



A CASE STUDY

# The combined management of floods & droughts in the Netherlands

An EPIC Response application



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### About Deltares

Deltares is an international research institute focused on climate-resilient water resources management. Throughout the world, Deltares works on smart solutions, innovations, and applications for society and the environment in deltas, coastal regions, and river basins. Deltares works closely with governments, the private sector, research institutes, and civil society organizations. Our mission is to Enable Delta Life. Please visit us at <https://www.linkedin.com/company/deltares>.

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## Foreword

Floods and droughts continue to be one of the most tangible and devastating consequences of the climate crisis. Over the last decade, these natural disasters have killed tens of thousands of people around the world, affected the lives of billions and caused damages of more than a trillion dollars. The threats from floods and drought are increasing because of climate change. The World Economic Forum states that extreme weather events and natural disasters are two of the likeliest global risks with the largest impact.

Faced with these growing challenges, governments around the world are grappling with the responsibility of better understanding flood and drought risks and manage their impacts in an equitable manner – as poor and vulnerable communities are often the hardest hit and the slowest to recover. As the severity and frequency of floods and drought intensify, countries must strengthen their management systems to respond to a heightened climate, one that often fluctuates between floods and droughts and presents unprecedented risks.

In the Netherlands, we know this well. A country known for our centuries-old experience managing floods, we are nowadays increasingly challenged by drought. This unprecedented situation forces us to advance in the combined management of hydro-climatic risks. We hope that this case study helps illustrate the point that no country in the world, developing or developed, is free of this task. Any country can benefit from systematically looking and strengthening at their flood and drought risk management systems.

We are proud to continue our partnership with the World Bank on the EPIC Response Program. The EPIC Response Program is at the forefront of the generation of innovative governance approaches to manage both floods and droughts. After the publication of the EPIC Response: Innovative Governance for Flood and Drought Risk Management on 2021, Deltares and the World Bank are now developing an EPIC Response Assessment Methodology aimed at helping countries to systematically assess their flood and drought risk management systems and identify areas where flood and drought risks management programs and their collaboration can be strengthened. This case study is another product of this fruitful partnership.

As we continue to put these concepts into practice, we hope that the EPIC Response products will help countries to deliver better resilience services to communities and not only reduce the toll of flood and drought risks but to create a more resilient and prosperous planet.

Let's get to work!



Toon Segeren  
Director of Deltares International

# 1 Introduction

## 1.1 Background

The World Bank and Deltares have partnered in the development of the global flagship report ‘An EPIC Response: Innovative Governance for Flood and Drought Risk Management.’ The report, launched in June 2021, provides a new perspective on hydro-climatic risks by looking at the combined management of floods and droughts. It identifies the roles of different government agencies in managing these risks and highlights where and how these agencies need to collaborate. It represents the most extensive compendium of flood and drought policies and programs that currently exists in the literature. The EPIC Response Framework consists of eleven different program areas in five clusters as illustrated in Figure 1. The report defines a program as a continuous set of activities undertaken by a national agency with well-defined objectives, authorized through national legislation and funded by the national government. The programs in the EPIC Response Framework interact synergistically and in complex ways, but generally in a downward cascading manner to ultimately influence the final economic, social, and environmental impacts of hydro-climatic events.

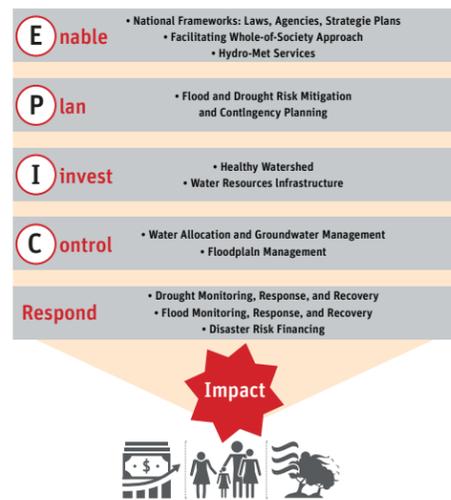


Figure 1. EPIC Response Framework

The EPIC Response Framework was developed based on a wide literature review and the combined experience of the World Bank and Deltares in carrying out flood and drought projects around the world. The EPIC Response Framework is also based on four case studies: the Netherlands, California (USA), the Philippines, and Tanzania. This document presents the findings of the Netherlands Case Study. It illustrates how the Framework can be used in evaluating the evolution of the Flood and Drought management system in the Netherlands – a country known worldwide for its effective water management systems.

## 1.2 Economic and Political Context of the Netherlands

The Netherlands has a population of 17.4 million and has the fifth-largest economy in the European Union. That economy is dominated by the agriculture, industrial, and services sectors, which all depend on some form of water management. The Netherlands is the world’s second largest agricultural exporter (after the United States), with a highly mechanized agricultural sector that employs just 2 percent of the labor force but that provides large surpluses that feed into a robust food processing industry.<sup>1</sup> The main products exported are dairy and horticultural products, cereals, and potatoes. The Netherlands is also the largest flower exporter in the world. In 2020, agriculture contributed around 1.58 percent to the GDP of the Netherlands.

Industrial activity generates around 17.8 percent of the Dutch GDP, mainly through food processing, the petrochemical industry, and the transport equipment industry. The services sector is focused mainly on transportation, distribution, logistics, banking and insurance, water engineering, and new technologies. Services account for more than 69.8 percent of national revenue and employ 82.2 percent of the workforce.<sup>2</sup> Total Dutch GDP was US\$912 billion in 2020, the 17th largest in the world and 11th in terms of GDP per capita.<sup>3</sup> Before the COVID-19 pandemic, the unemployment rate was relatively low, at 4.09 percent in 2020 (up from 3.3 percent the year before).

The Netherlands is a constitutional monarchy based on parliamentary democracy. The Chief of State is the King or the Queen, whose role is ceremonial. Following parliamentary elections, the leader of the majority party or leader of a coalition is appointed Prime Minister (head of the Government) to serve a four-year term. The Legislature is bicameral, and legislators also serve four-year terms. The Netherlands’ administrative structure consists of a national government, 12 provincial governments, and 355 municipal governments. Administrative arrangements are consensus oriented and are based on a planning culture, emerging from centuries-old water management practices and known as the polder model.



Figure 2. The Netherlands water system



## 1.3 Water Management System in the Netherlands

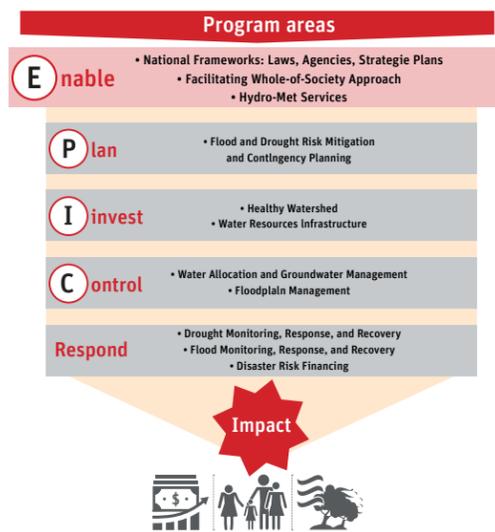
The Netherlands is located in the delta formed by the Rhine and Meuse rivers as they flow to the North Sea. The Ems and the Scheldt rivers also are part of the Netherlands water system. Lake IJssel at the center of the country acts as the largest reservoir and is an important asset in the management of floods and droughts. The Netherlands is a low-lying country, and 55 percent of its territory is considered flood prone (dark blue in Figure 2). An extensive system of flood defenses, locks, sluices, and pumping stations protects against flooding and supplies water when and where needed in times of drought. (For a detailed description of the water management system in the Netherlands, see the Rijkswaterstaat website).<sup>4</sup>

1. <https://www.cia.gov/library/publications/the-world-factbook/geos/nl.html>  
 2. Santander Netherlands: Economic and Political Outline <https://santandertrade.com/en/portal/analyse-markets/netherlands/economic-political-outline>  
 3. <https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=NL>

4. [https://www.helpdeskwater.nl/publish/pages/165190/rij\\_8475\\_watermanagement\\_en\\_dv\\_1.pdf](https://www.helpdeskwater.nl/publish/pages/165190/rij_8475_watermanagement_en_dv_1.pdf)

## 2. **E** - Enabling Environment

The enabling environment consists of laws, agencies, strategic plans, participation, and information. Its three program areas are: (i) the national frameworks, with laws, agencies, and strategic planning systems; (ii) the involvement of all stakeholders in a ‘whole-of-society’ effort for flood and drought management; and (iii) the provision of hydrological and meteorological (hydro-met) services that provide fundamental information to all the programs in the EPIC Response Framework.



