012	0.100	1.000	1.100

Source: Author based on HFA Progress Report for each country

In response to the need for DRM budget monitoring, several initiatives have progressed to date. The first effort has been to create a consolidated budget line for DRM. This approach has mainly been taken in Latin American countries. For example, Columbia established the Adaptation Fund (2010). Mexico has been utilizing the Natural Disaster Prevention Fund (FOPREDEN), the Natural Disaster Fund (FONDEN) and the Fund for Assistance of the Affected Rural Populations by Climate Contingencies (FAPRAC). Peru has also established a National Budgetary Programme for Vulnerability Reduction and Emergency Response.

The second effort is to assign codes to budgetary line items that indicate DRM measures. This is promoted by the World Bank and OECD in partnership with the UNISDR; they propose the "DRM marker" to monitor DRM elements in Official Development Assistances (ODAs) which are registered in OECD's Credit Reporting System[31]. DRM marking allows the monitoring of donors' policy objectives in relation to DRM in each aid activity. Compared to consolidated budget lines, the DRM marker is a less drastic reform and has potential to be the first and simplest analytical step toward risk-sensitive public investment. Therefore, the DRM Marker, with some adjustment, was applied to Comoros.

[31] The Rio Marker monitors CCA aid activity since 2011. DRM Marker is proposed using the similar methodology.

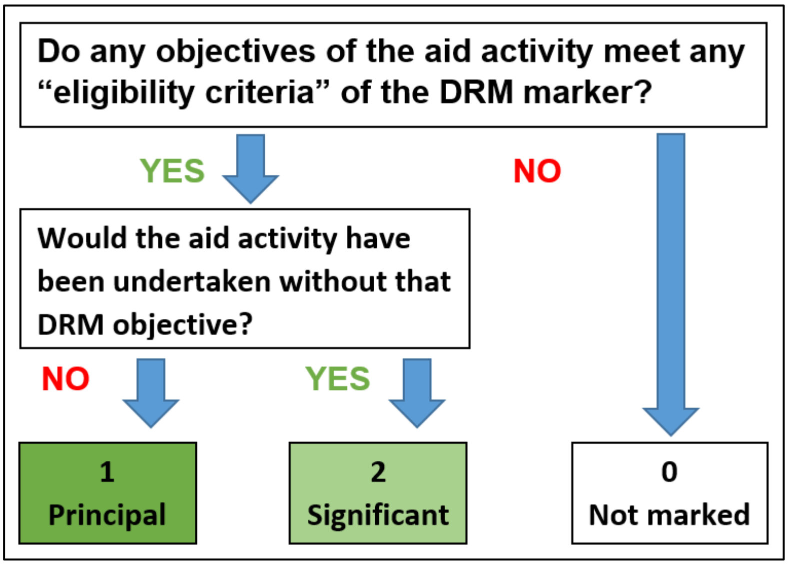
B. DRM Marker

The DRM marker allows (a) capturing "embedded" investment by distinguishing between stand-alone versus mainstreamed DRR investment (*e.g.* retrofitting in school renovation program), (b) strengthening the ability to analyse, measure and report activities in DRR, and (c) improving regulatory conditions to facilitate tracking of budgetary allocations and expenditure in DRR and even (d) tracking pre-disaster (DRR) versus post-disaster (relief/reconstruction) investments, with simple addition of a rule.

The first eligibility criterion for an element to be marked is that DRM must be included in "the programme objectives" (Figure 41). The DRM element is defined as any "strategy, policy, effort or measure that improves the understanding of disaster risk, fosters disaster risk reduction or transfer, and promotes continuous improvement in disaster preparedness, response and recovery practices" (OECD, 2014[32]). If a budgeted activity meets any of those elements, it becomes "marked" as DRM.

The second level criterion is to examine how important the DRM objective is to drive implementation of the activity. The exact question is "would the aid activity have been undertaken without that DRR objective?" If the answer is affirmative, then it is marked as "significant" and if negative, it is marked as "principal"[33].

Figure 41: DRM Marker process



Source: OECD (2014)

By applying this DRM Marker methodology across time and space, it is expected that data homogeneity and comparability will be assured. Furthermore, especially by introducing the "significant" category, incentives to mainstream DRM in development activities become visible. In the past, DRM has conventionally been delivered through stand-alone projects. However with progress achieved in implementing the HFA, more governments have been recognizing development mechanisms and instruments as important to reduce risks and strengthen resilience. It becomes more important to monitor a wide number of DRR related projects and investments embedded across different sectors either at central or local government levels in order to provide comprehensive overview of DRR policies.

In spite of such benefits, it is necessary to clarify the limitations of the DRM marker. The DRM marker cannot quantify the exact amount of DRM activity and only provides a best estimate. It is often impossible to extract a DRM element from overall programmes/projects, therefore overall programme/project budget are registered, leading to over-estimation of DRM budget. Furthermore, because the objective of the activity is the only criteria used to "mark" the budget item as DRM, if policy makers are unaware of DRM benefits, the activity will never be

[32] OECD, 2014. A Proposal to Establish a Policy Marker for Disaster Risk Management (DRM) in the OECD DAC Creditor Reporting System (CRS).
http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DCD/DAC/STAT%282014%293&docLanguage=En
[33] Still certain level of ambiguity remains. For example, distinction between principal and significant is not clear and might require subjective judgment. However this is a notable progress for systematic monitoring.

“marked“. While it is clear to most that flood control and early warning are DRR policies, policy makers may not naturally recognize the contributions to reduce disaster vulnerability made, for example, by poverty reduction and ecosystem restoration. In this regard, a DRM Marker system may miss DRR elements embedded in all development activities. The DRR activities, which must have DRR elements but are not recognized as DRR, might underline an awareness gap of policy makers in the given sector.

C. The budget review methodology: Application of DRM marker

In applying the methodology of the DRM Marker in a risk-sensitive budget review, the following three steps were taken (Figure 42, Annex A-1 for more details). The first step is to define what should be monitored, i.e. the scope of the budget review. In the DRM Marker, the target was ODA data stored in OECD Credit Reporting System. However, in budget review, the scope of review needs to be clarified in the given context.

Then, the second step is to mark budget line items as significant and principal using DRM Marker criteria, count the budget in each item and sum up the value. In this step, sub-categories based on DRM elements is added to the original DRM Marker to show the balance between DRR (including prevention and preparedness) and disaster management (response and recovery). The last step aims to assess the resulting gap by comparing budget with risk. This analysis enables the identification of lessons to feed into the following year’s budget.

Figure 42: Risk sensitive budget review process

STEP 1: Define what should be monitored/counted.

- **a. Coverage: national level, local level, state owned corporation, etc.**
- **b. Budget or Expenditure?**
- **c. Current and/or capital?**
- **d. Targeted hazards?**

STEP 2: Mark and Tag Budget items

- **a. Mark each line item as Principal (2) Significant (1) or leave unmarked.**
- **b. Tag all marked items where they make the greatest contribution.**
    - **Risk Prevention/Mitigation**
    - **Preparedness**
    - **Response**
    - **Reconstruction**

STEP 3: Count and analyse (*e.g.* comparison with risk, trend analysis)

Source: Author

In defining the scope of budget review, the following four aspects need to be clarified. The first is the coverage of monitored entities. Public sector consists of general government and state corporations. General government consists of central and sub-national governments. In developing countries, donor finance is also a non-negligible component of budget.

The second is whether to monitor budget or expenditure. In the context of developing countries, very often expenditure is far below the budget especially in capital investment due to its disposal of donor relationship.

The third point is whether to monitor current or capital budget/expenditure. Most infrastructures are classified under capital budget/expenditure, with sometimes multi-year budget commitment. Considering the importance of DRR in public investment, monitoring capital budget/expenditure is necessary. At the same time, current budget/expenditure includes important items such as expenses for training and early warning. Ideally, both should be monitored.

Lastly, there is often no disagreement in including activities targeted at geological (*e.g.* earthquake, tsunami, landslide), meteorological (*e.g.* cyclone, heat wave) and hydrological hazards (*e.g.* flood, landslide, drought). However, depending on countries context, epidemics and other hazards may also be included.

In Step 2, while the marking process based on DRM Marker methodology highlights investments in DRM in monetary terms, a parallel "tagging" process categorizes each marked activity as one of four components of DRM: prevention/mitigation, preparedness, response and reconstruction. Tagging is most easily represented as percentages in each category, the four categories summing to 100% of marked elements[34].

When each marked item is "tagged" in this way, we can start to understand how investments are distributed before and after a disaster. As countries can demonstrate more and more investment on the side of DRR (including prevention and preparedness), they can prove that they are accountable for risk reduction. As the value rises in components tagged as DRR, it will normally become evident that less funding is required in the post-disaster phase (response and reconstruction).

[34] In reality, the four components overlap. For example, some elements of reconstruction may be devoted to future disaster risk prevention/mitigation. However, for simplification, items are classified and tagged for four components based on their greatest contribution.

References

OECD (2014), A Proposal to Establish a Policy Marker for Disaster Risk Management (DRM) in the OECD DAC Creditor Reporting System (CRS).
http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DCD/DAC/STAT%282014%293&docLanguage=En

Annex A-1. CHECKLIST for a risk-sensitive budget review

CHECKLIST to CONDUCT a RISK-SENSITIVE BUDGET REVIEW (RSBR)

1. DETERMINE WHAT SHOULD BE COUNTED

a. IDENTIFY YEAR / PERIOD that is appropriate and feasible

EXAMPLE: last fully-completed year or current year underway

ADVICE: Start with a single year, add other periods later, as feasible.

b. DETERMINE COVERAGE

EXAMPLE: all public sector (general and state corporations) or only General budget (central and/or sub-national budgets)

ADVICE: All public sector is desirable, but start with central budget and budget of national disaster management entity before moving onto other budgets. Smaller countries should be able to review all.

c. IDENTIFY BASIS FOR REVIEW

EXAMPLE 1: budget or expenditure?

ADVICE: if difference between two is large, go with expenditure; if small, go with budget.

EXAMPLE 2: investment (capital) and/or consumption (current)?

ADVICE: ideal to use both, usually reported separately in budget

2. OBTAIN COPIES of budgets covering all elements determined above

EXAMPLE: hard-copy or electronic copy—with 'objectives' stipulated per line item in enough detail to conduct next steps

ADVICE: review / study guidance for DRM Marker, taking note of the "eligibility criteria" discussion on pp3-4: (Review document entitled: DAC Working Party on Development Finance Statistics, A Proposal to Establish a Policy Marker for DRM in the OECD DAC Creditor Reporting System, 2014)

3. MARK and TAG BUDGETARY ELEMENTS

a. DRM MARKING: go through the budget(s) line by line, asking the question(s) at each line:

• "do any objectives of the budgeted activity meet any 'eligibility criteria' of the DRM marker?

