Região Autónoma da Madeira
Governo Regional

Secretaria Regional
dos Equipamentos
e Infraestruturas

Measures of flood mitigation in Madeira watercourses

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Regional Secretariat of Equipments and Infrastructures

ORDEM DOS ENGENHEIROS REGIÃO MADEIRA
2018 ano de das alterações climáticas

O PAPEL DA ENGENHARIA
NA ADAPTAÇÃO ÀS ALTERAÇÕES CLIMÁTICAS
AUDITÓRIO DO MUSEU CASA DA LUZ | FUNCHAL
6 DE JULHO DE 2018

Key Issues

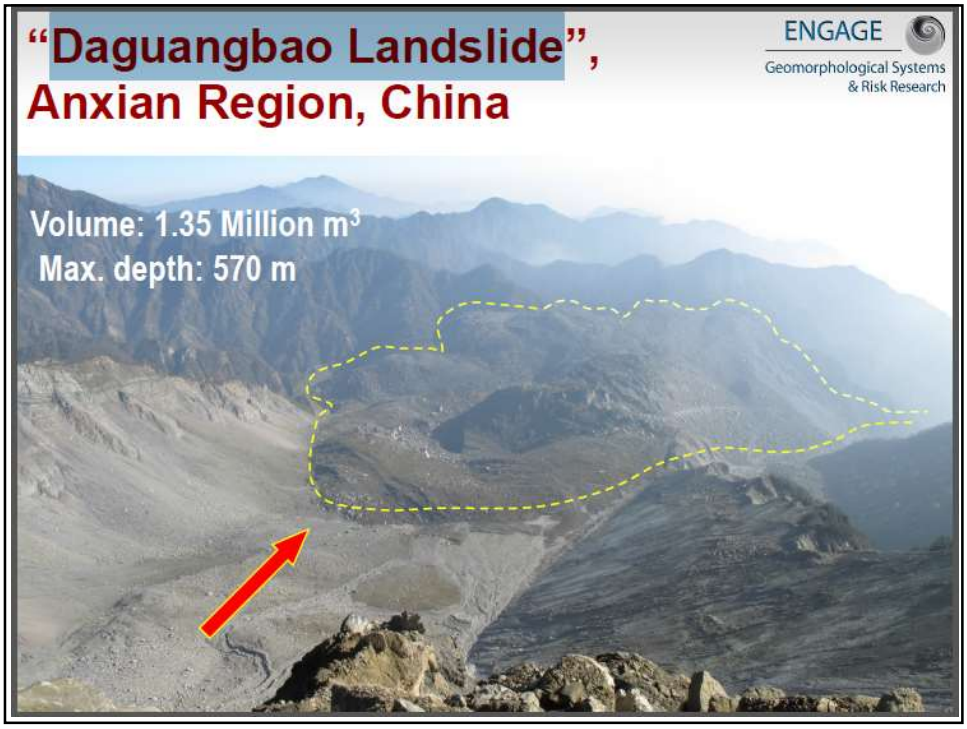
- Introduction: global climate change and local change;
- General framework of natural disasters in Madeira;
- Identification of problems and practices to avoid;
- Structural measures for risk mitigation;
- The integrated risk management model;
- Communication of risk;

In the approach to Risks it is essential:

• Knowledge (“To know to act well”)

• Understanding among the various actors (conceptual, skills, organization)

• Existence of a strategic vision ("the Art of seeing beyond")



Wenjiagou debris flow happened in August 13, 2010

INCREDIBLE FLASH FLOOD IN BAALBECK, LEBANON | June 13, 2018

Slide (deslizamento)

Madeira island
Ribeira Brava basin

Translational landslide occurred at 20 February 2010.

Main scarp and slip surface.

Madeira Island: debris flow and flash floods February 2010

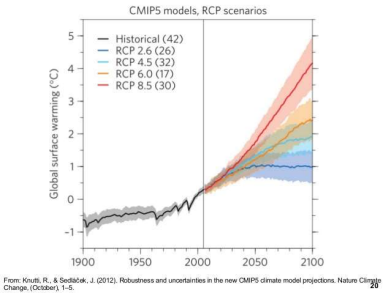
Austria

Madeira Island:
debris flow and flash floods February 2010

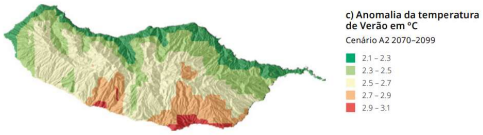
How plastic is slowly killing our sea creatures, fish and birds

The threat of space junk and orbital debris

Alterações climáticas ditas globais

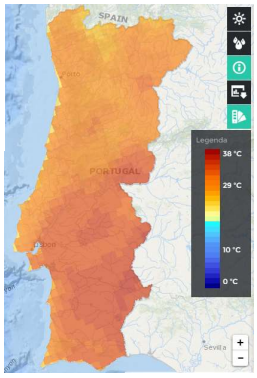


From: Knutti, R., & Sedláček, J. (2012). Robustness and uncertainties in the new CMIP5 climate model projections. Nature Climate Change, (October), 1–5.