### 2.1 National Frameworks

One of the key tenets of the EPIC Response Framework is that a joined-up government effort – one that breaks across sectoral silos and enables the government to work as a unit – is fundamental for effectively managing hydro-climatic risks. The Netherlands is advanced in creating interlocking national sectoral frameworks; one example is the recent transition from the 2009 Water Act<sup>5</sup> to the 2022 Environment and Planning Act, which mainstreams water, environment, disaster management, and agricultural elements under a unified land management process.

At a deeper level, the Netherlands’ joined-up government approach is rooted in a culture of governance that fosters collaboration. It also builds upon agreements that date

back to the polder model created in the Middle Ages, which uses consensus-based water management. Now, floods and drought are managed in a collaborative manner under the Delta Program, which enables both horizontal and vertical collaborations among different government agencies under a single program. The Delta Program is well financed with the robust Delta Fund.

Flood and drought management in the Netherlands is influenced by the fact that all Dutch water systems are part of transboundary basins. The European Union regulates key aspects of flood and drought management that the Government of the Netherlands then incorporates into the National Framework.

### General Water Resources Management Framework & Laws, Agencies, and Strategic Plans

#### General Description

Many of the programs identified in the upper part of the EPIC Response Framework fall under the general, but not necessarily exclusive, domain of the General Water Resources Management (WRM) Framework. An effective national framework for hydro-climatic risk management generally requires a functional national WRM system with important programs such as river basin planning, water resources infrastructure, and adaptable water allocation.

#### Legal Framework

The Netherlands has a long tradition of water management institutions, with Water Boards that date to the 13<sup>th</sup> Century and that represent one of the oldest forms of local government. The Water Management Framework in the Netherlands has evolved significantly over time. A notable development was the 2009 Water Act, which compiled previous key Acts such as the Water Management Act, the Flood Defences Act, and the Water Boards Act into a unified legal framework that also creates a structured linkage with the Spatial Planning Act. The 2009 Water Act is expected to be incorporated, along with other fifteen acts, into a new Environment Planning Act. The Environment Planning Act will mainstream water, environment, disaster management, and agricultural elements under a unified land management process. The Environment Planning Act is presently being approved by



Kinderdijk Mills

5. <https://www.government.nl/binaries/government/documents/leaflets/2009/12/31/water-act/water-act.pdf>

both Chambers of Parliament and is expected to take effect in 2023. The main provisions of the Water Act are expected to remain intact in the new Environment Planning Act.

### Institutional Framework

The main responsibilities for water management in the Netherlands are with the Ministry of Infrastructure and Water Management (MIWM) at the central government level and with the Water Boards at the regional level. Rijkswaterstaat (RWS), the national water authority<sup>6</sup> under MIWM, is responsible for the implementation of flood and drought risk management of the main water system as well as for navigation and coastal zone management. The Directorate General Water and Spatial Planning (DGWB) under MIWM, is responsible for the development of national policy including flood and drought risk management.

The 21 regional Water Boards are based on hydrological units which do not always coincide with the areas of the provinces and municipalities. The Water Boards are public agencies with an elected ‘water parliament’ and their own tax system. They are responsible for flood, drought, and water quality management in their areas, including the development and maintenance of local water infrastructure. They also manage wastewater treatment, which represents approximately 80 percent of their budgets. The municipalities also have roles in sanitation, urban drainage, and stormwater collection.

### National Strategic WRM Plan

The Water Act mandates the Cabinet to pass a National Water Plan (NWP) every 5-6 years.<sup>7</sup> The NWP aims to enable ‘effective protection against floods [...] and drought, and at achieving good water quality and a healthy ecosystem as the basis for welfare and prosperity.’ The Water Act establishes the main elements of the NWP including: (i) the proposed development, operation, and protection of the water systems, and the corresponding timetable; (ii) a description of the measures and provisions needed to realize such development, operation, and protection; and (iii) an indication of the financial and economic consequences of the proposed policy.

The NWP also includes the river basin management plans and the flood management plans for the Rhine, Meuse, Scheldt, and Ems river sub-basins within Dutch territory. The NWP also includes a North Sea policy and coastal

management efforts, mostly around sand nourishments.

The NWP provides the national-level framework under which the national and provincial water plans, as well as the Water Board plans, are developed. Rijkswaterstaat (RWS) develops a Management Plan for the National Waters that further operationalizes the NWP. With each iteration of the NWP, the Cabinet requires that provinces develop Provincial Water Plans describing how the main elements of the NWP are executed at the provincial level and how the NWP affects provincial spatial policy, especially around floodplain management. The Provincial Executive develops rules at the provincial level on the preparation, structure, and organization of regional Water Board plans. The rules specifically mandate that the preparation of the Water Board Plans should be carried out in consultation with Rijkswaterstaat, the municipal councils, and the Water Boards responsible for the relevant water systems in the province.

Following the direction of the NWP and the provincial water plans, the Water Boards prepare Water Board Plans specific to their management areas. These are operational plans for the water system under the Water Board management. All plans are subject to revision every six years. Interim revisions of plans are carried out on an as needed basis.

The overall planning system is illustrated in Figure 3. Although not being part of the regular planning structure, the Delta Program is included in this figure as it coordinates the activities on content between the levels and on timing of the implementation of the plans. The Delta Program also coordinates and partly finances the investment agendas related to the plans.

### The National Disaster Risk Management Framework

Floods and droughts are invariably included among the types of natural hazards that are subject to a disaster risk management (DRM) framework, along with storms, earthquakes, and disease outbreaks. Man-made disasters, such as industrial accidents or terrorist attacks, are also included in the framework. An effective national framework for hydro-climatic risk management includes the need for an effective, functional, and comprehensive national DRM Framework. In the Netherlands, floods and droughts are included in the DRM National Framework, a sign of the level of national concern about these hazards.

### Legal and Institutional Framework

The legal basis for DRM in the Netherlands is provided by the 2010 Safety Regions Act. The Safety Regions Act covers a variety of disasters such as fires, terrorism, and pandemics, as well as floods and droughts. The Safety Regions Act lays the foundations for organizing crisis and disaster risk management:

- It organizes emergency services and public health authorities into 25 Safety Regions, each with its own Safety Committee.
- The Safety Committees are supra-local entities that are headed by the mayors of major municipalities in the region, who are also Corps Managers of the Regional Boards of Police. The Safety Committees coordinate the responses of fire departments, medical services, and emergency management and crisis control.
- The Act describes the distribution of information and the official lines of communication during disasters and crisis control.

The Safety Regions Act requires the mayor of each municipality to prepare a Disaster Response Plan every four years. It also requires every Safety Region to prepare a Regional Control Plan that is activated as soon as an emergency affects more than one municipality.