• "If yes, would the budgeted activity have been undertaken without that DRM objective?"

ADVICE: Using spreadsheet, record total of the budget activity in three categories: Principle (2), Significant (1) and not marked (0) for easy summing

b. DRM TAGGING: go through the budget(s) again line by line, to categorize each MARKED activity by scheme in 3a above: "what percentage of total MARKED items fit best under prevention/mitigation, preparedness, relief and reconstruction?"

ADVICE: Work with DRM entity in your country to determine the best categorization

EXAMPLE: the most common standard is: 1. Prevention/mitigation, 2. Preparedness, 3. Response and 4. Reconstruction

4. CALCULATE AND COMPARE DRM INVESTMENT

a. Sum DRM/CCA investment per marker and DRM sub-category

b. Calculate gap by comparing sum with Risk/Loss data (Comp 1/2)

c. Document lessons learned

d. Time allowing, repeat all of the above with additional years, budgets, sectors, etc.

Annex B. CATSIM Assessment[35]

A. Overview

Generally regarded as the ‘insurer of last resort,’ national governments assume primary responsibility in providing response, recovery and reconstruction resources in times of disasters (Mechler, 2004). Governments play an important role in the post-disaster period, conducting timely and accurate damage assessments, devising rehabilitation plans, and financing and executing rehabilitation projects. Reconstruction is often very costly. Appropriate assessment of existing risk and contingency liability, and reducing risk and preparing for fiscal contingency as much as feasible before events occur is therefore of paramount importance for government’s strategic decision-making, planning and resource allocation.

To respond to such needs in 2006 the International Institute for Applied Systems Analysis (IIASA) invented the “CATSIM” (Catastrophe Simulation), an interactive simulation tool to build capacity of policy makers to estimate and reduce public sector financial vulnerability. The model has been applied to Madagascar in 2011 and to several other countries.

The CATSIM model consists of five-steps (See Table 13): In the first step, direct risk assessment is performed integrating information regarding the probability of natural hazard occurrence, the level of exposure and physical vulnerability (see Hochrainer-Stigler, 2012 for details). Direct risk is expressed in terms of economic value of asset at risk and return periods of natural hazards. In this initiative, we utilized the data collected in Components 2 to the maximum degree.

In the second step, public finance preparedness and vulnerability are determined by the national government’s current ability to raise internal and external funds for disaster response and reconstruction ex-ante or ex-post. The government’s ability to raise necessary fiscal means are typically constrained by a number of economic and institutional factors such as the country’s current level of public deficit and cumulative debt, capacity to raise tax revenue and its ability to borrow from domestic and international credit markets.

In the third step, the government’s current level of public finance preparedness is evaluated against the disaster risk. The model quantifies the notion of fiscal ‘resource gap year’—*i.e.* the return period at which the national government’s current level of fiscal preparedness will be insufficient against the risk it faces.

The potential occurrence of a fiscal resource gap and its longer-term growth implications are appraised through macroeconomic modelling in step four. Using the Monte-Carlo simulation approach, the model quantifies probabilistic macroeconomic growth trajectories based on the existing degrees of natural disaster risk and public finance preparedness.

Finally, a range of risk management options is evaluated against the costs and benefits in the fifth and final step. Governments may adopt a number of ex-ante and ex-post measures to prepare for the disaster risk, including structural mitigation, contingency fund, catastrophe insurance, catastrophe bonds, and contingent credit arrangements.

Since Comoros has not conducted CATSIM to date, as a first trial, this initiative has implemented only Steps 1 to 3.

[35] This chapter was drafted by Junko Mochizuki, Stefan Hochrainer, Keith Williges, and Reinhard Mechler, Risk Policy and Vulnerability Program, International Institute for Applied System Analysis (IIASA). Input was provided by UNISDR.

Table 13: 5 Step CATSIM Modules

Steps	Tasks
1. Direct Risk Assessment	To estimate **economic asset at risk and return periods** of natural hazards.
2. Fiscal Resilience Assessment	To assess the country's current **fiscal resources availability and preparedness**
3. Fiscal and Economic Vulnerability	To estimate a '**fiscal resources gap year**' combining step 1 & 2
4. Economic impact Assessment	To estimate **indirect impacts** in terms of potential risks to macroeconomic growth
5. Risk Management/Reduction Option Assessment	To evaluate the risk management options

Source: Author

B. CATSIM Analysis in Comoros

Step 1: Direct Risk Assessment

This study evaluated the ability of government to manage potential fiscal and economic risk arising from cyclone (wind) and earthquake combined. Probabilistic risk assessment using the CAPRA GIS software shows that Comoros faces considerable disaster risk relative to the size of their economy.

This study evaluated the fiscal resources gap using both current CAPRA estimates and statistical estimates available from Hochrainer-Stigler et al (2014). In general, the estimates based on CAPRA shows lower loss estimates than those of Hochrainer-Stigler et al. (2014) (Table 14).

Table 14: Estimated PML at varying return periods (in USD million)[36]

Return period	Comoros (CAPRA estimate)	Comoros(Hochrainer-Stigler et al. 2014)
5	0.1	-
10	1.0	-
20	3.6	9.4
50	13.3	19.8
100	27.1	42.5
500	66.5	317
1000	85.0	-
AAL	**1.07**	**-**

Source: Author

The government is generally not responsible to provide all reconstruction needs because private households and businesses will assume responsibility of their own reconstruction needs. We assume that the governments assume the following responsibility in case of a disaster:

- The Comoros government will be responsible to finance reconstruction of public assets, including roads, bridges, schools and hospitals, etc. (Explicit liability).
- The Comoros government will extend partial support for private relief and recovery including provision of support to the poor (Implicit liability).
-

Total contingent liabilities of Comoros Government were estimated as outlined in Table 15.

[36] The data collected from Component 2 was later revised to reflect new GAR 15 methodology. Chapter 2 was revised to update the data, but given short time frame, we could note reiterate the CATSIM assessment based on new data. The inconsistency with Chapter 2 stems from this issue.

Table 15: Estimated Government Direct and Contingent Liability

Item	Values in USD billion	References
Total Capital Stock	3.3	Penn World Table (2014)
Public Capital (a)	0.98	Assumed as 30% of total capital stock based on Hochrainer-Stigler (2012)
Private Capital	2.3	Assumed as 70% of total capital stock based on Hochrainer-Stigler (2012)
Relief Spending (b)	0.65	Assumed as 20% of total capital stock based on Hochrainer-Stigler (2012)
Governments Total Liability (a+b)	1.6	N/A

Source: Author

Step 2: Fiscal Resilience Assessment

The options to finance reconstruction and recovery may be divided into: i) ex-ante and ii) ex-post resources depending on whether arrangements are made prior to or after a disaster event. The below are some of the ways in which governments typically raise fund to finance reconstruction:

Ex-Ante Resources

- Preparing contingency budget line
- Establishing reserve fund
- Arranging contingent credit
- Obtaining insurance for public infrastructure
- Issuing catastrophe bonds

Ex-Post Resources

- Diverting funds from other budget expenditures
- Raising additional tax
- Obtaining credits from central bank
- Borrowing and issuing domestic bonds
- Receiving international assistance
- Borrowing from multilateral finance institutions
- Borrowing and issuing bonds in international market

In this study, we have estimated fiscal resources availability based on available economic and fiscal statistics. Table 16 provides an overview of the estimated availability of ex-post resources such as international assistance, budget diversion, domestic bonds and credit, and international / multilateral financial institution (MFI) bonds.

We did not consider the tax option because this is largely considered as infeasible or undesirable option by Comoros. We also did not consider ex-ante options because of data availability issues.

Table 16: Estimated Ex-post Fiscal Resources Availability

Sources	Assumptions	Value
International Donor Assistance	10.4% of public liability based on international average[37]	10.4% of public liability
Diversion from budget	5%>deficit, then 0 5%<deficit, then 5% of total revenue	0
Domestic Bonds and Credit	1% of gross domestic	USD 0.97 million

[37] This value depends on the size of disaster. Therefore, we do not have any single value. In CATSIM, the availability for each scenario is calculated using this percentage.

	credit from private bank	
MFI/ International bond market borrowing	SDR allocation	USD 9.6 million
Total excluding international assistance		USD 10.6 million

Source: Author

Assumptions for fiscal resource availability

International assistance

International assistance, the amount of money made available to a country post-event in the form of donations from other countries and aid organizations, is assumed to be 10.4% of damages, based on regression analysis of historic data from Freeman et al (2002).

Diversion from budget

Budget diversion, representing the amount of funding from the central government's budget which can be re-directed and focused towards recovery, is assumed to be only possible if a government has a budget surplus or small deficit. For this analysis, we assume that countries with a 5% or larger budget deficit relative to GDP are unable to divert funding; as Comoros does satisfy this criteria, available funds for diversion are calculated as zero. Data for this calculation are obtained from the World Bank's World Development Indicators.

Domestic bonds and credit

After an event, a nation has the possibility of trying to finance recovery via domestic credit, either by printing money, issuing bonds, or borrowing from domestic sources. A pitfall to this avenue of funding is the risk of increasing the total stock of domestic credit, which could crowd out private sector credit and lead to more monetary expansion and increasing inflation (World Bank, 2011). For this reason, we assume that a government will be limited in this regard to a maximum of 1% of gross domestic credit from private banks, the data being sourced from World Bank Development Indicators. There is high uncertainty whether the domestic credit market can be accessed and these estimates deserve further verification.