Estratégia de Adaptação às Alterações Climáticas da Região Autónoma da Madeira

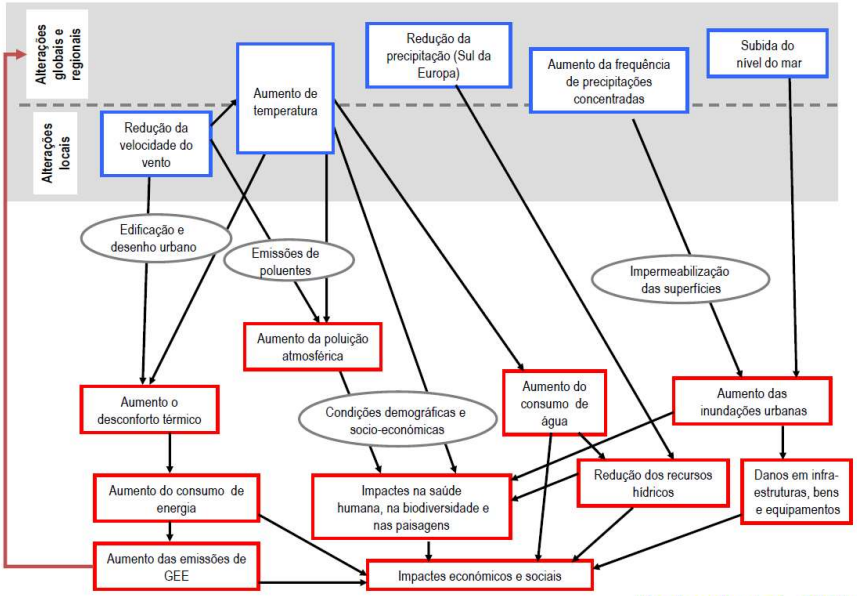
Projecção do aumento de temperatura em função de vários cenários IPCC, 2014



Cenário RCP4.5. 2071-2100 RCP (Representative Concentration Pathways) IPCC, 2014. Fifth Assessment Report (AR5).

IPCC 2012: Aumento de frequência (e/ou intensidade) das vagas de calor Aumento da frequência das precipitações intensas

Risk factors in urban areas and impacts on the territory



Alcoforado et al., 2009

Setting the scene: Madeira susceptibility to flash floods and drainage basin characteristics

Floods: natural aggravating factors

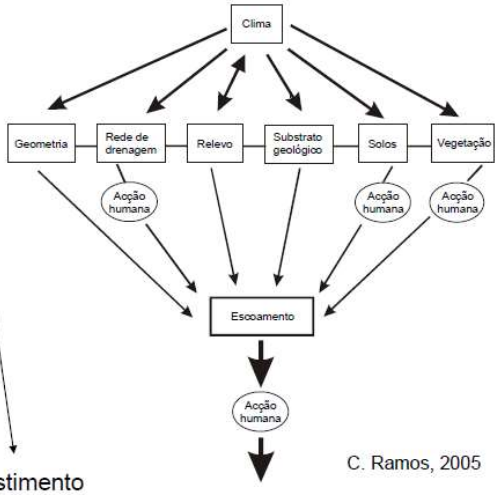
Geometria:
- área
- forma

Rede de drenagem:
- densidade
- sinuosidade
- inclinação

Relevo:
- posição
- exposição
- altitude
- desnível
- declive

Substrato geológico e Solos:
- permeabilidade
- porosidade

Vegetação:
- tipo de revestimento
- grau de cobertura



C. Ramos, 2005

Madeira Island: a territory very susceptible to a mixture of hydro-geomorphological complex processes

rock slide/rock fall

earth flow (landslide)

debris flow

flash floods

Madeira Island: a territory highly susceptible to flash-floods

- Hilly terrain, promote buoyancy effects of maritime tropical air masses, coming from southwest

- Large altitude differences (up to 1200 m)

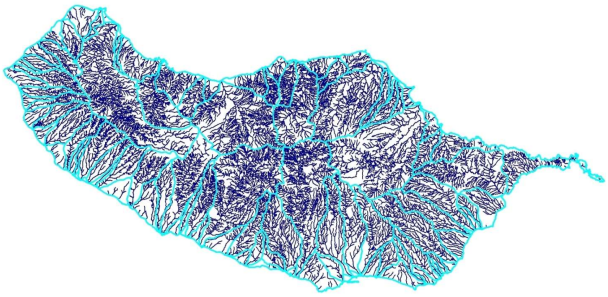
- Steep slopes

- Longitudinal profile of main water lines with steep inclination

Madeira Island: a territory highly susceptible to flash-floods

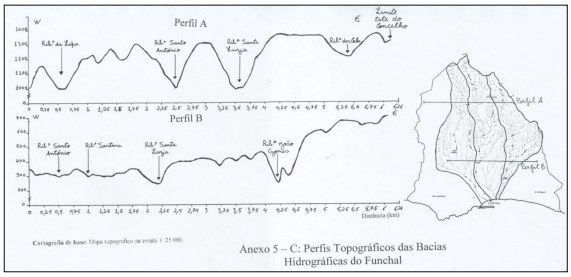
- Rapid concentration of runoff in the river channels
  very high drainage density

- Geological volcanic substrate highly weathered, with low perviousness of the terrain



Madeira Island: a territory highly susceptible to flash-floods

- The valleys are very deep, promoting a greater interaction between the slope movements and the streams - very high solid load ("aluviões")



Fonte:
Lopes, 2003

Fotos, CENOR, 2010

Madeira Island: a territory highly susceptible to flash-floods

The great severity of flash floods in Madeira comes, mainly from:
- water velocity
- the flows achieved
- the solid load they carry
- the speed with which they occur

Flash flood of 22 December 2009 in Vargem stream, one of the main tributaries of São Vicente basin. Detail of the stream flow peak

Aspect of the streambed in the day after the flash flood of 22 December 2009

Vegetation

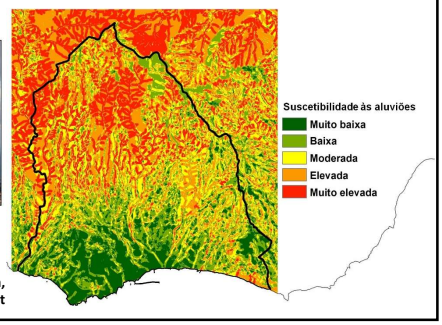
Afforestation and reforestation programs

Upper sector of São Joao Funchal basin.

- The extension of forest on Madeira island is 43% of their total area
- Part of the vegetation has an influence on soil protection
- Main problems are the fires and the difficulty for regeneration

Human occupation of basins

Only a small part of the island has biophysical conditions for settlements. Example: 37% of the area of Funchal Municipality has low susceptibility to the risk of torrential flood (S Lopes, 2015).