In 2016, the Ministry of Security and Justice prepared a National Guideline on Crisis Decision-Making that presented the main points of the central government’s crisis management policy and the national system in place to respond to crises (Figure 4). The Guideline outlines the powers, responsibilities, and core tasks of the main players in the national crisis structure. In general, the Guideline establishes two types of response chains. The general chain deals with general population care (in particular, maintaining public order and security) and general disaster response. The partners in this chain include the police, the security regions, and the municipalities. The functional chain deals with specific issues, such as power, transport,

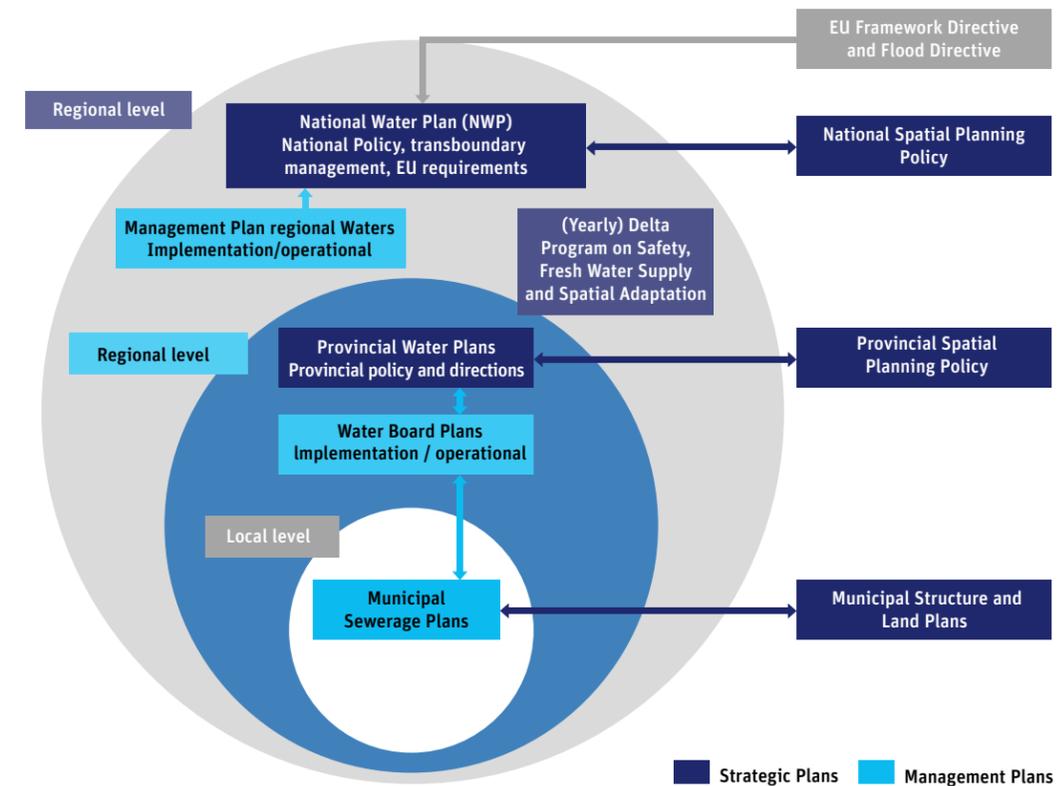


Figure 3. Strategic and Management Planning framework in the Netherlands

6. Rijkswaterstaat is the National Water Authority. Rijkswaterstaat was founded in 1798 to cope with repetitive and devastating fluvial flooding. Rijkswaterstaat is responsible for the North Sea, the large lakes, estuaries, the major rivers, and navigation channels.  
 7. <https://www.government.nl/binaries/government/documents/policy-notes/2015/12/14/national-water-plan-2016-2021/national-water-plan-2016-2021.pdf>

shipping, food, and the environment. Partners in this chain include the Ministry of Defence, the Water Boards, and private sector businesses, which are of vital importance. Government intervention in the functional chain is generally conducted centrally by ministers, while intervention in the general chain is conducted at the local level by mayors.

The Guideline applies to all inter-sectoral crisis situations or imminent crisis situations that require a coordinated, inter-ministerial response from the central government. The National crisis management structure consists of three inter-ministerial bodies: (i) the Advisory Team (AT); (ii) the Interdepartmental Crisis Management Committee (ICCb); and (iii) the Ministerial Crisis Management Committee (MCCb).

In addition to the inter-ministerial response at the national level, the National Crisis Centre (NCC), under the Ministry of Justice and Security, provides administrative advice and coordinates the government response during a crisis. If appropriate, the NCC distributes information concerning disasters with foreign partners. For example, the Minister could ask for assistance through the NCC from the European Commission to deal with a particular crisis, when considered desirable or necessary.

The National Operational Coordination Center (LOCC), also under the Ministry of Security and Justice, provides strategic operational advice during a crisis and manages response units on the operational level. The LOCC also coordinates responses from fire departments, police, ambulance services, military police, and the Municipality. In principle, the LOCC operates only upon request, but it has the capacity to initiate operations as well. The LOCC functions in the preparation as well as in the response phase. The LOCC is chaired by the Minister, unless the Prime Minister decides that he or she will preside. Liaison officers from Emergency Services and the Army are based permanently at the LOCC. The LOCC functions also as 'national training coordinator' for municipalities and other involved agencies to prepare themselves for disasters, including organizing regular emergency exercises.

Each Ministry has its own Departmental Crisis Coordination Centre (DCC). The Ministry of Infrastructure and Water Management DCC (MIWM-DCC) is responsible for the management of floods and drought-related emergencies. MIWM-DCC has developed: (i) a National Crisis Plan on Flooding, and (ii) a Guideline on Crisis Management. These documents are guided by and are

consistent with the National Guideline on Crisis Decision-Making (see Figure 4).

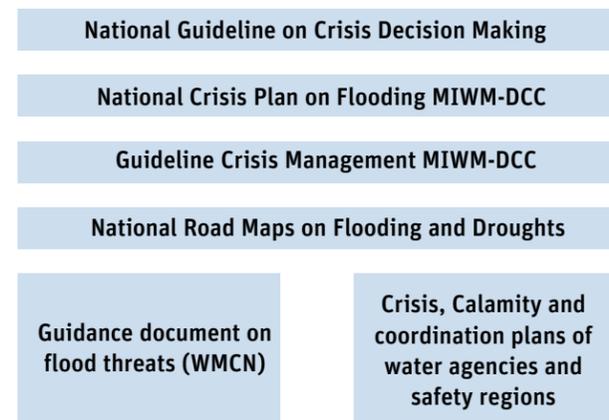


Figure 4. Guidelines and Crisis Plan for flood threats

**National Strategic DRM Plan**

The Ministry of Security and Justice prepares every three years a National Security Strategy (NSS) that connects all local, national, and international efforts to protect Dutch national security. The NSS refers to underlying sub-strategies that specify the strategic focus concerning specific threats and risks, such as the Delta Programme or the Counterterrorism Strategy.

The NSS considers floods and droughts to be natural disasters and sees climate change and accelerated sea level rise as important national security threats. The NSS refers to the Delta Programme as the key instrument for protecting the Netherlands against floods, droughts, and climate change. After the 2018 drought in the Netherlands, the NSS included an enhanced effort by the Ministry of Infrastructure and Water Management to work with key partners, such as the Fresh Water Delta Programme, Spatial Adaptation Delta Programme, the Ministry of Agriculture, Nature and Food Quality, and municipalities and Water Boards, to implement additional structural measures. Those included establishing a climate-proof groundwater and surface water system, along with spatial planning and land use, to better manage drought in the Netherlands.

**Flood and Drought Management Framework**

Managing for floods and droughts is an integral part of the water management framework in the Netherlands. Although no self-standing flood and drought strategic national plans are in place, flood and drought risk management objectives

are updated periodically through the NWP and are operationalized through the Delta Programme in three specific sub-programs: Safety (flooding), Fresh Water Supply (drought), and Spatial Adaptation (for both floods and droughts). The NWP also includes eight regional programs, along with programs for coast management and the North Sea.

The associated Delta Programme on Safety (2019-2022) consists of measures, analytical work, and knowledge issues relating to flood management and is funded – in whole or in part – from the Delta Fund.

Flood management in the Netherlands follows a multi-layered approach (see Figure 5). It includes prevention (to provide protection and reduce flood risk), land-use planning (to guide new developments and vital infrastructure), and emergency management (including flood fighting and evacuation).