Multi-lateral financial institution (MFI) / International bond market borrowing

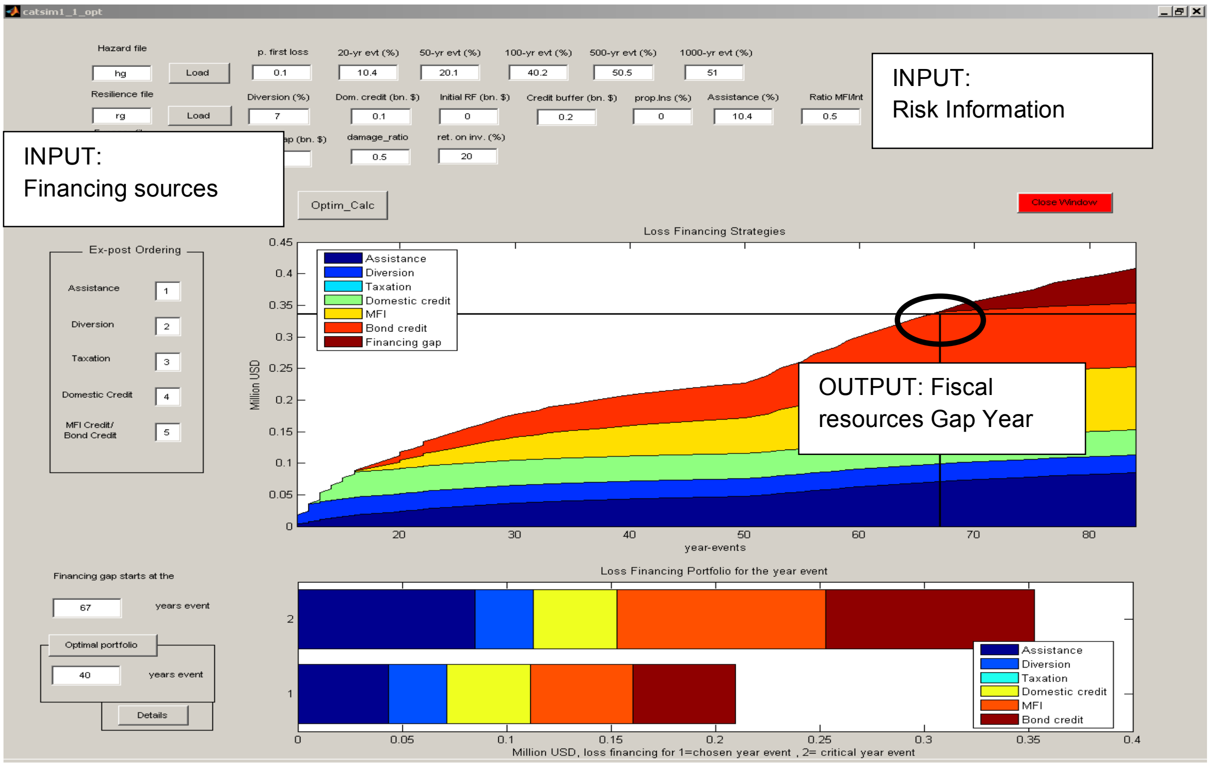
A further option for financing reconstruction and recovery comes from borrowing on international markets and from multi-lateral financing institutions. The International Monetary Fund's Special Drawing Rights (SDRs), which represent an international reserve asset, is used as a baseline estimate for how much international funding could be available post-event. SDRs are based on four currencies (the euro, Japanese yen, pound sterling, and U.S. dollar), and can be exchanged for usable currencies (IMF, 2014).

Step 3: Estimating potential "fiscal resources gap"

Combining direct risk and fiscal resources availability information obtained in previous steps, this section estimates the governments' potential fiscal resources gap year — the return period at which the government will face difficulty in raising sufficient funds for reconstruction (Figure 43). Given the considerable uncertainty regarding risk estimates, the result should be interpreted with caution and further studies are certainly advisable to validate assumptions in Steps 1 and 2.

While the concept of 'fiscal resources gap' illustrates the snapshot estimate of the country's resource availability, it is important to note that a large proportion of resources that will be used to meet this one-time disaster event is loan-based, suggesting that there will be a longer-term cost of repayment of these loans. While the precise fiscal and macroeconomic implications of such longer-term impacts must be analysed in a dynamic CATSIM framework, it is important to keep in mind that there are a number of costs associated with each option. In particular, the opportunity cost of diverting resources away from other development projects must be weighed carefully with the benefit of resources spent on disaster reconstruction and recovery.

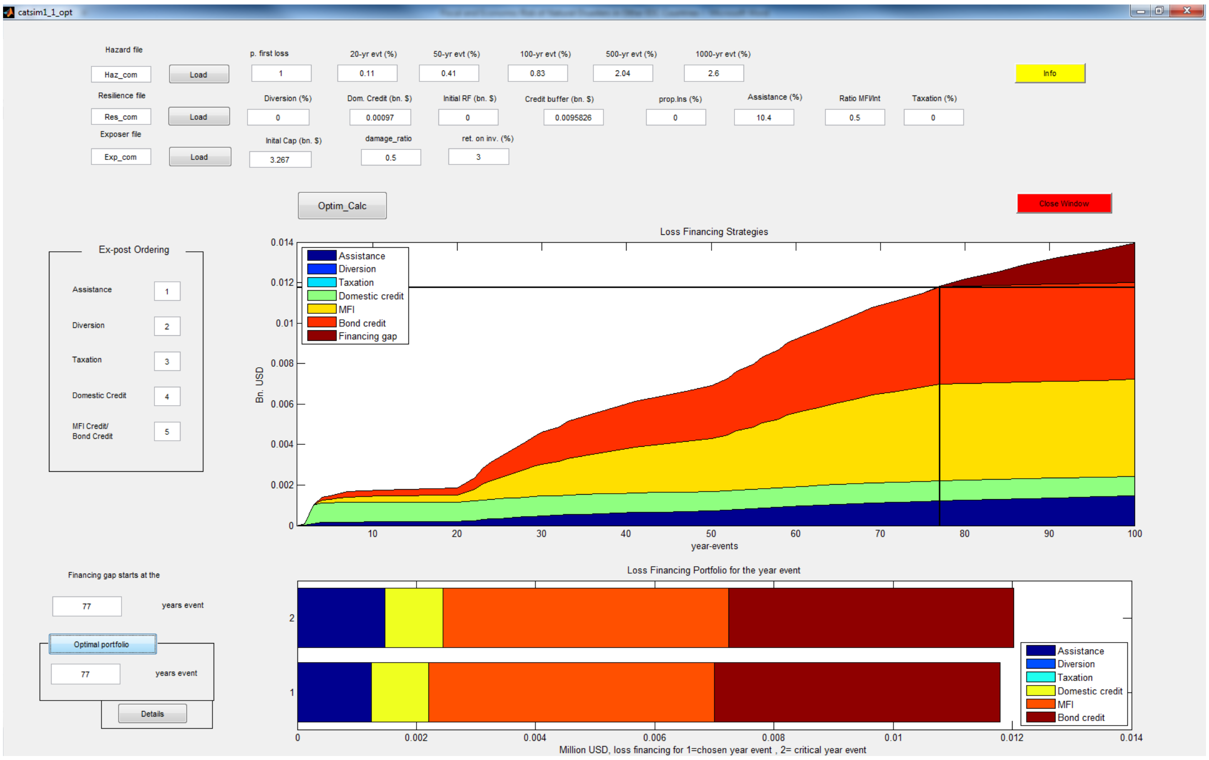
Figure 43: Display of results of fiscal resources gap year



Source: Author

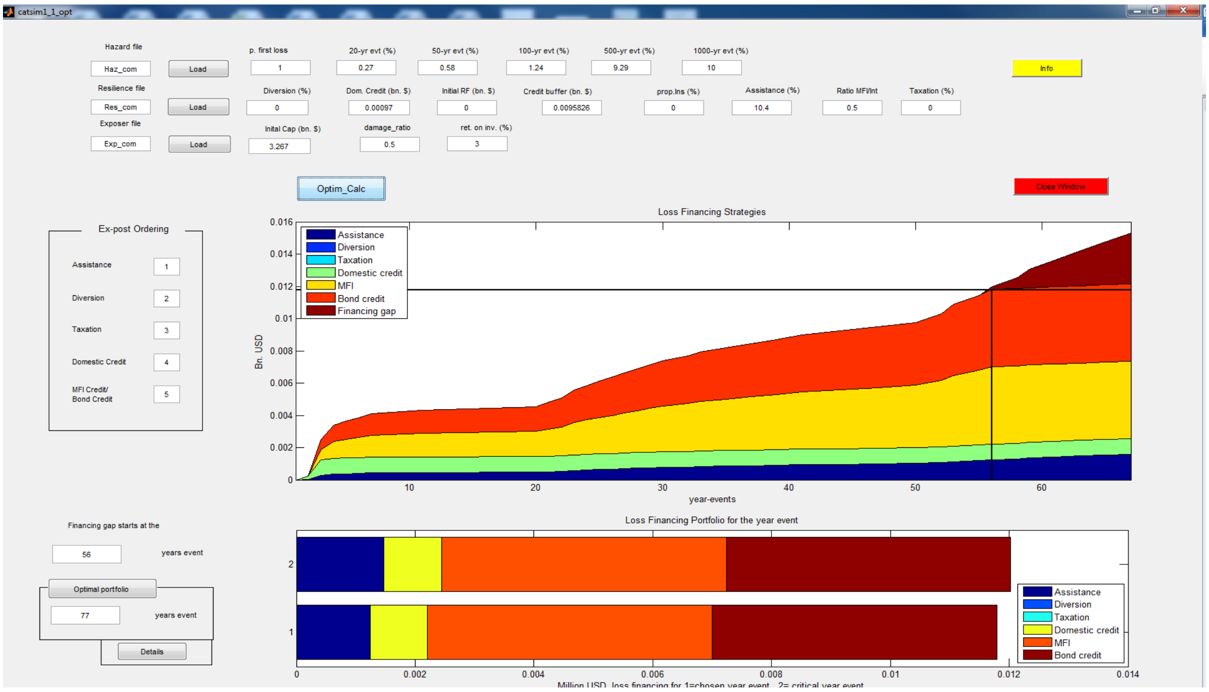
Assuming an AAL of USD 1.07 million (0.17% of GDP), Comoros was found to face a fiscal resources gap at year 77 (CAPRA estimate) (Figure 44). Based on the loss distribution available from Hochrainer-Stigler (2014), a fiscal resource gap year was estimated at 56 years (Figure 45). Based on the CAPRA estimate, the reconstruction and recovery capital needs are estimated at: USD 1.85 million (20 year event), USD 6.90 million (50 year event) and USD 14.0 million (100 year event) and USD 34 million (500 year event) respectively. MFI and international borrowing constitute a larger portion of reconstruction and recovery costs as return period increases where above 70 % of the costs will be financed through these means for the 50 year and 100 year events. The financing gaps are expected to increase to USD 1.96 million in the 100-year event and USD 20 million in the 500-year event (Figure 46).