Heavy rainfall events and flash floods in the Funchal area (Madeira, Portugal): spatial analysis and susceptibility assessment

Natural hazards in Madeira

- Processes such as landslides, debris flow and flash floods assume rapid movements of mixed flows, difficult to predict its spatial impact

↓

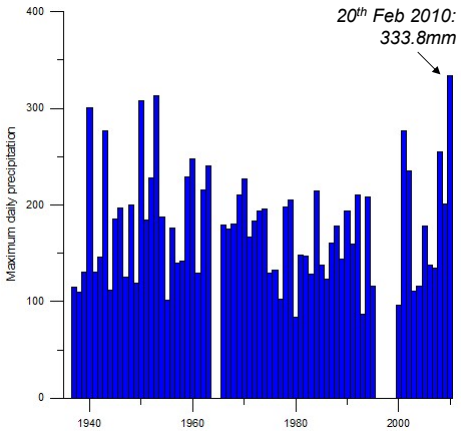
Early warning systems and subsequent emergency actions are limited

Natural hazards in Madeira

In the mountainous areas, the fluvial torrential processes are a threat to human occupation and to the physical integrity and security of persons, goods and infrastructure.

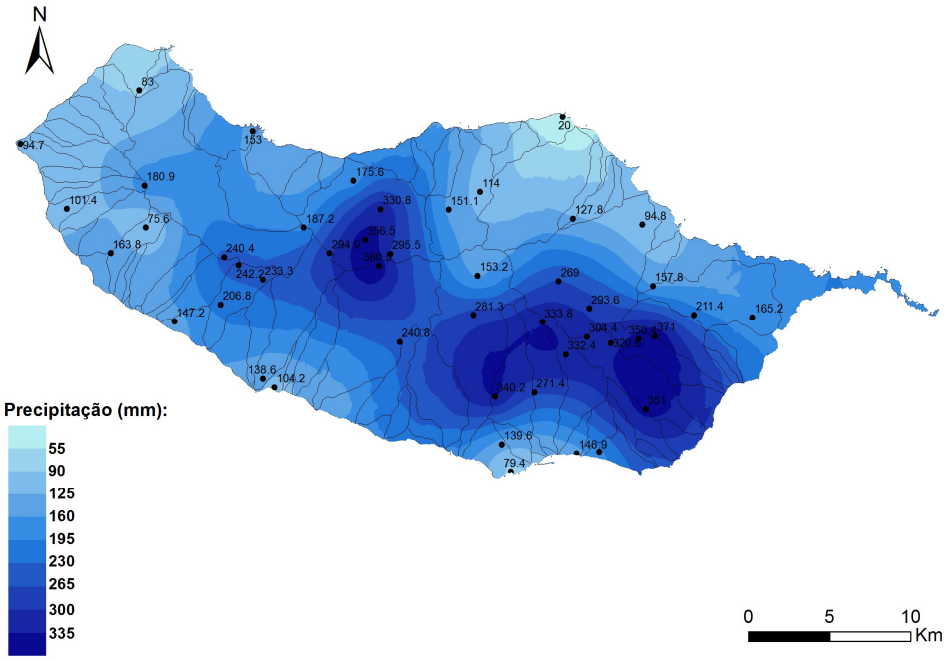
Biggest natural disaster: torrential flood of February 2010, damage costs were estimated at 1.4 billion EUR(EM-DAT CRED, 2010);

Return period estimation (Nakagami distribution)

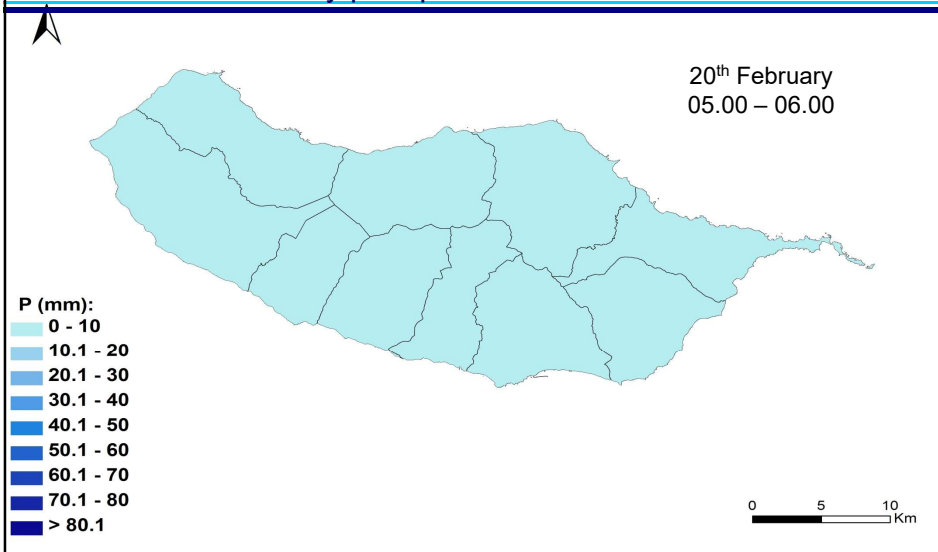


▶ Areeiro Peak: 333.8 mm, record breaking value since 1936

▶ An extreme event with a longer than 100 years return period



Evolution of hourly precipitation



Identification of problems and practices to be avoided

Construction on beds and stream banks

The lower floors below the top of the fluvial channel

Construction on beds and stream banks of mountain torrents

November 2009
(Google street view)

March 2010

The lower floors at the level of stream bed

Stream inside the house or the house within the stream?

