Royal HaskoningDHV
Enhancing Society Together

Ensuring business resilience with the Global Flood Risk Tool

Comprehensive flood risk analysis at your fingertip through cloud-computing

INTRODUCTION

In the past 35 years, 86 per cent of the total economic damage of natural disasters has been caused by storms and floods. The economic damage of floods has grown exponentially in the past decades. The effects of climate change will increase the damages during the following decades too. Therefore, the industry acknowledges the need for better insight in the present flood risks worldwide.

Changing mind-set is essential

Preventive measures, such as a dyke around a site, a drainage system, flood protection plans and flood insurance for individual sites are the traditional ingredients to increase flood resilience. However, Royal HaskoningDHV's experience of recent global assessments for multinationals shows that this approach is not comprehensive enough.

A change in mind-set is essential. Not just looking at individual sites, but looking at all their assets and locations within the global production chain (raw materials, people, and products). Thus, business continuity can be safeguarded and the impact on the business is minimised.

Thorough analysis of flood risks

Nowadays, several industries choose a proactive approach to make their operations more resilient regarding floods. These companies want a thorough analysis of the risks of floods for their assets worldwide. The results of these studies are at the base of smart, effective investments in awareness for protection and emergency planning during floods.

We help governments, industries, critical infrastructure owners, and the financial sector to reduce the impact of extreme weather, natural disasters and climate change before events occur in order to:

- *secure reliability and predictability of delivery and operations,*
- *ensure the efficient and uninterrupted operations of assets,*
- *potentially reduce the costs of insurance and loans,*
- *and enable informed investment decision making.*

In this whitepaper we'll discuss increasing the resilience of your business with regards to floods:

- our perspective on forming a flood resilient strategy
- how our Global Flood Risk Tool will help you form a resiliency strategy
- the case study of the Port of Rotterdam using our Global Flood Risk Tool

Key principles to become flood resilient

At Royal HaskoningDHV six key principles form the basis to come to a flood resilient strategy:

- transparent governance with strong policies regulations and institution to maintain the resiliency status that is achieved
- social inclusiveness through stakeholder consultation
- integrated system approach, looking at coastal, pluvial and fluvial flooding at once
- design for projected future events including climate change scenarios
- mix science based measures with local needs that are under planning
- combine efforts of private sector and government initiatives

Flood resilience strategies should be well-planned and include a balanced approach for the longer, strategic perspective with a focus on low-regret measures as well as short term measures that need to be taken to protect the people and assets in the high-risk areas.

Industries and communities are struggling to understand complicated flood risk analysis. This keeps them from obtaining a complete and comprehensive picture of the risk of flooding they are facing and prevents them from forming solid flood resilience strategies. Because of this, taking action and preventive measures to reduce economic damages to assets, infrastructure, business processes and reduce the loss of lives, is extremely challenging for these stakeholders.

Accurate and comprehensible information with the Global Flood Risk Tool

To help industries and communities, Royal HaskoningDHV has developed the Global Flood Risk Tool (GFRT). The GFRT is a cloud-based platform that delivers accurate and comprehensible flood risk analysis and recommends investment proposals to reduce risk on losing lives and economic damages.

The GFRT has been thoroughly tested and successfully applied in many international projects. These projects are at regional, district or community scale for local governments, at port scale for port authorities or for individual industrial sites for private clients.

With GFRT a thorough flood risk analysis can be conducted through a 5-steps approach providing a set of customized flood risk reduction strategies formulated in close contact with the stakeholders.

Flood risk assessment in 5 steps

Global Flood Risk Tool conducts a thorough flood risk assessment through a 5-steps approach and delivers a set of customized flood risk reduction strategies for your community, (air)port or industrial site. All steps are interlinked which means that when any parameter is changed the whole assessment is updated.

These five steps operate independently from each other, making the tool applicable for a wider audience and facilitating the use of external data such as:

- detailed hydraulic models results
- costs data bases
- various scenarios for development and measures

GLOBAL FLOOD RISK TOOL:

- **Fast calculations:** inundation and damage calculations within a minute instead of hours.
- **Online service:** Flood Risk calculations through cloud-based computing platform based on 5-steps approach.
- **Visually attractive:** User interface is interactive, visually attractive and understandable for non-experts to stimulate stakeholder dialogue.
- **Enables decision-making:** GFRT to be used for scenario modelling to support decision-making on business cases.