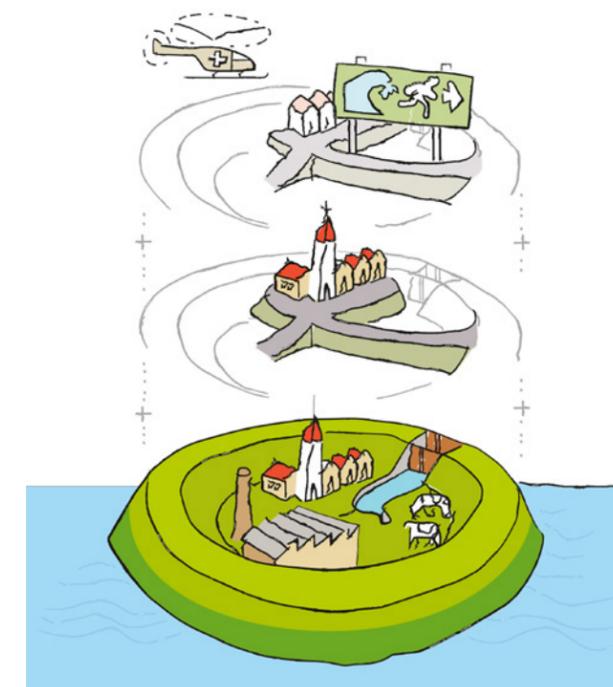


Figure 5. Multilayered approach in flood management in the Netherlands

The Water Act establishes flood standards for the main rivers, lakes, and coasts using a risk approach that considers the potential consequences of flooding. The probability of casualties caused by flood for any individual is set to be no

greater than 0.001 percent per year (1:100,000). The Water Act also allows for additional protection in areas with large numbers of potential victims, the potential for major economic damage, or possible serious damage from the failure of vital and vulnerable infrastructure of national importance. These targets have been computed into standard specifications for the flood defense system, with standards ranging from 1 in 300 years to 1 in 100,000 years. The flood defense system is set to meet the new standards by 2050.

The regional standards are legally founded in the Water Act and are made region-specific in provincial regulations related to the Provincial Water Plan. The Water Boards are responsible for ensuring that the standards are met. The regional flood safety standards are set by the provinces based on national uniform safety standards for land-use types: grasslands, arable land, horticulture, greenhouses, and urban areas. For each land-use type a minimum protection level is set. This minimum protection level is determined on social and economic grounds with consultation with local communities. The uniform regional standards are consistent with the standards of the national system.

The associated Delta Programme on Freshwater Supply (2019-2022) consists of measures, analytical work, and knowledge relating to a sustainable freshwater supply, and is funded – in whole or in part – by the Delta Fund. The aim of this program is to secure the water supply from both surface and groundwater sources. The Delta Programme on Freshwater Supply calls for a critical review of water demand and promotes efficient water use and water retention and storage optimization in the region as much as possible. In areas with water supply issues, the Programme focus in including conservation measures and better utilization of freshwater. A start has been made by specifying 'supply levels' for regional water systems although there is no formal commitment to maintain it. The supply level indicates the availability of freshwater and the probability of water shortages in a certain area.

The main organization for drought management is the National Coordination Commission for Water Distribution (Landelijke Coördinatie-commissie Waterverdeling or LCW) in which all water managers at national, provincial, and water board levels are represented (LCW is described in more detail in section 5.2).

## European Guidance on Flood and Drought Management

The Netherlands is a Member State of the European Union and as such follows the directions of the European Union (EU) Water Framework Directive (WFD). The WFD provides an integrating European legal framework for the protection and preservation of the aquatic environment, the prevention of its decline, and recovery of the environment when harmed if feasible. The focus of the WFD is on water quality and ecology, not on floods and droughts. However, the legal basis and the integrated river basin approach of the WFD, in combination with the Floods Directive and the EU Strategy on Adaptation to Climate Change, provides an additional framework for the Netherlands to develop policies and plans for floods and droughts. The European regulations add the transboundary dimension to the Netherlands water management. The NWP and the Water Act comply with the EU WFD.

The EU Floods Directive (2007/60/EC) specifically addresses floods. The goal of this directive is to have integrated flood risk management plans, covering flood alerts, spatial planning, flood defenses, and disaster relief, response, and recovery. The Floods Directive aims at limiting the negative consequences of floods on humans, the environment, cultural heritage, and economic activity. The directive mandates member states to create flood hazard maps and flood management plans by river basin. These plans should be coordinated with other countries in transnational river basins. The directive is implemented in the Netherlands through the Water Act, the Safety Regions Act, and the General Administrative Law Act, which together guide the production of flood hazard maps, flood risk maps, and flood risk management plans. The flood risk management plans are based on the water plans that are established on various administrative levels (state, province, and water board).

Drought Management is not addressed at the level of a directive, and member states are not required to produce Drought Management Plans. Still, the European network of experts on water scarcity and droughts produced a report in 2007 on drought management plans as part of the Common Implementation Strategy of the Water Framework Directive. This report was endorsed by the Water Directors of the Member States in November 2007. The report sets out recommendations for preparing operational drought

management plans to prevent and mitigate the impact of droughts on the environment, society, and the economy. On June 2020, the EU Committee of the Environment, Public Health and Food Safety presented a draft motion for a resolution on the implementation of EU water legislation to include drought in the upcoming EU Climate Adaptation Strategy and specifically calls on the Commission and the Member States to develop drought management strategies as part of the River Basin Management Plans and Flood Risk Management Plans.

The 2008 Marine Strategy Framework Directive mandates member states to prepare a marine strategy, including a program of measures designed to achieve good environmental conditions. Member states are mandated to perform assessments of their marine waters and establish environmental targets and monitoring programs to evaluate their performance on regular basis and inform the commission. Member states designate the competent authority in charge of developing a strategy and are required to coordinate with other member states and Third Countries in the case of regional marine areas. The EU provides financial incentives (such as community financial incentives or co-financing) to member states to prepare and implement marine strategies.

## 2.2 Whole of Society Approach

A whole of society approach is deeply embedded in water management in the Netherlands, dating back to the medieval organization of water allocation and infrastructure that required entire communities to organize the study, design, operation, and maintenance of their water management systems. This so-called Polder Model has transcended water management and is now understood as consensus-based policy making in the Netherlands.

In terms of disaster risk management, a whole-of society approach is prominently featured in the NSS, which states: 'National security is an issue that affects everyone, and accordingly, all government bodies, businesses, social organisations, knowledge institutions and citizens must fulfil their own responsibilities in order to realise a secure society.' The NSS includes both general and specific measures to achieve broad collaboration across different sections of society to develop and implement the NSS, define national security interests, identify threats and risks, and organize structural resilience.<sup>8</sup>

The Water Act mandates authorities to carry out public consultations with residents and interested parties in the preparation of the National Water Plan as well as in the implementation of projects. The Directorate of Participation of the Ministry of Infrastructure and Water Management provides knowledge support for such public consultations by developing methods and manuals on participatory processes. Rijkswaterstaat uses the Strategic Environment Management (SOM) approach in its operations which combines knowledge on consensus building, conflict resolution, project and program management, and social- psychology. The approach is described in a manual 'Handboek strategisch omgevingsmanagement.'<sup>9</sup>

A 2013 assessment on social inclusion in the Netherlands carried out by the European Commission stated that 'the Netherlands has an integrated and comprehensive policy design that contributes to the country's relatively strong position in terms of social inclusion.'<sup>10</sup> The study described the Netherlands Government's active strategy for social inclusion, which focuses mostly on socioeconomic aspects such as employment, poverty rates, and access to services. Social Inclusion is not prominently featured in national frameworks, but the Polder Model continues to be a core element in water management in the Netherlands. Social inclusion is starting to percolate into agencies' business models and human resources strategies. Rijkswaterstaat, for example, is currently carrying out a Strategic Corporate Staff Plan aimed at creating a more balanced workforce. The 2019 Annual Report stated that only 31 percent of Rijkswaterstaat employees were women, and that men were hired at almost twice the rate as women.<sup>11</sup>

Education and risk communication are prominently featured in the NSS and the NWP. For example, the NWP 2016-2021 includes collaboration between government authorities and stakeholders as a main principle 'based on a relationship of trust, transparency and equivalence.'<sup>12</sup> Both Rijkswaterstaat and disaster risk management agencies at the national and local level regularly engage in public awareness campaigns and have direct contact with primary and secondary schools. However, an OECD review of the water sector<sup>13</sup>, which was very positive overall about water governance in the Netherlands,

did cite a lack of risk awareness. The review pointed out that Dutch citizens are insufficiently aware of the concerted efforts needed for flood risk management. Some argue that the main reason behind the lack of awareness is the fact that no major floods have occurred in the Netherlands since 1953. Public opinion polls show that people have a lot of trust in water authorities and even take pride in the achievements in building infrastructure for flood protection.