“seemingly insignificant” streambed

Obstacles to the stream flow

Reconstruction of road stream crossing

Good practice, streamlined pillar to facilitate passage of large woody debris

Difficulty of access the streamline for cleaning and maintenance purposes

Bad land use example of the streambed, with the construction of a support wall

Structural measures of flood mitigation in Madeira streams

Torrent control and streambed stabilization

Design of slit dams for controlling debris flows and fluvial transport of solid material

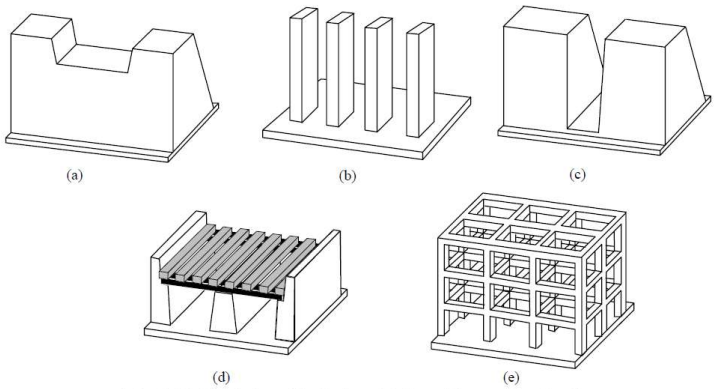
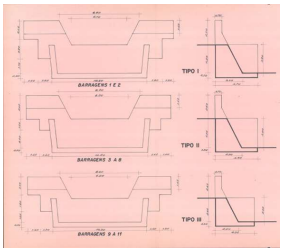


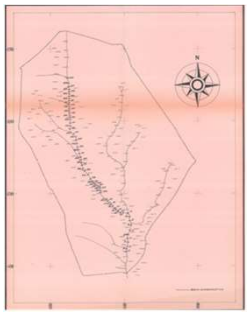
Fig. 1 (a) Check dam; (b) slit dam; (c) dam with a rectangular slit; (d) bottom infiltration screen; (e) grid dam

Lien, 2003

Fluvial erosion control and debris flow protecion in Madeira Island

Project developed in the decade of 1970 for the upper sector of Funchal basins.





The project included the construction of 69 check dams.

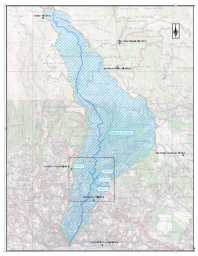
Control of stream erosion processes and debris flow

Project of torrential correction developed in the upper sector of Funchal Santa Luzia basin. 1970s

Austria, Tirol Region

Fluvial erosion control
Debris flow protecion

Slit dam in João Gomes stream, Funchal

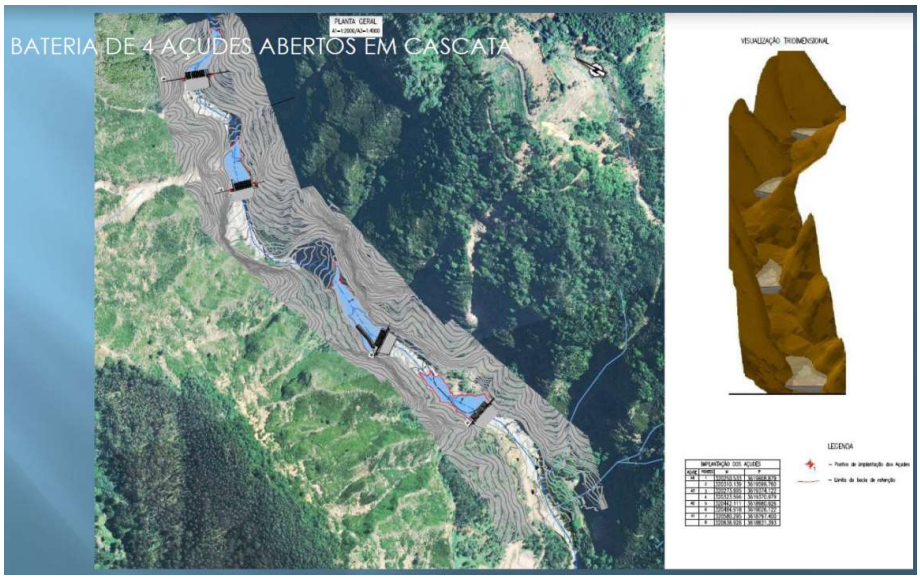


Execution project: Prosistemas - Consultores de Engenharia S.A

Slit dam in São João stream

Execution project: AQUALOGUS - Engenharia e Ambiente, Lda.

Slit dam in Ribeira de Santa Luzia stream



LCW Engineering

Austria

Austria

Austria

Slit barrier with horizontal slits

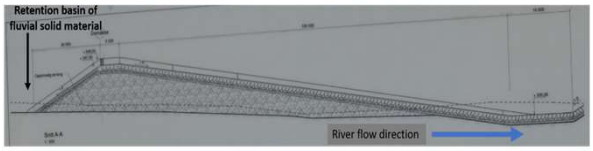
Austria

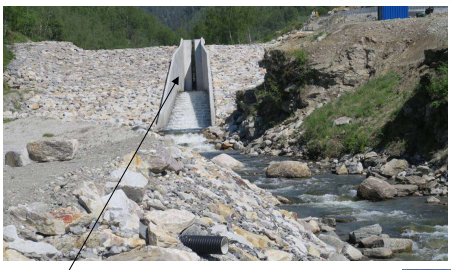
Austria

Madeira Island

Madeira Island

Norway, 2018





Perspective from downstream to upstream. A vertical narrow passage was created in the central part of the barrier for the liquid discharge, with a width of less than 1 meter.