Figure 44: Fiscal resources gap year estimate for Comoros (CAPRA estimate)



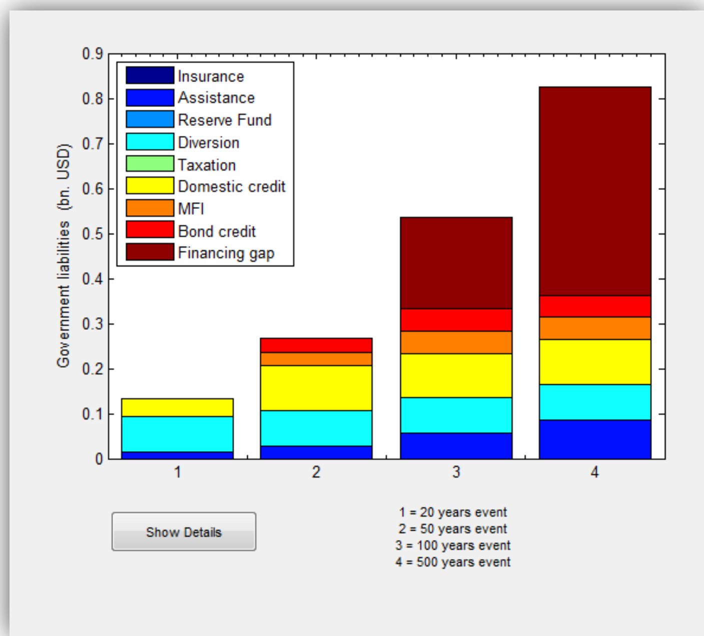
Source: Author

Figure 45: Fiscal resources gap year estimate for Comoros (based on Hochrainer-Stigler et al. 2014)



Source: Author

Figure 46: Fiscal resource gaps for Comoros



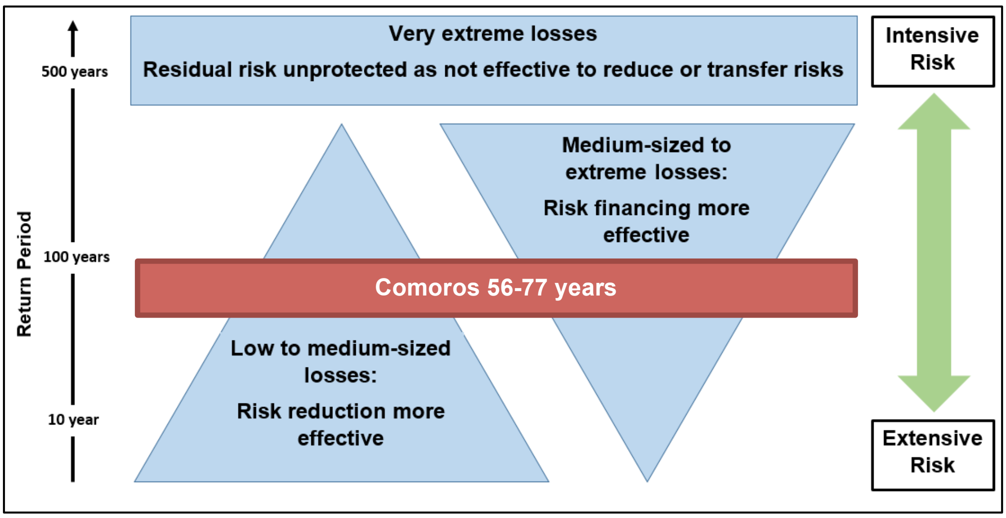
Source: Author

Conclusion: Toward risk layered approach

The government is encouraged to take a 'risk layered management' approach where resources are allocated based on the varying levels of risk facing the country, with a priority given to reducing existing risk and preventing the creation of new risks in the extensive risk layer (Figure 47). The CATSIM analysis conducted from Steps 1 to 3 has illustrated the need for improved management of disaster risk in Comoros.

For Comoros, the combination of risk reduction and risk financing will be most effective to manage fiscal risk from cyclone wind and earthquake risks in the country. Given that Comoros does have specific budget lines allocated for disaster risk reduction nor contingency budget that can be carried-over across fiscal years, that the establishment of a reserve fund where a certain percentage of unspent money can be used for DRR investment activities may provide good risk management strategies that can cover the mid-layer of risk.

Figure 47: Risk Layering Approach



Source: Author

Further challenge: Data gaps and way forward

The present study identified data gaps and sources of uncertainty regarding fiscal risk assessment. The present studies did not fully account for indirect effects of disaster damage, and further studies are needed to quantify and evaluate the indirect risks caused by disaster damage.

Risk assessments of additional hazards including cyclone (rain/storm surge), floods, volcanic eruption etc. are certainty needed to conclude on a more comprehensive assessment of fiscal risks.

Given the relatively short period of data availability, high uncertainty can be expected of catastrophic risks with return periods of above 500. It is advisable, therefore, further data collection, validation and analysis performed in an iterative fashion to reduce the range of uncertainty.

A technical and institutional support package is necessary to establish iterative risk management system in Comoros and other IOC countries (Table 17). In terms of technical needs, knowledge regarding probabilistic risk assessment and economic assessment tools (CATSIM) would be needed along with general awareness of risk related concepts and statistics. Given the limited availability of risk experts in IOC countries, a regional approach to training and capacity building (*e.g.* regional workshop for training of trainers/ regional sharing of risk knowledge experts, etc.) may be an effective way to leverage local capacity and resources. Institutional support for iterative management should be embedded in the existing DRR/CCA policy framework of Comoros.

It is important to discuss and update fiscal resilience parameter and value at critical time, for example, when administration changes or after disaster. Financing mechanism for disaster management (see Table 6 in Chapter 5) should be checked regularly. Defining government liability more concretely is also recommended.

Some of the important policy questions to ask in Comoros would be:

- What is the desirable level of fiscal preparedness in the country? What would be the policy goal in mid to long-term (maintain or reduce fiscal gap etc)?
- How can you balance the need for risk reduction and risk-transfer?
- What are the priority areas of action regarding DRR in your country?
- What are tangible milestones and goals in the DRR priority areas in your country?
- What further risk assessment is needed to achieve the goals of DRR priority areas in your country?

Table 17: Identified data gaps, technical and institutional capacity needs

Data needs:	-Risk information regarding additional hazards such as flood, cyclone (rain & storm surge), drought will improve the scope of analysis -Uncertainty regarding larger return period events is high given the relatively short period of data availability (In Component 1, loss data was collected since 1980). Further data collection will improve accuracy especially for higher return period events
Technical capacity needs:	-Technical training on risk assessment and economic modeling including CAPRA and CATSIM training. -Further sensitization of risk-based thinking. General familiarity of risk based terms such as the annual average loss, the probable maximum loss, exceedance probability must be explained to decision-makers.
Institutional capacity needs:	-Coordination, where both risk and socio-economic data are jointly collected and managed by relevant agencies (DRM agency plus Ministry of Finance). -Clarity on the specification of the role of each agency in data collection and analysis to avoid the duplication of the efforts.

Source: Author

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Annex C. Probabilistic Cost-Benefit Analysis (CBA) for Comoros[38]

A. Overview

Cost benefit analysis (CBA) is an established tool in economics. This analysis can be used for both sectorial and project analysis. Many countries already adopt cost benefit analysis as a requirement of large-scale public investment projects. Although imperfect, CBA is one of the most important tools for financial decision making around the world.

There are two important general objectives in CBA. One is to improve efficiency of the project selection, because CBA facilitates the rational comparison of available options. The second objective is to improve accountability. In democratized countries, it is increasingly important that government explains why a given project is selected. This will also contribute to reduce corruption and in some cases, lessen inappropriate interference of politicians. In this regard, it is important to disclose the methodology and the original data for the analysis.

We can apply this methodology into public investment projects that contributes to DRR. However, there is a unique concern to be considered. For usual projects, the benefits can be tangible and visible. For example, in the case of a public transportation project, we can estimate the number of passengers and total fees paid by passengers. On the other hand, in a DRR project, the main benefit is avoided loss. In this case, we need to somehow estimate the benefit relating with an event not occurring. This introduces technical difficulty in DRR cost benefit analysis.

CBA can measure the impact of policy on DRR at sectorial or project level. While a budget review and CATSIM provide overviews of the country and help raise awareness of the effectiveness of DRR investment, CBA can provide more detailed insight for decision-making.

Depending on precise objectives and the resolution of available data, different levels of CBA are possible (Table 18). If the objective is an informational study to provide overview over costs and benefits, resource requirements (e.g. data, time and human capacity) are relatively not so demanding. However, if the objective is project appraisal, the resource requirements can be enormous in terms of financial and time aspects.

Table 18: Cost benefit analysis at different scopes

Product	Objectives	Resource requirements
Informational study	Provide a broad overview over costs and benefits	+
Pre-project appraisal	Singling out most effective measures	++
Project appraisal	Detailed evaluation of project	+++
Ex-post evaluation	Evaluation of project after completion	++

Source: Mechler (2008)

CBA is based on the following simple principle: If **the benefit-to-cost (B/C) ratio** (benefit divided by cost) is greater than one, invest. Comparing multiple projects, the higher the B/C ratio, the more preferable the project. Also, where the **net present value (NPV)** (benefit minus cost) is positive, invest. The larger the NPV, the more preferable the project.

[38] Sections A and B of this chapter were drafted by Kazuko Ishigaki (UNISDR). The Section C was drafted by Callahan Egan, Junko Mochizuki, Stefan Hochrainer and Reinhard Mechler, Risk Policy and Vulnerability Program, International Institute for Applied System Analysis (IIASA).