FLOOD HAZARD | FLOOD DAMAGE | FLOOD RISK | FLOOD MEASURES | BUSINESS CASE

Step 1: Flood Hazard

The GFRT will calculate and visualise the flood hazard, providing flood maps for multiple return periods and scenarios based on existing hydraulic models, or series of water levels. Scenarios can be either related to climate change (with or without sea level rise), structural implementations (dikes vs no dikes, dike breaching vs no dike breaching) or economic development (with land use or without future land use development).

Step 2: Flood Damage

Next, the geospatial distributed economic damage is calculated and visualised, providing economic damage maps per return period and damage graphs based on land uses in a given area for each scenario specified in the first step.

Step 3: Flood Risk

Through risk maps and risk graphs we'll calculate and visualise your flood risk, including calculated damage and annual expected and avoided damage for the different scenarios.

Step 4: Flood Measures

To help you transform the information gained in steps 1, 2 and 3 into next steps we'll draw conceptual flood measures based on a multi-level safety approach and include information on investment costs for the various protection levels.

Step 5: Business Case

You will be provided with a presentation of your business case, including an overview of the optimum investment level with subsequent protection levels for the specified scenarios. This will equip you as an industry (air)port or community to draw up a flood resilient strategy.

CASE STUDY

How Flood Resilience Strategy strengthens Rotterdam's position as Water City of the Future

The Port of Rotterdam is one of the safest large ports in the world in terms of flood safety. However, due to climate change induced sea level rise, the probability of flooding is increasing. The type of industry, vulnerable infrastructure and economic value of this port area are important factors, and the economic damage due to flooding would be substantial. The safety of citizens and companies is also a vital consideration, as it is crucial for investors to perceive the city and port of Rotterdam as permanently safe, accessible and attractive.

The Port of Rotterdam and the City of Rotterdam, together with key stakeholders, have therefore taken the initiative to analyse flood risks and form an adaptation strategy to reduce these risks in this area. The port area is largely located outside the Flood Defence System but, due to its elevation, the risk of flooding is small. However, as a result of climate change and rising sea levels, some places will be at greater risk of flooding in the future.

It is therefore important that the Port of Rotterdam joined forces with industry and government to explore how they could optimally protect the whole port area in the coming years. Businesses in the port area are now also much more aware of the possible risks and are brainstorming with the Port Authority about possible measures they can take themselves.

"Our aim is to create a safe port, now and in the future."

An adaptive, collaborative strategy

Royal HaskoningDHV conducted an assessment for the current situation in the Port of Rotterdam, the situation in 2050 and 2100; and delivered climate adaptation strategies for 100% of the port using GFRT. Detailed flood modelling was undertaken to assess the flood risk in terms of the probability of loss of life, economic damages and environmental impact; and an efficient, multi-level safety approach was designed comprising Prevention, Adaptation, Emergency response and Resilience measures.

Interested parties, port tenants, utility companies, government agencies and knowledge institutes were involved in this entire process; and participatory mapping was done to verify the results of the study. In this way, we managed to establish broad support from our stakeholders, a prerequisite for success.

In addition, the Joint Fact-Finding process has made all stakeholders in the area aware of the present and future flood risks; and the dialogues have created support for the adaptation strategy among all stakeholders who would like to sustain the new momentum, network, partnership and knowledge by continuing work on the pilot projects.

The 5 steps for the Port of Rotterdam

The Port of Rotterdam specified for how many return periods and scenarios this hazard assessment was required. Only all areas which are lower than the sea water level and have a connection to the original water body will flood. If there was no connection, the area wasn't taken into account in the GFRT.

A choice can be made between a model upload of an existing map (inundation grid) and calculation of a grid with the Flat or River method.

Figure 1 – *Flood map climate scenario 2050 (+35cm SLR) for 1,000 years (left) and for 10,000 years (right) return period*

Direct Damages

For the Port of Rotterdam, the damage curves and economic land use values have been made project specific together with the industries in the port. The results of the damage calculation needed to be calibrated against actual historic event from which damages are known.

Damage curves express the basic relation between occurring hazards by means of water depth at an asset and damage sustained as a fraction of the economic value of that asset.
The assets within an area are covered by land use maps.

Damage curves are generally location specific and include characteristics and vulnerabilities of the project area. Damage curves from literature can be used as a starting point and can be tailormade together with stakeholder and local available data.