Terminal section of São João stream

Previous situation

significant variations of **channel cross section** with influence in the flow capacity of stream

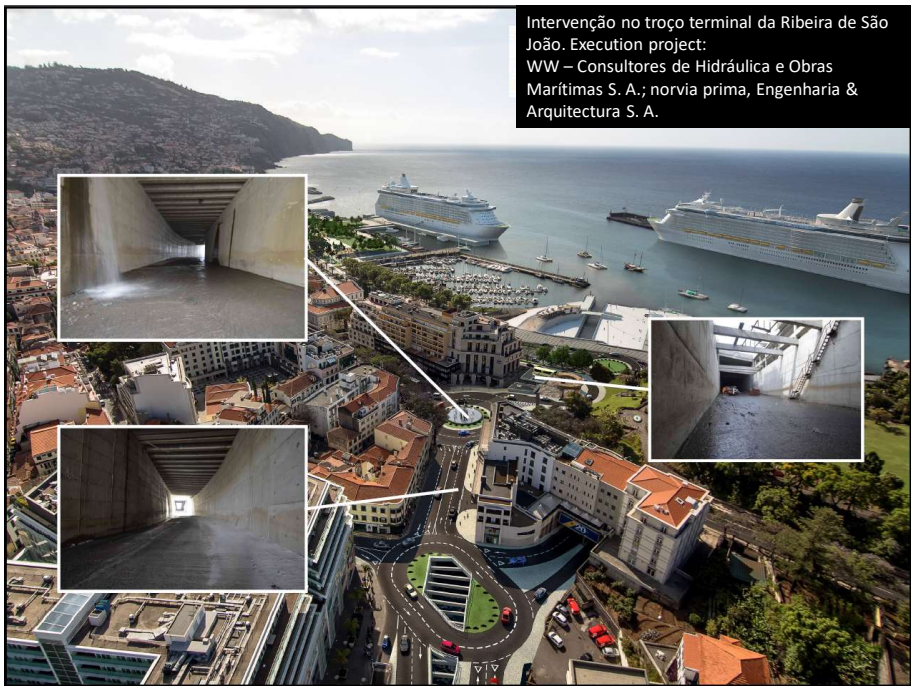
Fotos: António Luís

Terminal section of São João streams

Redirected
Repositioned
New alignment with 90 m of length

Before

After



Regularization and channeling project of the middle sector of Ribeira Brava main stream, after the 2010 flash floods.

Channeling of a tributary of Santa Luzia basin, in Funchal, after the 2010 flash floods.

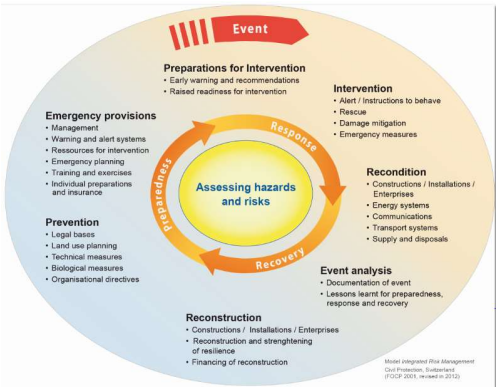
Are we now totally safe from flash floods?

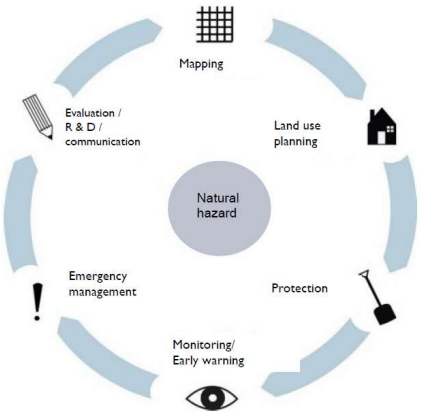
Integrated risk management model

Flood Risk: The Holistic Perspective

"Risk management is about people and processes and not about models and technology."
Trevor Levine

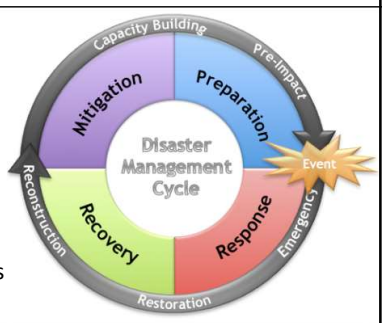
Integral Risk Management Cycle





Tasks of the competent services

Global Risk Management



Where are we?

- Investigate the processes
- Analyse the triggers
- Approximate the consequences
- Options: Response; Recovery; Mitigation; Prepardness

How is it commonly done?

Local solutions (e.g. stabilizations)

Local and Regional Early Warning Systems

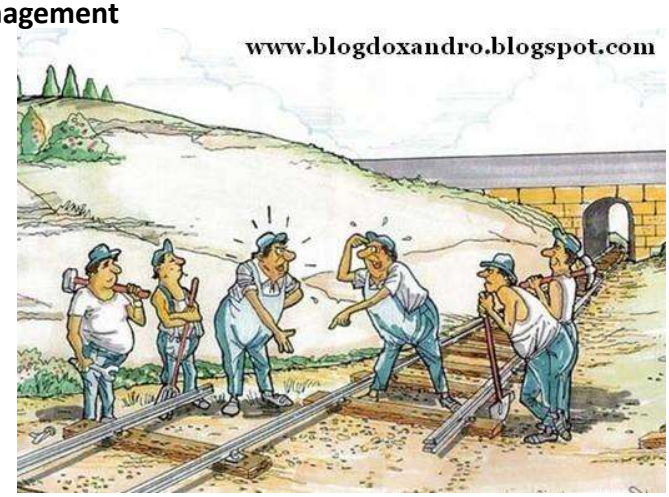
Spatial planning through:

- Inventory maps
- Susceptibility maps
- Hazard maps
- Exposure maps
- Risk maps

Global Risk Management

Importance of multidisciplinary approach in risk management

Global Risk Management

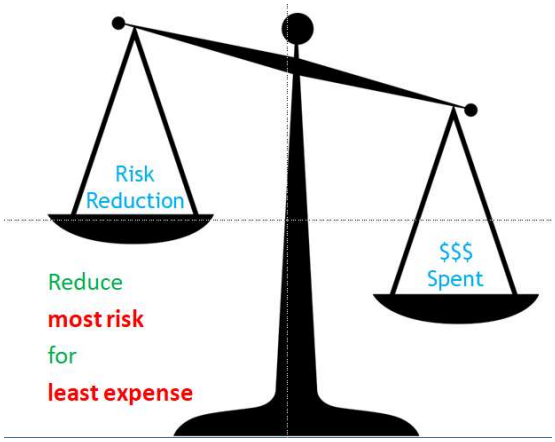


Importance of coordination procedures between all levels of government

Global Risk Management

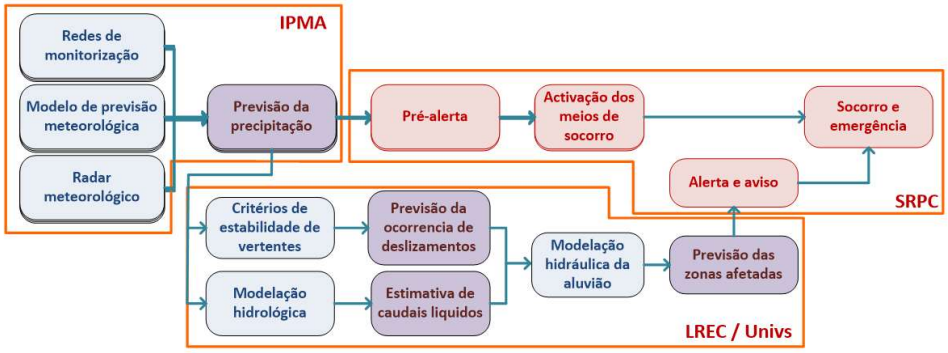
Reconstruction: Considering – the next event WILL occur!!

Global Risk Management: challenges for policy and practice



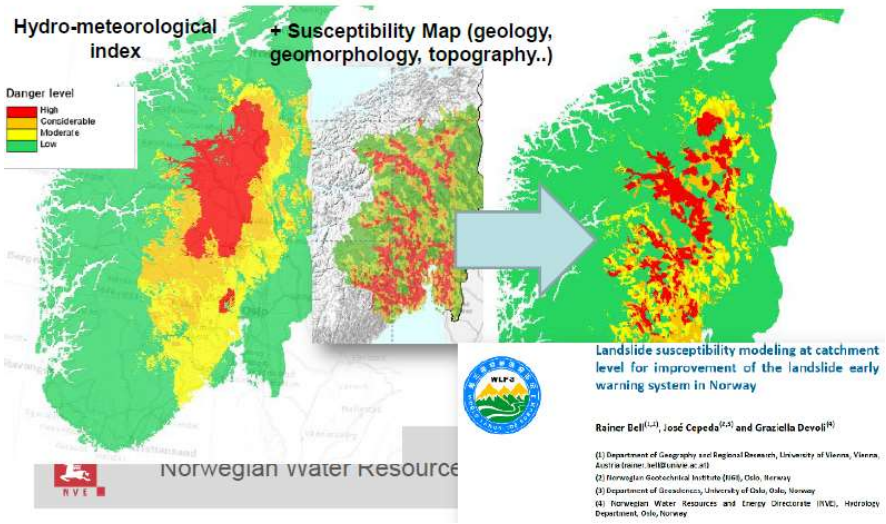
Limited resources (financial, human, structural) – how best to allocate these resources in terms of balancing regional development potentials and disparities, while following the principle: **No protection at all costs?**

Vision of the early warning system



- It is a vision for there is lots of work to do.
- The responsability is distributed among diferent parts
- It can be executed by phases; it is partly done.

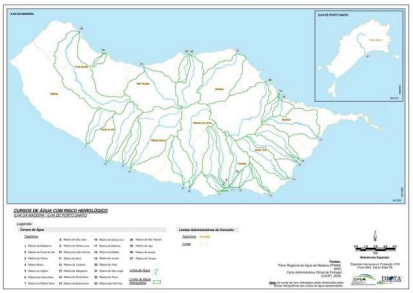
Susceptibility maps, at water basin level, may be combined with hydro meteorological index to more precise forecasts

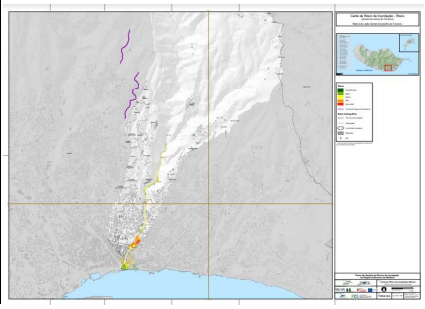


Norwegian Flood and Landslide Hazard Forecasting and Warning Service, 2018.

Mapping

- Susceptibility maps;
- Hazard and risk mapping in areas with high (anticipated) risk;
- Make risk information available through webportals;
- Contribute to the development of mapping methodology;
- Develop guidelines for mapping;
- Expert seminars;



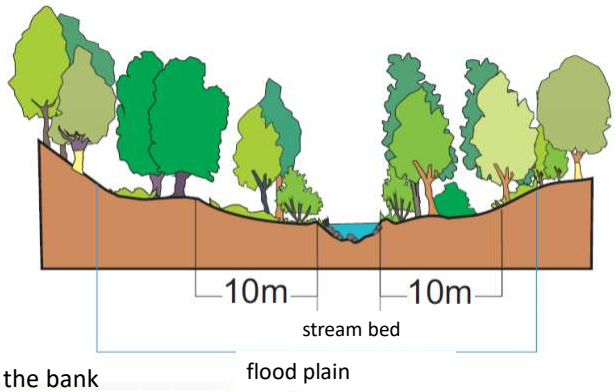


Legal concepts of hydrology in the Portuguese law

Law no. 54/2005 of 15 November

Article 10 – Bed is the land covered by water under conditions of average floods

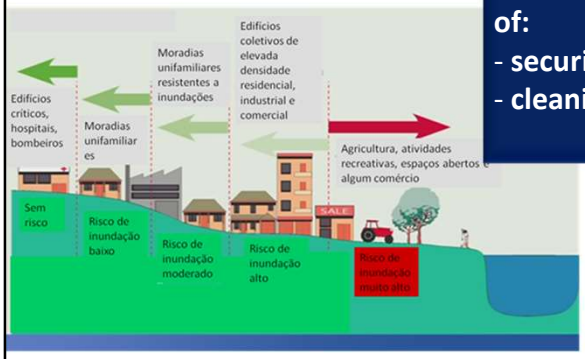
Article 11 – Bank is the portion of land adjacent or above the water line, which limits the bed of waters, with wide legally established