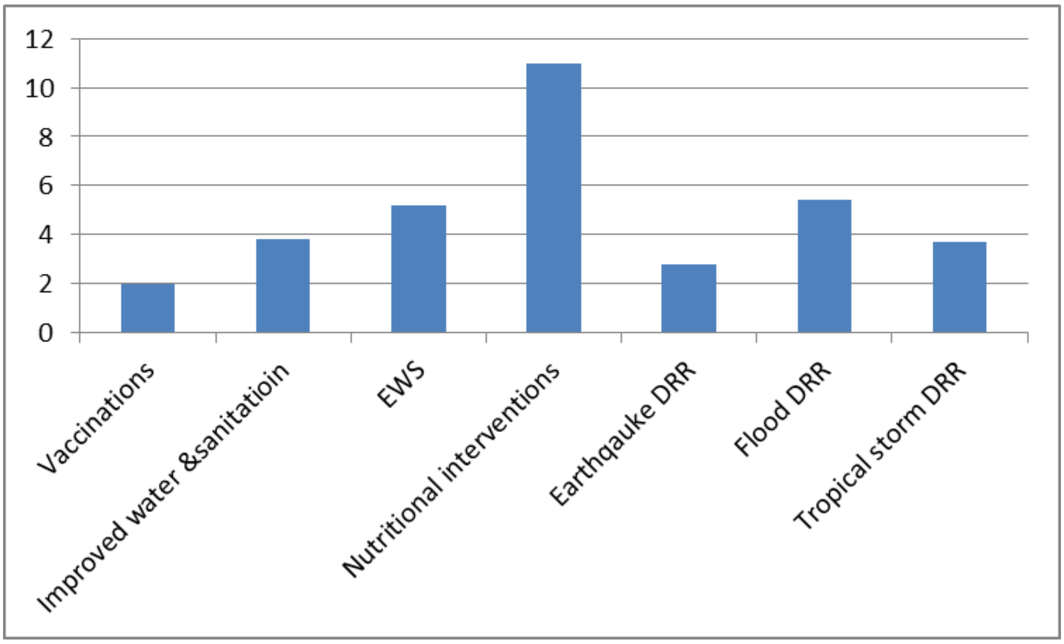
However, there are complex methodological problems that survive to date with no consensus of even modern economists (*e.g.* how to set the discount rate? How to assign monetary value to immeasurable, intangible items?). Furthermore, there are concerns regarding who conducts the CBA in order to retain objectiveness and accountability. Administrative costs for implementing CBA are also a concern for government.

When we assess from HFA Monitor the current status of CBA applications to DRR related projects, two issues arise. The first is that disaster risk is very often not accounted for in CBA for public investments, for example investment in infrastructure for transportation, education and health. The second issue is that direct risk preventive projects such as flood control infrastructure are often implemented without the routine grounding of a CBA framework.

The strength of the CBA is its ability to compare several options. For example, in reducing flood loss, the practical issue that financially constrained governments often face is how to choose between competing options such as Early Warning Systems (EWS), evacuation planning, sea wall construction, building retrofitting etc. Or in countries that face several hazards, questions are whether to prioritize risk reduction for earthquakes, floods, or cyclones, etc. CBA is a useful tool to provide insight on such prioritization issues.

Figure 48 summarizes examples of CBA to DRR policy implemented in several studies. We need to interpret the figure with caution because it is based on several studies and different contexts, however the interesting point is that in all of the featured projects benefit exceeds cost.

Figure 48: Benefit to cost ratio of DRR policies



Source: Wethli 2013 cited by the World Bank

In this initiative, probabilistic CBA was applied. The most important difference between probabilistic and non-probabilistic CBA is that the former accounts for the probabilistic benefits of risk reduction. While non-probabilistic CBA answers the question “what is the cost and benefit of sea wall construction *if a cyclone of a 50-year return period occurs*?”, probabilistic CBA answers the question “what is the cost and benefit of sea wall construction *given that cyclones of different sizes occur stochastically with different return periods*?”.

Probabilistic cost benefit analysis based on probabilistic risk assessment (forward looking probabilistic CBA) has been applied in several cases. When and where probabilistic risk assessment has not developed well, economists use historic disaster loss data (backward- looking probabilistic CBA) (Table 19). Now that more countries have risk profiles, more accurate forward-looking benefit estimation is increasingly possible.

Table 19: Forward-looking and backward-looking assessment

Type of assessment	Methodology	Data requirements	Cost and applicability
Forward looking assessment (*future risk* based)	Estimate risk as a function of hazard, exposure and vulnerability	Local and asset specific data on hazard, exposure and vulnerability	More accurate, but time and data intensive
Backward looking assessment (*past loss* based)	Use past losses as manifestations of past risk, then update to current risk	Data on past events and information on changes in hazard exposure and vulnerability Note: At least four credible data points of past loss are required	Rougher estimate, but more realistic for developing country contexts

Source: Mechler 2005, underlined by UNISDR.

In this initiative in the IOC region, forward-looking CBA was applied for Madagascar and Mauritius and backward-looking CBA was applied for Seychelles, Comoros and Zanzibar.

B. Methodology of CBA

CBA generally gets through five steps (Figure 49). CBA starts with setting project alternatives (Step 1). For example, when constructing dykes against flood, the government must choose the strength: how resilient should the dyke be? When planning dam building for river management, the government might need to decide between investing in two small dams or one big dam. It is also sometimes needed to compare investment and non-investment.

Step 2 is to estimate the benefit of policy. This is the most difficult step for DRR projects that will be explained below. Step 3 is to calculate benefit to cost ratio or/and net present value. Once benefit is defined and estimated, this is very simple. Step 4 is to carry out a sensitivity analysis to consider the possible variation in results due to the uncertainty of input variables (*e.g.* inflation costs).

Step 5 is distributional, or stakeholder analysis. CBA aims to measure the impact of a project on the society. Driven by strong economic assumption that the people who benefit will compensate for the loss to those who carry costs (Kaldor-Hicks Criterion), CBA does not consider distributional effects. However, reality is different. In making policy, distributional analysis is important to define stakeholders and care for those who may be negatively impacted. Therefore, in some cases, this complements the CBA. When those who benefit and those who pay for a project cost (including explicit and implicit) are self-evident, the government may be able to quantify the distributional impact. When it is not clear, qualitative analysis is implemented.

Figure 49: 5 steps of CBA

STEP 1: Consider project alternatives

STEP 2: Expect the benefit of policy (what are the expected benefits)?

STEP 3: Calculate Benefit to Cost Ratio (and/or Net Present Value)

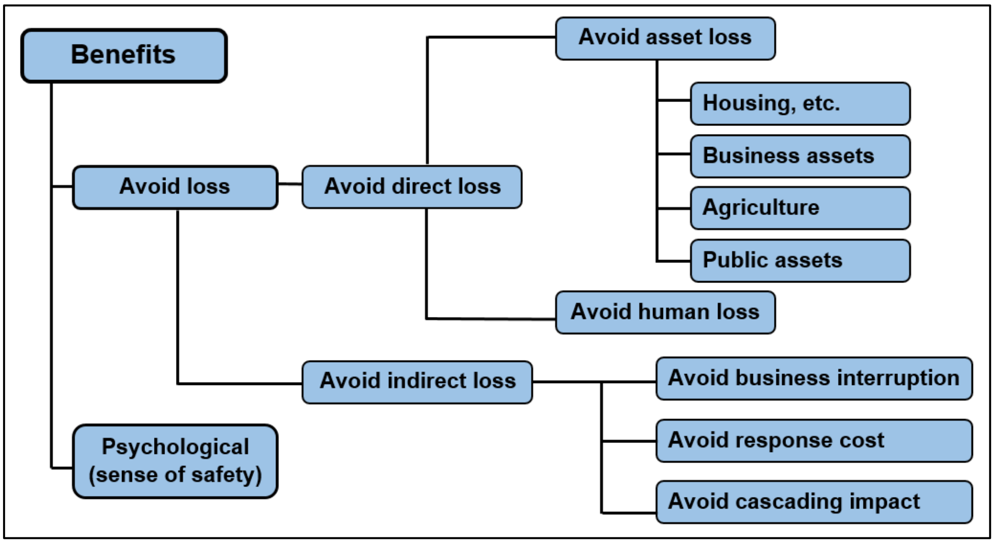
STEP 4: Sensitivity Analysis

STEP 5: Distributional Analysis, Stakeholder Analysis

Source: Author

The expected benefits from DRR investments are diverse. These might include avoided direct damage or loss to physical assets, avoided indirect loss (*e.g.* avoided business interruption), and even purely psychological benefits (*e.g.* sense of safety). Although listing benefits in a systematic way is important, we are not necessarily able to estimate or calculate all of the listed benefits (Figure 50).

Figure 50: Expected benefits from DRR investment

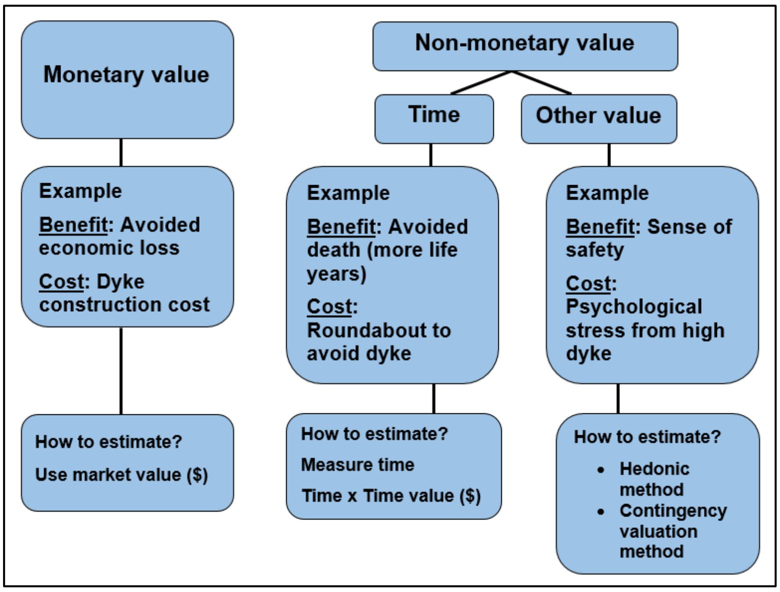


Source: Author

In estimating benefit, a main challenge is to assign monetary values to each expected benefit (Figure 51). If the benefits and costs have monetary values, the government can use them39. If the benefit is expressed by time (*e.g.* reduction of commuting time due to road infrastructure), the government needs to estimate the time gained and multiply it by the value of time (*e.g.* the average wage or minimum wage per hour).

Environmental economists have long tackled the monetization of intangible benefits and developed many methods. For example, one method is directly asking people how much he/she is willing to pay if the project is implemented and estimating the monetary benefits from the answers to that question.