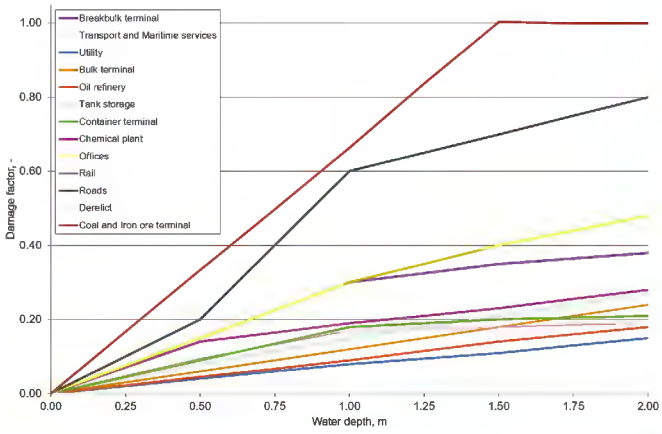


Figure 2 – *Damage curve for land use categories*

Figure 3 – *Land use map for port area*

The data required for the Land use maps in many occasions comes from the client or local stakeholders. If that is not available, it can be modelled for satellite imagery in combination with for instance Open Street Map and Google maps.

The direct damage output is generated instantly on geospatial rasters. This gives the advantage that damages can be interpreted at local scale. It is immediately clear for you as a stakeholder which areas are most vulnerable to flooding and would most heavily be impacted in case of a severe event. The figure below shows the output of the direct damage calculation for the 1,000 and 10,000 return period for the 2050 climate scenario.

Figure 4 – *Damage maps climate scenario 2050 (+35cm SLR) for 1,000 years (left) and 10,000 years (right) return period*

Indirect Damages

Next to direct damages, indirect damages are an important part of flood damage. Indirect damage due to flooding consisting of disruption to productive activities, employment, travel and additional costs associated with flood management and flood proofing the private sector.

In this case the indirect damages is calculated with an input-output (ARIO) model. When no model is available a multiplication factor is applied.

Risk & Vulnerabilities

Risk is defined as Probability x Consequence. The Probability for the Port of Rotterdam is the probability associated with the occurrence of the hazard of flooding. The Consequence is the damage to assets and land.

Indicators relevant to the risk calculation and vulnerability assessment are:

1. Flood direct damage modelled return periods for different scenario's
2. Indirect damage based on modelled direct damage or on multiplier
3. Annual Expected Damage (AED)
4. Annual Avoided Damage (AAD)
5. Vulnerability assessment of sectors at risk
6. Number of Affected people per year
7. Risk on losing lives due to flood

In figure 5 the damage and risk outcome for the Port of Rotterdam are shown. The direct and indirect damage results are aggregated in the red line for the different return periods for the 2050 scenario. The risk for these periods is shown by the bars.

Figure 5 – Damage & risk chart

There can be multiple reasons that determine when, how and how much can be invested. Our Global Flood Risk Tool can consider the following for you:

- Timing of measure when threshold for residual risk is reached
- Risk matrix with identified scenario's, according to corporate risk procedures investment could be triggered
- Percentage of AED that is required to be protected;
- Threshold of total economic damage that needs to be protected
- Protection level enforced by law
- Timing of measures to have synergy with planned investments
- Available budget to limit risk to maximum protection level

Drafting multi-level safety measures

Based on the hazard, damage and risk & vulnerability assessment we will provide you with appropriate measures based on the multi-level safety approach to reduce the impact of hazards and to reduce the risks.

- **Level 1:** preventive structural measures dikes, spillways, culvert, sluices (grey) mangroves, wetlands, foreshores, nourishments, increasing conveyance by dredging and river widening (green) and storage areas, side channels and dike in dune system (hybrid).
- **Level 2:** adaptive and non-structural measures raising terrains or floors, dry/wet proofing (adaptive), land use planning, relocation/ managed retreat, operation and maintenance protocols, monitoring, building codes and laws and regulations (non-structural).
- **Level 3:** emergency response measures early warning response systems, emergency response and crisis management plans (controlled shutdown, stock removal), evacuation routes and storm shelters and temporary dikes.

There are different types of measures and interventions in our portfolio which can either reduce the risk by lowering the probability of a flood by increasing the protection level, or by reducing the consequences (impact) by emergency response and crisis management.