Rijkswaterstaat is responsible for organizing scientific collaboration in the field of flood and drought risk management. The Water, Transport, and Environment department (WVL by its Dutch acronym) of Rijkswaterstaat coordinates and oversees the research agenda. The WVL is responsible for making the knowledge available to other government departments (e.g. DGWB), the scientific community, and the general public. The WVL also participates in partnerships, forming strategic alliances with partners from knowledge institutes (such as Deltares and universities) and stimulates knowledge development and innovation with the private sector. The Delta Programme includes a knowledge development program on floods and droughts, has a yearly research agenda and includes as one of its pillars joint fact-finding efforts in collaboration with key stakeholders. Rijkswaterstaat, the Delta Programme, the National Science Organization (NWO), and other partners cooperate in a National Knowledge and Innovation Programme Water and Climate (NKWK). The NKWK organizes a national knowledge conference each year, with the objectives of sharing recently generated knowledge and agreeing on the future knowledge agenda.

In terms of disaster risk, a scientific advisory committee, the National Security Analysts Network (ANV) advises the Ministry of Security and Justice in every iteration of the NSS with an updated analysis of national security interests and concerns. The ANV is a multidisciplinary network of knowledge institutes that aims to collect and safeguard knowledge about national security and to ensure a multidisciplinary approach to analyses of national security.

Finally, regarding open information, the 2016 Re-Use of Public Information Act grants access to information that

8. 2019 National Security Strategy [https://english.nctv.nl/binaries/nctv-en/documents/publications/2019/09/19/national-security-strategy/National+Security+Strategy\\_2019.pdf](https://english.nctv.nl/binaries/nctv-en/documents/publications/2019/09/19/national-security-strategy/National+Security+Strategy_2019.pdf)

9. Wesselink, M and R. Paul (2010). Handboek strategisch omgevingsmanagement. Management Impact

10. <http://ec.europa.eu/social/BlobServlet?docId=9952&langId=en>

11. Rijkswaterstaat Annual Report 2019 <https://www.magazinesrikswaterstaat.nl/rwsjaarbericht/2019/01/h6-organisatieontwikkeling-algemeen>

12. NWP 2016

13. OECD (Organization for Economic Co-operation and Development). 2014. Water Governance in the Netherlands, fit for the future? OECD Studies on Water. OECD Publishing. <http://dx.doi.org/10.1787/9789264102637-en>

agencies produce or collect, such as geographic information and data collected from remote sensing and monitoring frameworks. The act ensures that users do not have to justify their interest to access information. It also directs that information be made available in a manner that facilitates both access and reuse (by electronic means in an open and machine-readable format). This Act was passed in response to the implementation of European directives on open data and reuse of public information.<sup>14</sup>

## 2.3 Hydro-met Services in the Netherlands

Information related to weather, water, and climate is fundamental to managing hydro-climatic risks for every program in the EPIC Response Framework. The hydro-met services program area sits near the top of the Framework because hydro-met information provides the most basic parameter for all forms of water-related planning, water infrastructure design and operation, and water management. Hydro-met information helps to delineate flood plains to better enable floodplain management. Monitoring and forecasting of floods drive emergency management responses. Drought forecasting enables drought managers to zero in on potentially affected areas to perform assessment impacts and identify vulnerable populations. Hydro-met information also serves to inform flood and drought recovery programs. The quality of hydro-met services is of such critical importance to a country's hydro-climatic risk management that it sits at the top of the EPIC Response Framework.

### National Sector Framework for Hydro-met Services

The National Hydrological Services (NHS) and Meteorological Services (NMS) operate as different agencies in the Netherlands. The Royal Netherlands Meteorological Institute (KNMI), originally founded in 1854, is an agency under the Ministry of Infrastructure and Water Management. The Water Management Center of the Netherlands (WMCN), which is part of Rijkswaterstaat, provides hydro-met services for flood and drought management. WMCN combines meteorological information from the KNMI with actual and forecast data on river discharge, water levels, and sea levels in collaboration with water boards and the scientific community (e.g. Deltares).

The activities and responsibilities of KNMI and Rijkswaterstaat have a legal basis in national laws. The latest iteration

of the meteorological legal framework, the Meteorology and Seismology Tasks Act of 2016, directs the Ministry of Infrastructure and Water Management to perform the following tasks: (i) maintaining a national meteorological observational network for weather and climate applications; (ii) sharing national meteorological data with other national and international agencies; (iii) providing very short-, short-, medium-, and long-range forecasts of various hazards; (iv) preparing and issuing warnings related to high impact weather; (v) providing warnings of other phenomena, such as tsunamis and other seismic hazards; and (vi) contributing to a multi-hazard impact-based early warning system. In addition, the Meteorology and Seismology Tasks Act provides a source of public funding to meet the needs of the government and society for weather and climate information, offers an avenue for the KNMI to provide additional services to the private sector, and facilitates an open data environment by making meteorological, seismological, and other geophysical data, as well as research results, available for re-use as referred to in the Re-use of Public Sector Information Act. A regulation of the Ministry of Infrastructure and Water Management mandates that Rijkswaterstaat operates and maintains a hydrological observation network and collects hydrological observations from other parties.

KNMI bases its forecasts on data collected in cooperation with the European Center for Medium-Range Forecasts (ECMWF), the Network of European Meteorological Services (EUMETNET) and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT). The hydrological forecasts are based on models and data developed for Rijkswaterstaat in cooperation with partner institutes in upstream countries. Besides data and short- and mid-term weather forecasts, the KNMI also provides science-based long-term climate scenarios for climate change and sea level rise. This is done in cooperation with other national and international scientific institutes and the IPCC (Intergovernmental Panel on Climate Change).

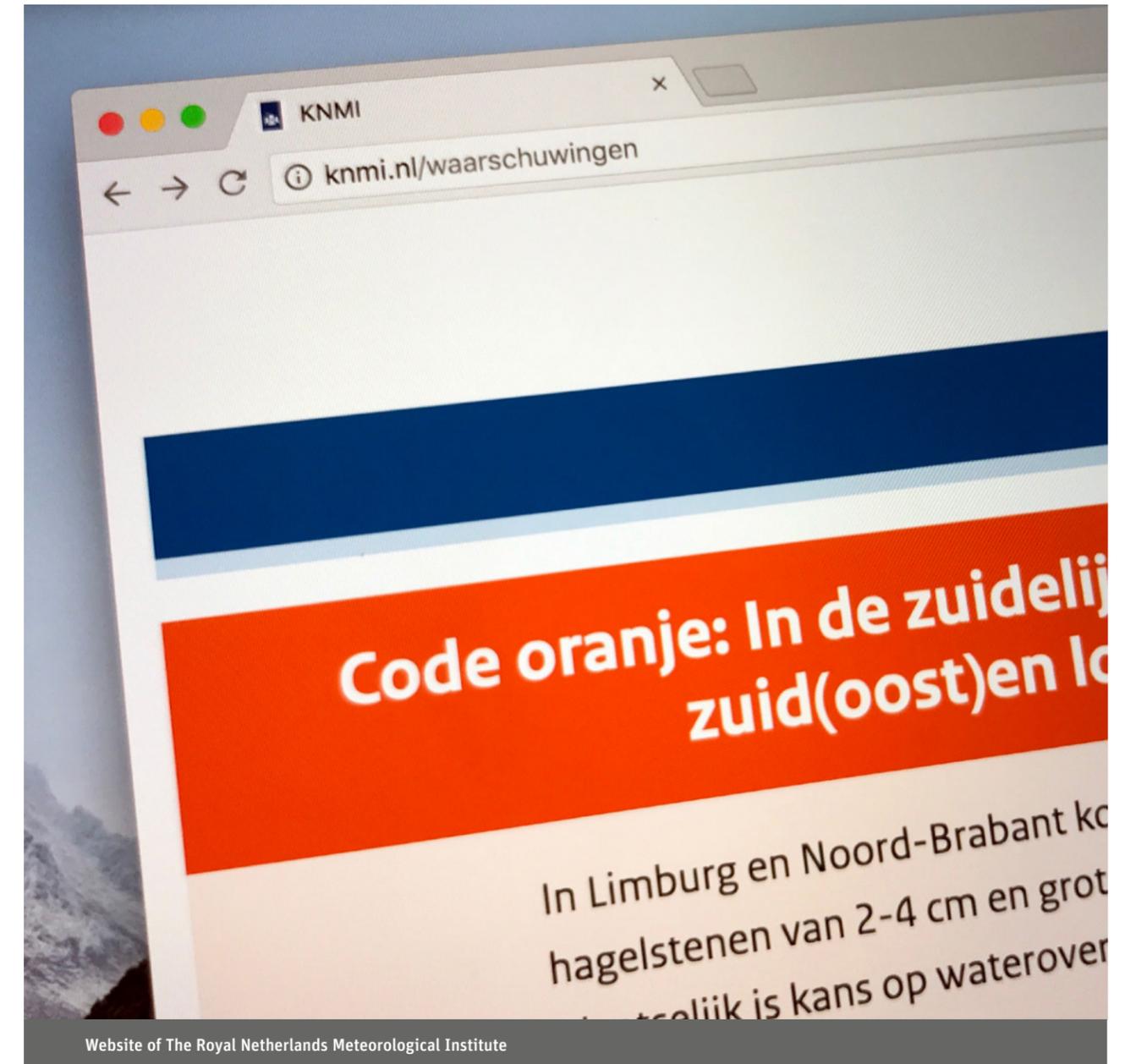
Much of the weather data in Europe are in the public domain and are being used by the private sector to make weather forecasts. The private sector in the Netherlands is not involved in hydro-met services related to floods but is active in providing agro-met services.