Figure 51: Expected benefit classification



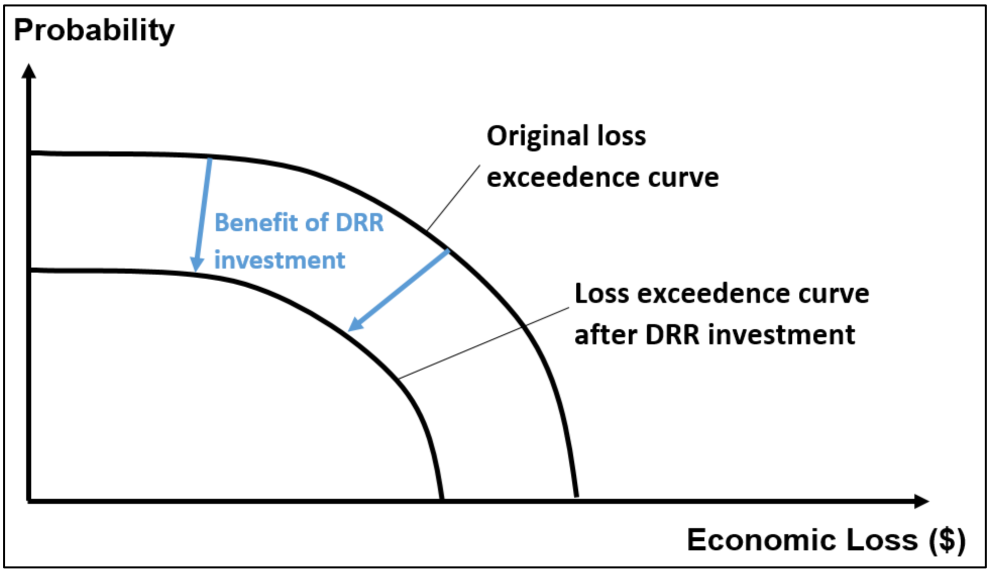
[39] More technically told, economists advocates using opportunity costs instead of the monetary value

Source: Author

It is important to keep it in mind that this CBA often reflects only partial benefits. In probabilistic CBA, estimation of avoided loss is based on probabilistic risk assessment (forward-looking CBA) or historic loss database (backward-looking CBA). In that sense, the scope of CBA analysis is defined by the scope of risk and loss data. For the case study described below, the risk assessment was limited to direct loss. Therefore, the CBA study also focuses only on the direct loss (written in bold in Figure 50). However, this is nonetheless a meaningful first step, because physical loss often needs to be recovered by reconstruction, which is very costly.

The benefit is estimated by measuring how much annual average loss (AAL) will be reduced after the investment (Figure 52). In case of forward-looking CBA, the data can be input into software such as CAPRA to estimate the AAL before and after investment. In case of backward-looking CBA, AAL before and after investment is calculated by using statistical methods (Simpson rule[40]).

Figure 52: Benefits in terms of reduced AAL



Source: Author

Estimating cost is relatively simple. Project cost and maintenance cost will be listed. Intangible costs (*e.g.* negative environmental impact) are sometimes also estimated.

After having translated benefit and cost into monetary value, the discount rate will be a critical issue with a large impact on the result of a CBA[41]. Discount rates express time preferences within the society. Low discount rates will evaluate future benefit higher than the case applying high discount rate. For example the present value of USD 100 million in 100 years later is about USD 37 million in 1% discount rate, USD 2 million in 4% discount rate and only USD 0.1 million in 7% discount rate. The discount rate has more impact when the project sustains for a long time, which is often the case for big infrastructure.

In CBA for public project, social discount rates are often defined by government (Table 20). If the government considers opportunity cost of capital, with more market based consideration, then discount rate tends to be

[40] To estimate the AAL given probabilistic losses and return period data, the Simpson rule is applied. If we know several data points of (return period, PML), depending on the amount of data points available, we can create probabilistic ranges between two data points and multiply the range by the estimated midpoint of loss in this given range. This is expressed by

AAL for range p1, p2= (p2-p1)*((L1+L2)/2)

L1 and L2 represent the maximum loss associated with a given event. P1 and p2 are the probabilities associated with each event. By summing up the AAL for each interval, or range (p1 to p2, p2 to p3,..) we have a an estimate for the total AAL.

[41] When setting discount rate, it is important to consider the impact of expected inflation, if discount rate is 10%, but expected inflation rate is also 10%, the inflation rate will offset the discount rate.

higher. However, if the government wants to politically reflect social time preference to balance the benefit of current and future generation, the rate tends to be set low. The International Panel for Climate Change (IPCC) recommends that governments adopt a low discount rate to recognize that benefits of future generations are equally important as those of current generation and future generation will be able to enjoy benefits from our actions today, in accordance with the concept of sustainable development (IPCC, 2012). It is important that government clarifies the rationale behind social discount rate setting; gaining accountability from the process is as important, or more, than the actual rate chosen.

Table 20: Discount rates in several countries

Country	Social discount rate	Rationale
USA	7%	Opportunity cost of capital
	3%	Social time preference
	4% (water)	Social time preference
New Zealand	7%	Opportunity cost of capital
Japan	4%	Opportunity cost of capital
EU	3.5%	Social time preference
UK	3.5%	Social time preference
France	4%	Social time preference

Source: Satoru Otani et al (n.d.).

The result of CBA is dependent on some critical variables. It is therefore always good to implement sensitivity analysis to observe how the result changes when we apply different values to those variables. For example, changing the social discount rate explained above will significantly change the result of the CBA. Construction periods and costs are also critical uncertain factors. Approving uncertainty and preparing several scenarios will strengthen the credibility of analysis instead of weakening it.

While CBA is an explicit and rigorous accounting framework for systematic cost-efficient decision making and common yardstick with a money metric against which to measure projects for social improvement, there are some limitations. CBA often does not assess non-market values and indirect impacts, lacks accounting for the distribution of benefits and costs (due to Kaldor-Hicks Criterion), cannot resolve strong differences in value judgments, and is strongly influenced by discount rates. CBA should not be the sole criterion for evaluating policies and projects, but should be complemented by other, non-economic considerations.

C. CASE STUDY: Housing retrofitting against flooding and cyclonic wind

I Selection of Scenario

We estimate the net benefits of retrofitting residential housings of different categories in Comoros against both flood (including cyclone-induced rain) and cyclone wind damage and compare Benefit/ Cost (B/C) ratios among several retrofitting scenarios. Given there is no probabilistic risk assessment of flood using hazard, exposure and vulnerability information, we decided to implement **backward looking** probabilistic CBA. We follow the general methodology for conducting cost-benefit analysis laid out by Mechler (2005).

The selection of the scenario is based on the availability of loss data for Comoros. Flood risk on housing was selected based on discussions with the Comores team. However the available data on risk and losses was only for aggregated flood (including cyclone-induced rain) and cyclone (wind), therefore the analysis is targeted on retrofitting houses against both flood (including cyclone-induced rain) and cyclone wind damage.

II Key Assumptions

1. Residential house value and retrofit options in Comoros.

In order to conduct cost-benefit analysis of retrofitting housings and residential buildings, we needed to first identify the total value of housings and their exposed assets. We identified the total value of exposed assets in the residential sector to be USD 1,036 million based on the assessment of CAPRA which identified the value of the residential sector to be 53% of the total value of exposed assets in the Comoros and Hochrainer et al (2014) who identified the total capital stock value of the Comoros to be USD 1,952 million (Table 21).

Table 21: Sources and assumed value of exposed assets in the housing sector of Comoros (in USD)

Source	CAPRA	Hochrainer et al 2014	Assumed
Residential value	428,870,000	-	**1,036,075,596**
Total asset value	808,100,000	1,952,230,000	1,952,230,000
% Residential value	53%	-	53%

In this study, we assess the following two retrofitting options in Comoros:

1. Flood risk reduction by raising floors of houses, which reduces potential losses from flooding (including cyclone-induced rain) to zero.
2. Cyclone wind retrofitting, which raises the building quality from “low design quality” to “high design quality”.

2. Flood and Wind losses for residential sector

Hochrainer et al (2014) provides maximum losses with associated return periods[42] from which we were able to estimate the average annual loss (AAL) due to flood (including cyclone-induced rain) and cyclone wind (Table 22)

Table 22: AAL estimated from return periods and associated maximum losses (in million USD) due to flood and cyclone

Return period	Exceedance probability	Maximum loss	Expected annual loss
0	1	0	0
20	0.05	8.9	4.2
50	0.02	19	0.4
100	0.01	40.6	0.3
500	0.002	303.6	1.3
<500	0	303.6	0.6
			AAL=6.95

Source: Hochrainer et al (2014)

The expected annual loss is estimated applying the Simpson rule[43]. For example, based on the return periods identified, the expected loss up to a 20 year event is the cumulative probability of the 20 year event (0.95) minus the cumulative probability of the 0 year event (0) multiplied by the average loss between the 0 and 20 year events. In numerical terms:

EL(20-0 years)= (0.95-0)*((8.93+0)/2)= 4.2

This process is then done for all other intervals. For the last interval, it is assumed for this CBA that losses associated with events of more than a 500 year return period will result in the same losses as the 500 year event. Therefore in the last interval, the expected loss is simply (1-0.998)*303.6, yielding the value of 0.6. Cumulating the losses for all events, the AAL for all sectors resulting from flood and wind damage is USD 6.95 million.

[42] Disaster loss database developed in Component 1 could not be used because it was not complete at the timing of analysis.
[43] Please see the footnote 40 regarding Simpson rule.

However, this figure needs to be adjusted to losses for the residential sector only, as the CBA is done on retrofitting only residential housings. As our data is limited regarding losses specific to the residential sector, we had to assume that the amount of AAL to the residential sector would be exactly proportional to the percentage of value of the residential sector relative to all sectors. Since we assumed this to be 53% based on the exposed assets file provided, we assumed the AAL loss to the housing sector to be 6.95*(0.53)= **USD 3.7 million**.

3. Costs

As there is no readily available cost estimate for flood (including cyclone-induced rain) or wind retrofitting , this rough estimates were made based on existing literature. For flood retrofitting, a common option is raising the floor heights of existing housings. From Woodruff (2008) study conducted in Samoa, the cost estimates of raising the floor heights of housings can range anywhere from 11-50% of the house value (11% minimum, 31% medium, 50% maximum). With regards to wind retrofitting, estimates from different literature suggest retrofitting typically costs anywhere from 1-20% of the house value (Gujarat 2001; Li, Stewart 2011, Stewart, Rosowsky, Huang, 2003; Pinelli, Torkian, Gurley, Subramanian, Hamid, 2009). We make assumptions that retrofitting against cyclone wind can cost 5%, 7% or 10% of the housing value.

We also assume that retrofitting against flood (including cyclone-induced rain) does not contribute to retrofitting against wind. Therefore the cost of retrofitting against flood (including cyclone-induced rain) and cyclone wind is the sum of the two retrofitting costs. From these assumptions, we estimated the total costs of retrofitting all housings against flood (including cyclone-induced rain) and cyclone wind damage. Table 23 below shows the cost in three different scenarios.