In non-navigable streams, the bank has a width of 10 meters

Avoid new risks

Forbid the construction in the stream bed and banks, for reasons of:
- security of persons and property
- cleaning and maintenance



Definition of correct land use and occupation restrictions that should be applied in the areas affected by floods

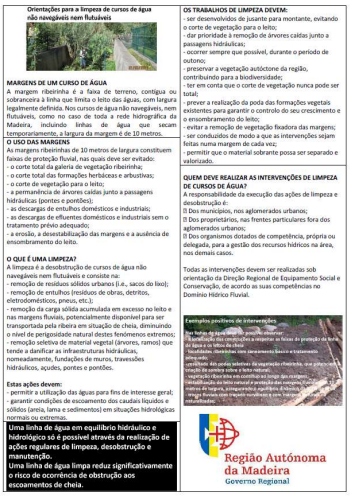
Follow the basic principle "non aedificandi"

Natural Flood Management: clearing and reabilitation of stream lines

Natural flood management handbook

Clearing and reabilitation of stream lines

How to do



Orientações para a limpeza de cursos de água não navegáveis nem flutuáveis

MARGENS DE UM CURSO DE ÁGUA
A margem ribeirinha é a faixa de terreno, contígua ou sobranceira à linha que limita o leito das águas, com largura legalmente definida. Nos cursos de água não navegáveis, nem flutuáveis, como no caso de toda a rede hidrográfica da Madeira, incluindo linhas de água que secam temporariamente, a largura da margem é de 10 metros.

O USO DAS MARGENS
As margens ribeirinhas de 10 metros de largura constituem faixas de proteção fluvial, nas quais deve ser evitado:
- o corte total da galeria de vegetação ribeirinha;
- o corte total das formações herbáceas e arbustivas;
- o corte de vegetação para o leito;
- a permanência de árvores caídas junto a passagens hidráulicas (pontes e pontões);
- as descargas de entulhos domésticos e industriais;
- as descargas de efluentes domésticos e industriais sem o tratamento prévio adequado;
- a erosão, a desestabilização das margens e a ausência de ensombramento do leito.

O QUE É UMA LIMPEZA?
A limpeza é a desobstrução de cursos de água não navegáveis nem flutuáveis e consiste na:
- remoção de resíduos sólidos urbanos (i.e., sacos do lixo);
- remoção de entulhos (resíduos de obras, detritos, eletrodomésticos, pneus, etc.);
- remoção da carga sólida acumulada em excesso no leito e nas margens fluviais, potencialmente disponível para ser transportada pela ribeira em situação de cheia, diminuindo o nível de perigosidade natural destes fenómenos extremos;
- remoção seletiva de material vegetal (árvores, ramos) que tende a danificar as infraestruturas hidráulicas, nomeadamente, fundações de muros, travessões hidráulicos, açudes, pontes e pontões.

Estas ações devem:
- permitir a utilização das águas para fins de interesse geral;
- garantir condições de escoamento dos caudais líquidos e sólidos (areia, lama e sedimentos) em situações hidrológicas normais ou extremas.

Uma linha de água em equilíbrio hidráulico e hidrológico só é possível através da realização de ações regulares de limpeza, desobstrução e manutenção.
Uma linha de água limpa reduz significativamente o risco de ocorrência de obstrução aos escoamentos de cheia.

OS TRABALHOS DE LIMPEZA DEVEM:
- ser desenvolvidos de jusante para montante, evitando o corte de vegetação para o leito;
- dar prioridade à remoção de árvores caídas junto a passagens hidráulicas;
- ocorrer sempre que possível, durante o período de outono;
- preservar a vegetação autóctone da região, contribuindo para a biodiversidade;
- ter em conta que o corte de vegetação nunca pode ser total;
- prever a realização da poda das formações vegetais existentes para garantir o controlo do seu crescimento e o ensombramento do leito;
- evitar a remoção de vegetação fixadora das margens;
- ser conduzidos de modo a que as intervenções sejam feitas numa margem de cada vez;
- permitir que o material sobrante possa ser separado e valorizado.

QUEM DEVE REALIZAR AS INTERVENÇÕES DE LIMPEZA DE CURSOS DE ÁGUA?
A responsabilidade da execução das ações de limpeza e desobstrução é:
☐ Dos municípios, nos aglomerados urbanos;
☐ Dos proprietários, nas frentes particulares fora dos aglomerados urbanos;
☐ Dos organismos dotados de competência, própria ou delegada, para a gestão dos recursos hídricos na área, nos demais casos.

Todas as intervenções devem ser realizadas sob orientação da Direção Regional de Equipamento Social e Conservação, de acordo as suas competências no Domínio Hídrico Fluvial.

Exemplos positivos de intervenções
Boa folhas de água mais próximas possível
- Eliminação das construções a remover as faixas de protecção ao leito de água e ao leito de cheia
- Vantagens, desde logo, no escoamento basico e tratamento silvo-ecol
- Limitação dos cortes seletivos da vegetação ribeirinha, que prejudica a criação de sombra sobre o leito natural
- Limpeza dos leitos e remoção dos entulhos das ribeiras
- Desafogamento das secções de estrangulamento, nomeadamente, cortes de largura, comprimento e profundidade
- Vingar florestas com espécies autóctones com funções ecológicas diversificadas

Região Autónoma da Madeira
Governo Regional

Give priority to the removal of trees that have fallen in the stream bed

Large woody debris tend to cause obstruction to the stream flow, with the consequent formation of critical levels of discharge retention, with catastrophic effects in case of collapse