### National Sector Framework for the Co-Production of Hydro-Met Services

Basic weather and hydrological services are the foundation

for hydro-climatic risk management, and the agencies involved in providing meteorological and hydrological services need to collaborate with other agencies to offer services. Developing interagency collaboration for the provision of hydro-met services is a complex ongoing task in the Netherlands. The co-production of services is not prominently featured in the Water Act or the Meteorological Law, and inter-agency collaborations for the development of

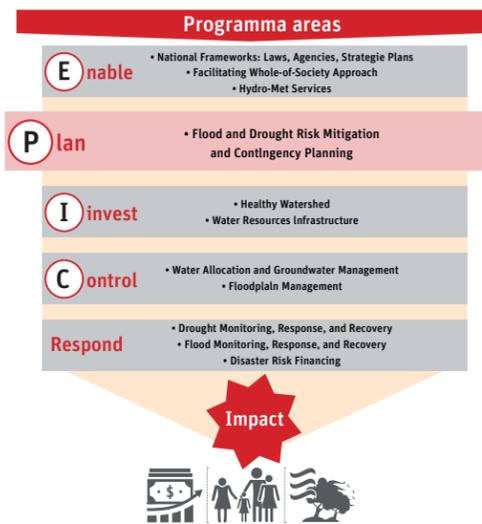
drought monitoring and impact-based flood forecasting exist only in an ad hoc manner – not coordinated formally. In the Netherlands, agro-meteorological services are generally provided by the private sector and normally consist of combining weather forecasts (rainfall and evaporation) with satellite-based information (for example, on soil moisture) to advise on water management and irrigation at local scales to optimize crop production.



14. Re-use of Public Information Act (2016) [wetten.nl - Regulation - Re-use of public sector information Act - BWBRO036795 \(overheid.nl\)](https://wetten.nl/Regulation-Re-use-of-public-sector-information-Act-BWBRO036795-overheid.nl)

### 3. P - Planning: Floods and Droughts Risk Mitigation and Contingency Planning

The second cluster of EPIC Response programs focus on planning at multiple and nested geographical levels to ensure that mitigation measures on floods and droughts are well included in mitigation and contingency plans.



Flood and drought mitigation and contingency planning establish a road map for many of the other programs in the lower parts of the EPIC Response Framework: Planning guides investments in green and grey infrastructure and helps set parameters for water allocation and flood plain management programs. Contingency planning provides a basis for responding to flood and drought events when they do occur. For the purposes of the EPIC Response, mitigation planning refers to actions to reduce hazard magnitude and frequency, exposure to the hazard, and vulnerability to the hazard.

The EPIC Response Framework focuses on five types of plans: river basin plans, coastal zone plans, urban water supply plans, irrigation water supply plans, and local flood risk mitigation plans. For the Netherlands, these plans are presented in the next sections.

#### 3.1 Integrated River Basin Planning

All the main basins in the Netherlands – the Rhine, Meuse, Scheldt, and Ems – are transboundary (Figure 6). Therefore, integrated river basin planning is done both at the national level and at the level of riparian countries. The 2009 Water Act mandates the periodic preparation of river basin plans, and those are included as a section in the National Water Policy. Planning at the level of riparian countries follows the EU Water Framework Directive and the Flood Directive and is integrated with the basin plans of the upstream countries.

Rijkswaterstaat develops national river basin plans for the four river basins, which include an international part (part A) and a national part (part B). The planning authority lies in a national entity, Rijkswaterstaat, because the river basins in the Netherlands are transboundary and a self-standing



Figure 6. Four river basins in Netherlands addressed in EU planning

basin authority or committee does not exist in the Netherlands. The river basin plans are integrated plans that address water quality, quantity, groundwater management, and protection of aquatic ecosystems according to both national laws and applicable European directives. The basin plans include measures to mitigate flood and drought risks. Rijkswaterstaat also prepares four separate flood risk management plans for the four basins. The Basin Plans and the Flood Risk Management Plans are approved by the Cabinet and are included in the NWP.

Drought risk is operationalized through the freshwater provisions of the Delta Programme. They include a national adaptive drought management plan to ensure a sufficient supply of fresh water. At this moment, the Netherlands does not have a self-standing national drought plan in the NWP or a basin drought contingency plan at the basin level.

#### Linkages with National Frameworks

The National Water Act requires the preparation of basin plans, which are updated in every iteration of the National Water Policy (NWP). The Water Act describes the minimum content of river basin plans and their relationship with other plans and legislation, including European Directives. The Water Act also describes the procedure and approval process.

#### 3.2 Agriculture and Public Water Supply Planning

The Water Boards are responsible for managing the water levels in the regional water system and managing surface water supply for agricultural purposes. The Water Boards and Rijkswaterstaat prepare emergency plans for droughts, which often include restrictions on the use of the water for agricultural purposes (such as irrigation) and the implementation of priority uses in times of drought. These plans are prepared and discussed in the National Commission for the Coordination of Water Distribution (LCW) and are explained in Section 10.2 of this case study.

Water Utilities also prepare emergency plans for drought situations. The emergency plans focus on demand management. In addition to drought, emergency plans also tackle water quality issues since supply can also be restricted by water quality issues with surface water or groundwater. Urban flooding is managed in Municipal Sewerage Plans, which are developed in cooperation with the Water Boards.

#### 3.3 Coastal Zone Planning

Coastal planning in the Netherlands is included in the National Water Plan and covers the North Sea, the Coast, and the Wadden Islands. There is not a separate and Integrated Coastal Zone Management (ICZM) Plan; instead, the NWP includes a 2016-2021 North Sea Policy Document establishing a vision, a series of principles, and an outline of the desired uses of the coastal zone. Those uses are mostly renewable energy (wind farms), shipping corridors, and healthy ecosystems. This North Sea Policy Document also aims to comply with the Marine Strategy Framework Directive. The basic principle for the coastal zone in the Netherlands is 'soft' (green) infrastructure where possible and 'hard' (grey) infrastructure where necessary.

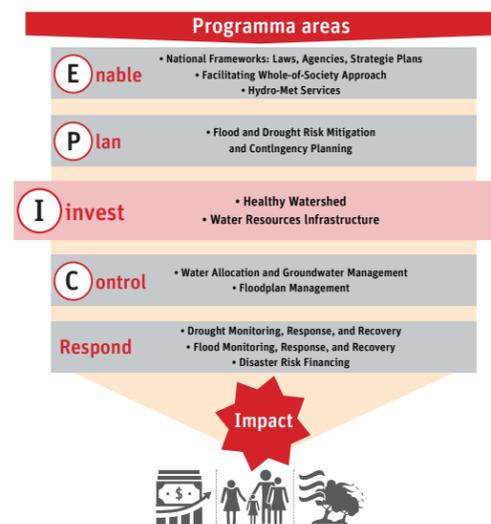
The NWP Coastal Zone section focuses on the control of erosion along the coastline and increasing protection from coastal flooding. The NWP Coast section outlines further research and operations required to continue with a beach nourishment program. That program includes a first-of-its-kind effort to move large amounts of sand from offshore to the coast in a mega artificial beach nourishment project called the Sand Motor. The Sand Motor is designed to build defense dunes and lower long-term flood risks in the Southwest Delta, the Coast of Holland, and the Wadden region.