Table 23: Costs of retrofitting all housings against flood (including cyclone-induced rain) and wind damage

	Low	Medium	High
Project cost (% of residential housing value)	16% - 11% flood - 5% wind	38% -31% flood - 7% wind	60% - 50% flood - 10% wind
Total (USD)	165,772,095	393,708,726	621,645,357

Furthermore, since retrofitting is a one-time intervention, we assume for now that there is no maintenance cost associated. We also assume the lifetime of the retrofit to be 30 years.

4. Benefits

To assess the benefits of the housing retrofitting, assumptions have to be made about the economic losses that would be reduced as a result of the project. With regards to flood (including cyclone-induced rain) retrofitting, we follow the assumption that raising floor height reduces all potential losses from flooding to zero.

For cyclone wind, we assume that retrofitting houses brings all houses up to the “high design quality” from the assumed state of “low design quality” according to the GAR 2013. According to the exposure file for Comoros used in Component II of this initiative, there are five housing structure types: adobe, concrete, unrefined masonry, refined masonry, and wood. The breakdown of house by type is seen in Table 24 below.

Table 24: % of housings types in Comoros (based on housing value)

Type	Adobe	Concrete	Unrefined mansory (URML)	Refined mansory (RML)	Wood
% of total value	1	11	61	9	18

Based on Table 25, we identify the change in losses from wind damage to houses resulting from a shift in vulnerability from a low to high design quality. In order to do this we needed to identify the amount of damage associated with both “low” and “high design quality” housings relative to the strength of wind speed. This can be seen in Table 26 below.

Table 25: % of damaged value based on house type and wind speed

	Category of the cyclone (wind speed in kph)							
	1 (118-153)	**2** (154-177)	**3** (178-210)	**4** (211-249)	**1** (118-153)	**2** (154-177)	**3** (178-210)	**4** (211-249)
Type of the house	LOW QUALITY				HIGH QUALITY			
Adobe	0	2	12	53	0	0	2	8
Concrete	0	1	3	18	0	0	0	2
URML	1	3	13	53	0	0	1	8
RML	0	2	9	40	0	0	1	5
Wood	3	10	40	86	0	1	5	25

Source: INGENIAR, 2014

Using the CAPRA-GIS software, we estimated the percentage of loss reduction given the return period as a result of wind retrofitting. We can see initially that all losses up to a category 2 storm will go to zero. Table 26 below shows the loss reduction for given return period estimated from wind speed information in the CAPRA-GIS software.

Table 26: Loss reduction as a result of retrofitting against tropical cyclonic wind

Storm Category	Category 2	Category 3	Category 4	Category 5
return period	<50	50	100	>500
loss reduction	100%	90%	80%	25%

Before estimating the annual benefit of retrofitting housings against flood (including cyclone-induced rain) and wind damage we had to estimate the AAL resulting from flood (including cyclone-induced rain) and wind separately. There was no precise way to identify this without applying more advanced analyses of the potential dependency between hazards using statistical methods such as Copula.

As a first step of analysis, it was simply assumed that risk of flood (including cyclone induced rain) and cyclone wind is independent, and disaggregated the risk by taking the difference in estimated losses according to Hochrainer et al (2014) (USD 3.7 million, which includes both flood and cyclone (rain and wind)) and that of CAPRA estimate provided by the risk analyst team in Component II of this initiative (USD 0.95 million, which only includes cyclone wind). The latter figure was further adjusted to match the total asset exposure used in Hochrainer et al (2014). This step was necessary given the large discrepancy found in the total asset values cited by these studies. After the adjustment[44], the AAL due to wind was estimated to be USD 1.2 million of the estimated USD 3.7 million total AAL for the housing sector. Given that AAL estimate based on Hochrainer-Stigler 2014 (which include both flood and cyclone risks) is USD 3.7 million and cyclone wind-only AAL estimate based on the CARPA model is USD 1.2 million, we have calculated that 33% of the AAL is due to wind and the remaining 67 % of damages due to flood.

From the procedures above we were able to estimate, the annual average benefit of retrofitting against flood (including cyclone-induced rain) and wind. Table 28 below shows the annual average benefit (reduction in AAL) as a result of retrofitting housings in Comoros.

As can be seen, Table 27 the reduction in AAL is USD 3.4 million. Figure 53 displays the reduction in losses as a result of the project in graphic form. The shift in the loss distribution curve represents the risk reduction due to housing retrofitting.

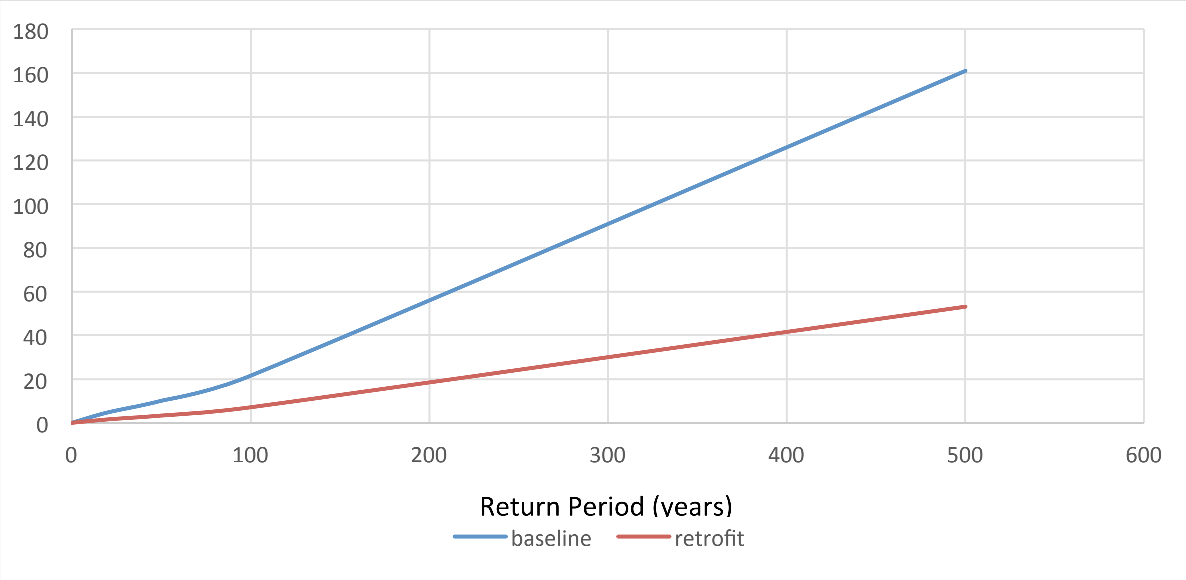
[44] As outlined in II.1., adjustment is based on CAPRA housing asset value data showing 53% of national assets in the housing sector. This was applied to the economic data of Hochrainer-Stigler (2014) showing USD 1.95 billion in national assets. By multiplying 0.53* 1.95 billion we obtained the adjusted housing sector value of USD 1.03 billion and applied this figure to the risk data provided by Hochrainer-Stigler (2014) to estimate the AAL for the housing sector.

Table 27: Estimated annual benefits as reduction in AAL due to retrofitting housings against wind and flood (including cyclone-induced rain) (in million USD)

Return period	Exceedence probability	Maximum loss	Loss from flood (67%)	Loss from wind (33%)	Expected loss for period no action	Flood loss reduction	Wind loss reduction	Expected loss for period after retrofit
0	1.000	0.0	0.0	0.0	0.00	100.0	100.0	0.000
20	0.050	4.7	3.2	1.6	2.25	100.0	100.0	0.000
50	0.020	10.1	6.8	3.3	0.22	100.0	90.0	0.007
100	0.010	21.6	14.4	7.1	0.16	100.0	80.0	0.010
500	0.002	161.1	108.0	53.2	0.73	100.0	25.0	0.181
<500	0.002	161.1	108.0	53.2	0.32	100.0	25.0	0.080
					AAL Baseline: 3.69			AAL after retrofitting: 0.278
							Reduced AAL: Benefit	**3.41**

Source: Author

Figure 53: Loss Return Period Curves Pre and Post housing retrofitting Project (in Million USD)



Source: Author

5. Time Factors

5.1. Discount Rate

There has been no official discount rate applied in Comoros. Therefore, we start with initial assumption of 5% (International Monetary Fund, 2013) but apply different rates as a means of sensitivity analysis.

5.2 Increase in exposed assets

As the retrofitting will only affect current houses in Comoros, it is assumed that future housings built would not benefit in any way from the retrofitting. The characteristics of retrofitting policy are different from infrastructure community project in which the benefits spread and influence external factors. Therefore it can be assumed that the benefits will remain at the values specified in Table 28, despite the increase or decrease of exposed assets due to socio-economic trends.

III Results

Using the data, provided information, and assumptions described to this point, we are able to conduct a cost-benefit analysis for the project. Table 28 below shows the net present value of retrofitting all housings against flood and wind damage, assuming the benefits will last 30 years, and at a 5% discount rate. The cost of retrofitting in this scenario is 16% (11% for flood (including cyclone induced rain) and 5% for wind). In this case, retrofitting all housings against wind and flood appears to be cost-inefficient with a net present value of USD -113 million. In the conclusion we discuss reasons for the negative outcomes of this cost-benefit analysis and why the results may potentially be due to limited or unclear data, resulting in assumptions that limit the robustness of the results.