Hard Infrastructure

Green Infrastructure
Building with Nature

Master Planning

Strategies & Policies

Emergency Response
& Disaster Management

Forecasting, Early warning
& Alerting

Monitoring
& Real-time control

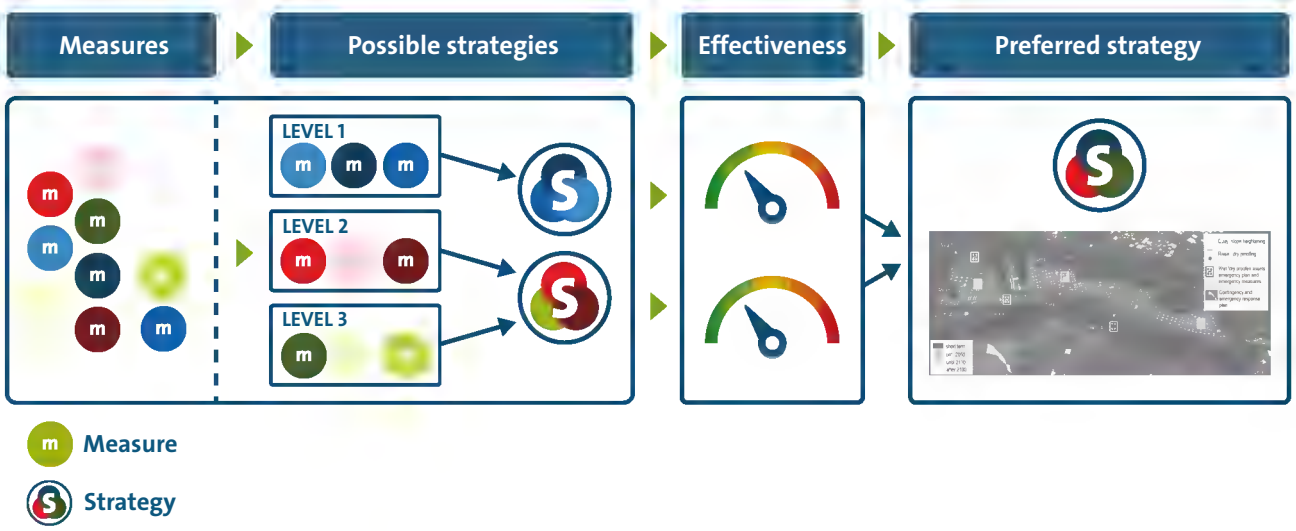
Adaptive Building

Water Management
Store - Delay - Discharge

Compare strategies to come to preferred strategy

Our Global Flood Risk Tool is designed in such a way that scenarios and strategic options can be easily compared to each other. All scenarios and strategic options are modelled in a single project environment in order to find the preferred strategy for you.

The effectiveness of the possible strategies will be modelled through an economic assessment that includes a financial cost-benefit analysis and multi-criteria analysis to include for non-tangible environmental, technical and social-economic benefits.



The financial assessment progresses on the economic optimization assessment and emergency response measures are proposed additionally to the protective and adaptive measures.

The GFRT analyses can be customized for specific projects. This way the strategies can be compared based on the non-tangible benefits related to:

- **Technical aspects**
  e.g. adaptive to climate change, effectiveness, does it require relocation, does it have stakeholder support, replicable and scalable
- **Economic/planning aspects**
  e.g. urgency, consistent with policy and plans, does it stimulate the economy
- **Socio-economic aspects**
  e.g. protect people affected, reduce risk on losing lives, benefiting women or minority or vulnerable groups
- **Environmental impacts**
  e.g. disturbance or destroys habitats

Conclusion

With our Global Flood Risk Tool you will be able to get a preferred flood resilience strategy for your community, port, airport or industry. It will be clear where and what you should focus on first, what measures should be implemented as soon as possible and what areas of your location need attention, based on multiple scenarios and timeframes. Next to the flood resiliency strategy you will be able to draw up an emergency response plan for the project area.

Even though the Global Flood Risk Tool can and will provide you with detailed input for your strategy and emergency plan, it is important to be aware of the fact that climate change scenarios have to be closely monitored. In case of a large deviation compared to the applied scenarios in the GFRT it is recommended to perform an update on the advised and preferred strategy.

Want to explore what the Global Flood Risk Tool can do for you?

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