In order to comply with the 2012 ICZM European Recommendation, the Netherlands prepared a 2013 National Coastal Vision for the development of 'a safe, attractive, and economically robust coast.' As regional governments are responsible for spatial development, the National Government is piloting initiatives to support the regional governments in implementing the Vision with defense systems and nature-based solutions.



## 4. **I** - Investing in Healthy Watersheds and Water Resources Infrastructure

The third cluster of the EPIC Response Framework is about investing in healthy watersheds and water Resources infrastructure to reduce the hazards from floods and droughts.



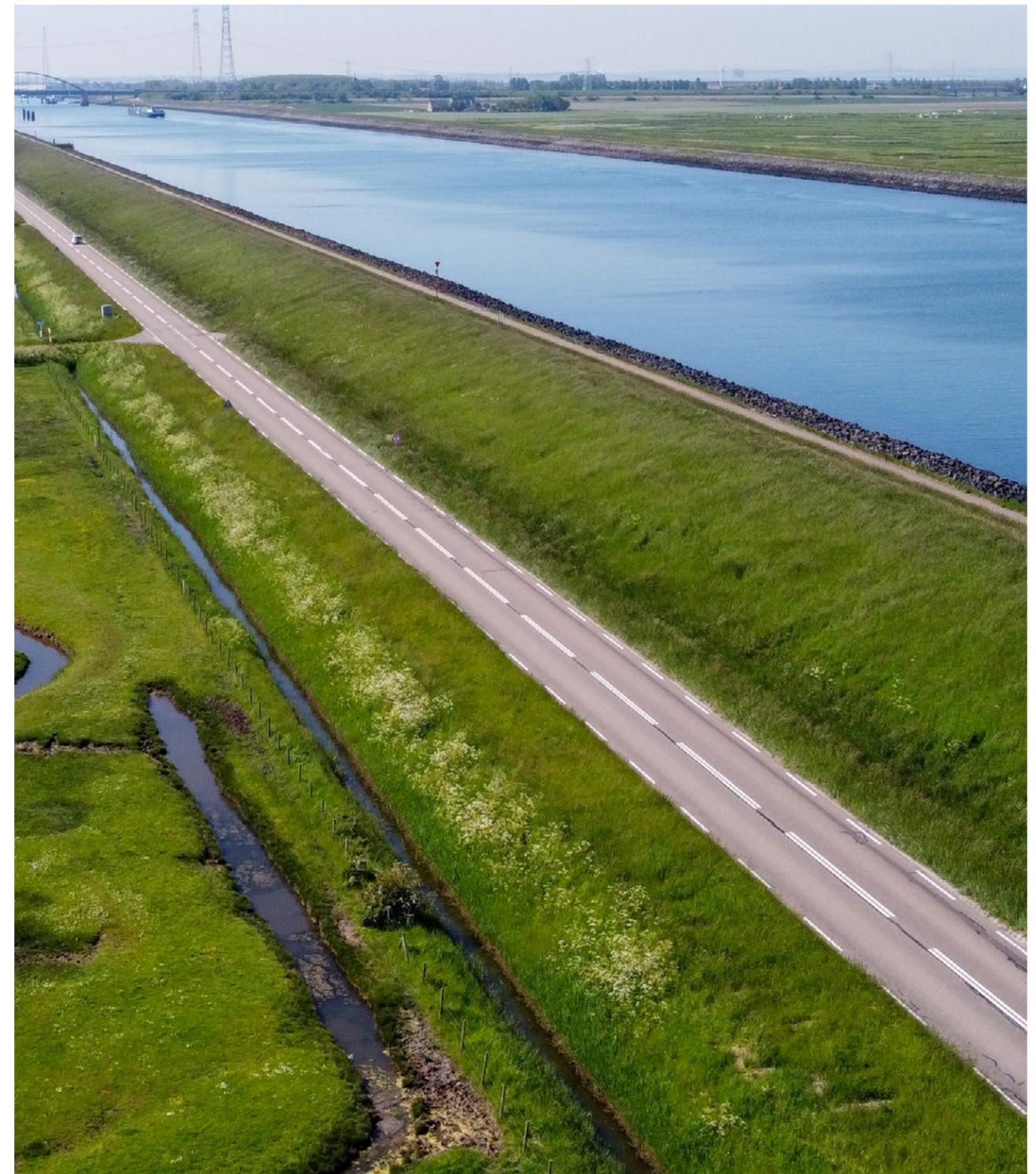
### 4.1 Healthy Watersheds

Healthy watersheds are the first physical line of defense in the EPIC Response Framework because they can reduce flood and drought hazards through natural processes. These 'nature-based solutions' in turn can help reduce the demands on water resources infrastructure by providing eco-based services that reduce flood peaks, increase base flows, and improve water quality (UNESCO 2018). Healthy watersheds not only help reduce hydro-climatic hazards, but they often also generate many other benefits, such as improved livelihoods, increased biodiversity, and broader ecosystem services. The EPIC Response Framework includes the following key elements of healthy watersheds with an important role in managing floods and drought: forests, wetlands, and climate-smart agriculture.<sup>15</sup>

Key elements of healthy watersheds are addressed in the Netherlands by taking actions that improve water conditions upstream and by integrating water management with environmental and agriculture planning programs. Developing healthy watersheds is a joint responsibility of the water agencies mentioned earlier and the Ministry of Agriculture, Nature and Food Quality with its associated agencies. The integration of the agricultural sector with planning for nature plays a major role, not only in creating healthy watersheds but also in managing floodplains to reduce flood risks, as in the Room for the River program.

In the past, water management in the Netherlands focused on drainage to prevent flooding and on creating better conditions for farming. Recent increased variations in rainfall due to climate change, however, have caused more flooding downstream in the wet season and more droughts (with lower groundwater tables) in the dry season. In 2000, the Government published a report called A different approach to water: Water Management Policy in the 21<sup>st</sup> Century. That report abandoned the traditional focus on grey infrastructure in water management and introduced several new concepts, such as 'Room for the River' (see Section 5.2) and the use of systems thinking in water management. The drainage approach was replaced by a three-step strategy to avoid passing on problems in upstream areas to downstream areas. The three steps are retention, storage, and drainage, as illustrated in Figure 7. This strategy also raises groundwater levels in watersheds and helps to reduce the negative impacts of droughts.

The Netherlands floodplain policy offers a successful example of using both enhanced ecosystem services and agricultural intensification to increase protections against flooding – and was also aided by the issuance of key European directives. The approach increases the peak flow capacity relatively easily and cheaply, compared with revamping the dike infrastructure, by actively restoring floodplains through hydrological landscaping and by limiting or relocating agriculture and urbanization to areas with lower flood risks.<sup>16</sup>



Green polders, meadows and water transportation channel in South Beveland, Zeeland, Netherlands

15. Browder, Greg, Ana Nunez Sanchez, Brenden Jongman, Nathan Engle, Eelco Van Beek, Melissa Castera Errea, and Stephen Hodgson. 2021. "An EPIC Response: Innovative Governance for Flood and Drought Risk Management—Executive Summary." World Bank, Washington, DC

16. FAO (2008) Scoping agriculture-wetland interactions. Chapter 5: The Netherlands Floodplain Policy. Rome Italy

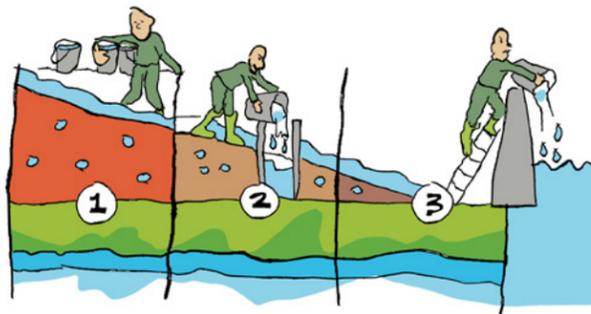


Figure 7. Three-step approach on drainage retention, storage, and drainage

### Linkages to the National Framework

The 2016-2021 NWP aims to mainstream or to put healthy watersheds into operation in a number of initiatives. These include the integration of the Water Act into a new Environmental Planning Act. The Act seeks to modernize, harmonize, and simplify current rules on land use planning, environmental protection, nature conservation, construction of buildings, protection of cultural heritage, water management, urban and rural redevelopment, development of major public and private works, and mining and earth removal, and integrate these rules into one legal framework. The Act highlights the importance of a healthy physical environment and operationalizes a paradigm shift from protecting nature from society to taking advantage of the services nature can provide to society. The Act includes a statement of environmental values, instructions for government action, a planning system, and general rules governing projects and activities in the physical environment. The NWP expects that key elements for hydro-climatic risk management (such as water-robust design and climate-proofing) will be incorporated in the regulations operationalizing the Environmental Planning Act.