Table 28: Cost benefit analysis of retrofitting all housings against flood and wind, 5% discount rate, project cost of 16% of the house value (in USD)

Year	Calendar Year	Costs USD	Benefits	Net benefits: benefits-costs	Discounted costs	Discounted benefits	Discounted net benefits
1	2013	165,772,095	0	-165,772,095	165,772,095	0	-165,772,095
2	2014	0	3,410,000	3,410,000	0	3,247,619	3,247,619
3	2015	0	3,410,000	3,410,000	0	3,092,971	3,092,971
4	2016	0	3,410,000	3,410,000	0	2,945,686	2,945,686
5	2017	0	3,410,000	3,410,000	0	2,805,415	2,805,415
6	2018	0	3,410,000	3,410,000	0	2,671,824	2,671,824
7	2019	0	3,410,000	3,410,000	0	2,544,595	2,544,595
8	2020	0	3,410,000	3,410,000	0	2,423,423	2,423,423
9	2021	0	3,410,000	3,410,000	0	2,308,022	2,308,022
10	2022	0	3,410,000	3,410,000	0	2,198,116	2,198,116
11	2023	0	3,410,000	3,410,000	0	2,093,444	2,093,444
12	2024	0	3,410,000	3,410,000	0	1,993,756	1,993,756
13	2025	0	3,410,000	3,410,000	0	1,898,816	1,898,816
14	2026	0	3,410,000	3,410,000	0	1,808,396	1,808,396
15	2027	0	3,410,000	3,410,000	0	1,722,282	1,722,282
16	2028	0	3,410,000	3,410,000	0	1,640,268	1,640,268
17	2029	0	3,410,000	3,410,000	0	1,562,160	1,562,160
18	2030	0	3,410,000	3,410,000	0	1,487,772	1,487,772
19	2031	0	3,410,000	3,410,000	0	1,416,925	1,416,925
20	2032	0	3,410,000	3,410,000	0	1,349,453	1,349,453
21	2033	0	3,410,000	3,410,000	0	1,285,193	1,285,193
22	2034	0	3,410,000	3,410,000	0	1,223,993	1,223,993
23	2035	0	3,410,000	3,410,000	0	1,165,708	1,165,708
24	2036	0	3,410,000	3,410,000	0	1,110,198	1,110,198
25	2037	0	3,410,000	3,410,000	0	1,057,332	1,057,332
26	2038	0	3,410,000	3,410,000	0	1,006,982	1,006,982
27	2039	0	3,410,000	3,410,000	0	959,031	959,031
28	2040	0	3,410,000	3,410,000	0	913,363	913,363
29	2041	0	3,410,000	3,410,000	0	869,869	869,869
30	2042	0	3,410,000	3,410,000	0	828,447	828,447
31	2043	0	3,410,000	3,410,000	0	788,997	788,997
	Sum	0	**102,300,000**	-63,472,095	165,772,095	**52,420,058**	**-113,352,037**

Table 29 and Table 30 will show sensitivity analysis with regards to the discount rate and the cost of the project. For Table 30 we will make some changes in the assumptions with regards to the project costs. In the current state, it is assumed that all housings in Comoros will be retrofitted. However, it is probable that housings in certain regions are much more exposed and vulnerable than housings in other regions. While there was no available data on specific regional vulnerability, we still are interested in plausible scenarios. Therefore, Table 31 shows the NPV and B/C ratio when a different percentage of housings are retrofitted, but resulting in the same annual benefit. While we initially assume that all housings are retrofitted to reduce the vulnerability and bring about the annual benefit of USD 3.41 million, we here show what the net benefit and B/C ratio would be if only 50%, 33%, and 25% of the housings would need retrofitting to result in the same annual benefit. By changing the number of houses to be retrofitted, we are changing the overall cost of the project while keeping the annual average loss caused by wind and flood damage, as well as annual average benefit of retrofitting the same value. With no specific data on the number of housings, we assume that the cost of retrofitting a certain percentage of the housings is the same as the percentage in terms of total housing value.

Table 29: Sensitivity analysis with regards to the discount rate

discount rate	0%	2%	5%	7%	10%	15%
NPV	-63,472,095	-89,400,182	**-113,352,037**	-123,457,265	-133,626,317	-143,382,104
B/C ratio	0.62	0.46	**0.32**	0.26	0.19	0.14

Table 30: Sensitivity analysis with regards to percentage of houses retrofitted

houses retrofitted	100%	50%	33%	20%
NPV	**-113,352,037**	-30,465,989	-2,284,733	19,265,639
B/C ratio	**0.32**	0.63	0.96	1.58

IV Conclusion

The results of the cost-benefit analysis for retrofitting housings against flood (including cyclone-induced rain) and wind damage suggest that it would be a cost-inefficient project. However, there are a number of factors regarding the data and the assumptions that potentially limit the validity of the figures found in this report.

For example, we have no concrete data on house value. The only metric provided from potential housing value comes from an exposed asset file, which shows 53% of the national assets falling into the residential sector. It is unclear if this figure is the value of the housings itself (which is the assumption used in this analysis), or if it includes all of the assets owned by households. If the latter is the case, then the estimation of the value of housings would be significantly over-estimated, resulting in an overestimation of both ALL and total retrofitting costs.

The second issue is with regards to the project retrofitting costs. With no local estimate, the cost of retrofitting for wind and flood could be significantly different than the figures taken from previous findings based in other countries. For example, in this study, we used the figures from Woodruff (2008) which estimated that cost of raising the floor heights of housings to be anywhere from 11-50% of the housing value in Samoa. We also have no information on flood exposure in the country, which significantly limits the quality of present analysis.

It is also important to keep in mind that the present assessment did not take into account many of the indirect and intangible losses, such as loss due to business interruption and any reduction in land values that may result due to frequent disasters. These are clear limitations of this current analysis and further studies are certainly needed to improve the accuracy and comprehensiveness of our analysis.

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Annex D: Workshops and Meetings in IOC region

Inception meeting

Dates: 15-17 April 2013

Venue: ICCS, Seychelles

Host: Ministry of Environment

UNISDR staff in charge: Julio Serje, Kazuko Ishigaki, Manuela Di Mauro

Participants: 34

Component 1: capacity building for national disaster loss database

Comoros national workshop:

Dates: June 11-13, 2013

Venue: Hotel Retaj

Host: the Civil Protection and the Ministry of Environment.

UNISDR staff in charge: Sylvain Ponserre and Julio Serje

Participants: 25

Seychelles national workshop:

Dates: 14 - 19 Jul 2013.

Venue: Seychelles Fishing Authority, Division of Risk and Disaster Management (DRDM)

Host: the Division of Risk and Disaster Management (DRDM)

UNISDR staff in charge: Sylvain Ponserre

Participants: 22

Madagascar national workshop:

Dates: 28 Jul - 01 Aug 2013.

Venue: Hotel Colbert

Host: The "Cellule de Prévention et Gestion des Urgences"(CPGU)

UNISDR staff in charge: Sylvain Ponserre

Participants: 36

Mauritius national workshop:

Dates: 24 - 29 Aug 2013.

Venue: Indian Ocean Commission headquarters

Host: Ministry of Environment

UNISDR staff in charge: Sylvain Ponserre

Participants: 40

Zanzibar national workshop:

Dates: 11-14 June 2013

Venue: Zanzibar Ocean View Hotel

Host: NBI Office

UNISDR staff in charge: XXXXX

Participants: 37

Component2: Capacity building for Probabilistic Risk Assessment:

First regional workshop

Dates: 21-23 October 2013

Venue: Indian Ocean Commission headquarters, Mauritius

Host: Ministry of Environment

UNISDR staff in charge: Manuela Di Mauro, Mabel Cristina Marulanda Fraume (consultant)

Participants: 40

Second regional workshop

Dates: 20-22 November 2013

Venue: Indian Ocean Commission headquarters, Mauritius

Host: Ministry of Finance

UNISDR staff in charge: Mabel Cristina Marulanda Fraume (consultant)

Participants: 22

Third regional workshop

Dates: 19-21 March 2014

Venue: Indian Ocean Commission headquarters, Mauritius

Host:

UNISDR staff in charge: Mabel Cristina Marulanda Fraume (consultant)

Participants: 31

Mauritius national workshop:

Dates: 17-18 February 2014

Venue: Indian Ocean Commission Secretariat

Host:

UNISDR staff in charge: Mabel Cristina Marulanda Fraume (consultant)

Participants: 10

Seychelles national workshop:

Dates: 23-27 June 2014

Venue:

Host: The Division of Risk and Disaster Management (DRDM)

UNISDR staff in charge: Mabel Cristina Marulanda Fraume (consultant)

Participants:

Component 3: economic analysis and public investment planning

First regional workshop

Dates: 24-26 June, 2014

Venue: ICCS, Seychelles

UNISDR staff in charge: Kazuko Ishigaki, Lezlie Moriniere (consultant)

Host: Ministry of finance

Participants: 15

Second regional workshop

Dates: 20-22, October, 2014

Venue: Indian Ocean Commission headquarters, Mauritius

Host: Ministry of Finance

UNISDR staff in charge: Kazuko Ishigaki, Lezlie Moriniere (consultant)

Participants: 19

Zanzibar national workshop:

Dates: 10 December, 2014

Venue: Zanzibar Ocean View Hotel

Host: Department of Environment

UNISDR staff in charge: Kazuko Ishigaki, Lezlie Morinière (consultant)

Participants: 30

Seychelles national workshop:

Dates: 02-03 Feb 2015
Venue: Conference Center
Host: Ministry of Finance
UNISDR staff in charge: Kazuko Ishigaki, Julio Serje, Lezlie Moriniere (consultant)
Participants: 30

Comoros national workshop:

Dates: 05-06 Feb 2015

Venue: Direction générale de la Sécurité Civile

Host: Direction générale de la sécurité civile

UNISDR staff in charge: Julio Serje, Lezlie Morinière (consultant)

Participants:55

Madagascar national workshop:

Dates: 28-30 Feb 2015

Venue: STC

Host: Ministry of Finance

UNISDR staff in charge: Kazuko Ishigaki, Lezlie Morinière (consultant)

Participants: 30

Mauritius national workshop:

Dates: tbc

Venue: tbc

Host: tbc

UNISDR staff in charge: tbc

Participants: tbc

UNISDR Working Papers on
Public Investment Planning and Financing Strategy for Disaster Risk Reduction

1. Public Investment Planning and Financing Strategy to Reduce and Mange Disaster Risk: Review of Mauritius, February 2015
2. Public Investment Planning and Financing Strategy to Reduce and Mange Disaster Risk: Review of Madagascar, February 2015
3. Public Investment Planning and Financing Strategy to Reduce and Mange Disaster Risk: Review of Seychelles, February 2015
4. Public Investment Planning and Financing Strategy to Reduce and Mange Disaster Risk: Review of Comoros, February 2015
5. Public Investment Planning and Financing Strategy to Reduce and Mange Disaster Risk: Review of Zanzibar, February 2015
6. Public Investment Planning and Financing Strategy to Reduce and Mange Disaster Risk: Review of South-West Indian Ocean Region, February 2015

The series offers analysis and policy guidance to national governments and other stakeholders to strengthen public investment planning and financing strategy to reduce and manage disaster risk. These reviews are part of a larger body of UNISDR work on disaster risk reduction, including loss database building, global probabilistic risk assessment, HFA Monitor and others. This work includes both theoretical reports and reports on specific countries or regions.

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