Give priority to the removal of trees that have fallen in the stream bed

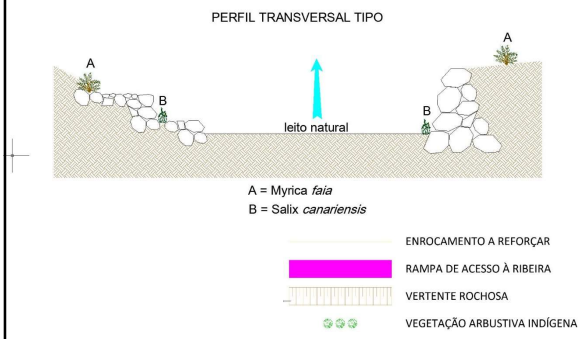
Riparian vegetation has an important influence on bank erodibility and near-bank hydraulic conditions, and is also a source of in-channel large woody debris (LWD)

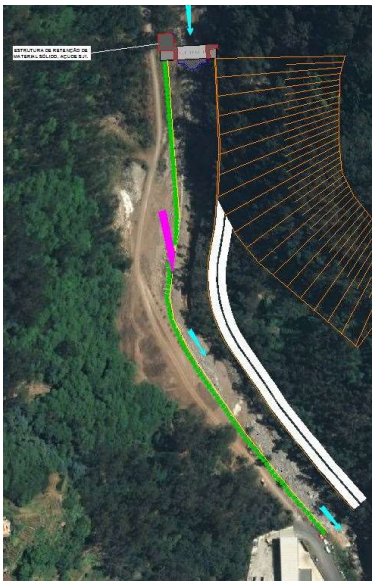
What to keep?

Myrica faya
faia-das-ilhas ou samouco

Salix canariensis
seixeiro, seiceiro ou seixo

Stream flow rehabilitation





Repair and revitalize the degraded fluvial ecosystems: important measure in risk management

Stream flow rehabilitation

The healthier and more resilient an ecosystem is, the less damage it will experience from natural hazards and the easier and faster it will recover from impacts

Rehabilitation of the main watercourse of the Faial basin, in Madeira Island

Natural approach to flood management that repairs and revitalizes our broken ecosystems

Rehabilitation of the main watercourse of the Faial basin

Mountain torrent stream in Seixal, at the north side of Madeira island, after the 2012 flash flood

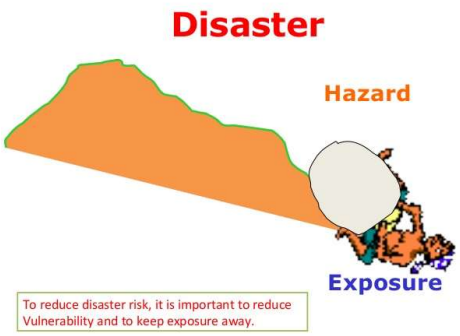
Aspect of the fluvial channel after the intervention of natural regularization in 2016, using the technique of riprap, to protect the stream banks and consolidate the bottom of the channel

Increasing demand for the maintenance and reconstruction of protective structures in use, because of ageing and loosing functionality.

Communication of risk

- Education of the society
- Utilizing the new social media for communication

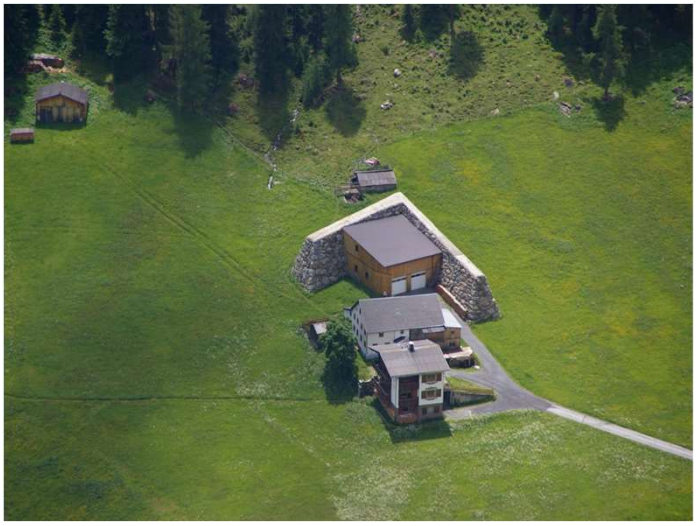
Public Awareness and Education for Disaster Risk Reduction



Raising awareness of owners of land bordering water lines, about their particular situation of exposure to natural hazards

Public Awareness and Education for Disaster Risk Reduction

Let know available solutions to improve resilience against potential disasters



Public Awareness and Education for Disaster Risk Reduction

A clean stream is a safely stream.

The cleaning of streams is a responsibility of all citizens

Information prevention measures must be communicated to the population

Sendai Framework for Disaster Risk Reduction

Definition of warnings

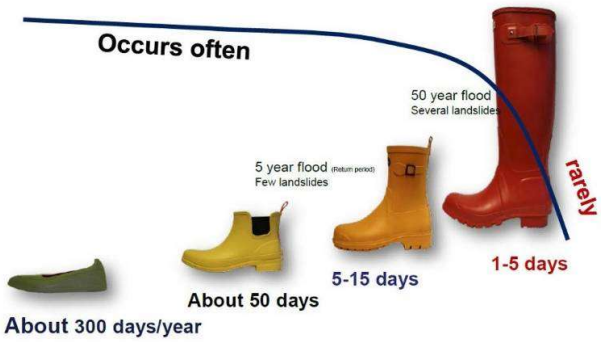
What is a warning?

Tangible and understandable description of an expected damage scenario

&

a clear advice what to do

In order to decode the message – to make it accessible to the population, NVE adopted a simple and visual communication strategy, matching the severity and magnitude of the event with the type of footwear.



Norway early warning system symbology

…the phenomena associated with torrential floods is complex and cannot be fully controlled, only mitigated. 100% safety against natural hazards is not an achievable goal.

Memorial created as a reminder of the terrible events of 1905 and 1936 in Norway.

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