Another initiative is to connect water management with spatial planning and infrastructure by linking the NWP with the Multi-Year Programme for Infrastructure, Space and Transport (abbreviated as MIRT in Dutch). Linking the NWP with the MIRT will require the central government, provinces, and water boards to jointly consider how water and space can be interconnected. In practice this mandate is operationalized by requesting water managers to participate in the various bodies of the MIRT on matters related to water. It will also include water-land-nature and infrastructure linkages in the operationalization of the Delta Programme.

## 4.2 Investing in Infrastructure

Water resources infrastructure (WRI) broadly refers to assets such as dams and their reservoirs, regional bulk water systems, flood control structures along rivers and coasts, and regional drainage channels and floodways. In broad terms, it is the infrastructure that the WRM agency normally operates or regulates. This infrastructure is used to help control blue water flows through the watershed and is an important tool in the arsenal to reduce hydro-climatic hazards.<sup>17</sup>

A new paradigm is emerging which also looks at how to integrate green infrastructure with traditional gray infrastructure.<sup>18</sup> Green infrastructure refers to nature-based solutions that are directly linked to gray infrastructure. For example, a watershed (green) immediately upstream of a dam (gray) can be considered part of the same WRI system as it affects water and sediment flows into the reservoir. Another example is floodplains (green) that retain flood waters and can be combined with river dikes (gray) to form integrated green-gray flood infrastructure. Like all nature-based solutions, green infrastructure typically generates many environmental and social co-benefits. Green infrastructure can also boost resilience as it is unlikely to catastrophically fail.

### Investments in Water Resources Infrastructure

The Netherlands water resources system relies heavily on grey infrastructure. The water levels in 60 percent of the country's canals, lakes, and ditches are managed by a complicated system of pumps and water discharge and inlet facilities. These water levels also help manage groundwater levels, especially in polders, and prevent land subsidence caused by peat oxidation in the subsurface. The same infrastructure is also used to control water quality and salinity by flushing the system with fresh river water. The Dutch Government has built locks, large and small, to enable the canals to be used also for navigation, both commercial and recreational. The main purpose of grey water resources infrastructure is to prevent waterlogging and flooding, but the system of canals and ditches is also used to supply water to regions in case of drought and control water levels. Safety from flooding is provided by river and sea dikes in combination with controllable infrastructure to protect the country against storm surges from the sea, such as the Eastern Scheldt Barrier and the Maeslantkering barrier.

### Linkage to the National Frameworks

Investments in water resources infrastructure require sophisticated economic justifications and environmental and social impact assessments, and should be grounded in nested spatial planning exercises – basin, provincial, coastal, and urban. The Netherlands has advanced cost allocation and sharing policies that encourage national and local collaboration as well as among sectors in infrastructure development and maintenance. The Water Act describes the responsibilities of the Rijkswaterstaat and the Water Boards in terms of water resources infrastructure. The responsibility of maintaining and further developing infrastructure lays in Rijkswaterstaat for the national system, the main rivers and lakes of national importance, while the Water Boards are responsible for the regional systems. The Water Act also establishes the Delta Fund, which provides financing to Rijkswaterstaat infrastructure programs as well as to the Delta Programme. In contrast, Water Boards finance their regular activities from taxes from residents and businesses. Provinces do not have major responsibilities in water infrastructure management in the Netherlands. Municipalities are responsible for the urban sewage and drainage systems and they finance their infrastructure investments by levying municipal taxes.

## 4.3 Flood Control Infrastructure Safety

The Netherlands is protected by approximately 3,500 kilometers of primary flood defenses<sup>19</sup>. The history of building protection from flooding dates back to 500 BC in what is now the northern Netherlands, where inhabitants built dwelling mounds, or 'terps,' and started stacking sods of clay to form low earthworks. Local village and communities would build these dikes around small fields. This practice eventually led to contiguous lines of flood defenses, the levee systems. These systems became so large that individuals and small communities could no longer build and maintain the levees themselves, so water authorities were established in the Late Middle Ages.

The central government is responsible for setting the standards for the primary flood defense system. Each section of dike is assigned a standard specification commensurate to the accepted level of residual risk, using standards set in the Water

Act or by ministerial or administrative order. The provinces set the standards for secondary dike systems and provide construction permits for large infrastructure projects like dikes. Rijkswaterstaat is responsible for preparing the rules to assess the safety of the water infrastructure.

Operational water management in the Netherlands is the joint responsibility of Rijkswaterstaat and the Water Boards. Their responsibilities were originally prescribed in the 1996 Flood Defences Act and then in the 2009 Water Act. The laws stipulate that the manager of a levee must assess its safety. The Minister of Infrastructure and Water Management issues new assessment rules and hydraulic boundary conditions for each round of assessment in what is called Statutory Assessment Instruments (WTI). WTI are periodically updated based on extensive analytical work and can be changed in response to climate change or anthropogenic changes in riverbeds or seabeds. The results of the assessment are reported to the Minister, who informs Parliament, which provides funding. Water Authorities must improve any flood defenses to ensure that they comply with the flood protection standards. Then, Rijkswaterstaat and the Water Boards periodically develop plans for managing the systems safety in periodic planning periods. The plans cover the maintenance and further development of dams and flood control infrastructure as well as the operational procedures for managing the systems. Procedures are also developed for emergency situations (floods and droughts). These procedures will be described in Section 6.

The Water Board submits a report on the general structural condition of primary flood defense systems to the Provincial Executive every six years. The Provincial Executive submits a report to MIWM on each of the dike sections in its territory for that specific period. The Minister of MIWM forwards the reports of the Provincial Executive, as well as his comments, to Parliament for action, including funding allocation.

The Living Environment and Transport Inspectorate of MIWM supervises the activities of Rijkswaterstaat and the Water Boards. MIWM also develops technical guidelines for the design, management, and maintenance of primary flood defense structures. These guidelines serve as recommendations for the national and regional water authorities.

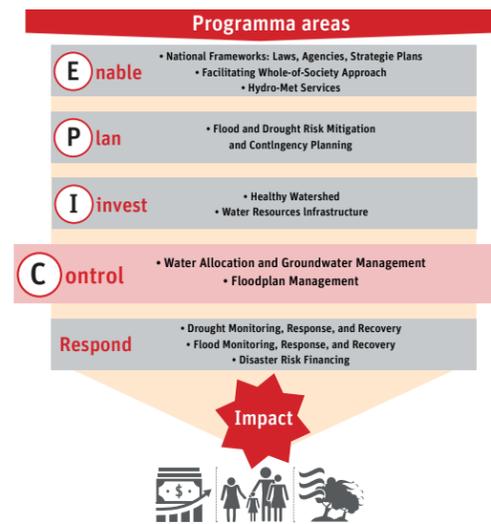
17. Browder, Greg, Ana Nunez Sanchez, Brenden Jongman, Nathan Engle, Eelco Van Beek, Melissa Castera Errea, and Stephen Hodgson. 2021. "An EPIC Response: Innovative Governance for Flood and Drought Risk Management—Executive Summary." World Bank, Washington, DC

18. Browder, Greg, Suzanne Ozment, Irene Rehberger Bescos, Todd Gartner, and Glenn-Marie Lange. 2019.

19. The National Flood Risk Analysis for the Netherlands (2017) Rijkswaterstaat VNK Project Office

## 5. C - Controlling Surface Water and Groundwater Use

The fourth cluster is about controlling surface water and groundwater use and floodplain development to reduce exposure and minimize vulnerabilities.



### 5.1 Water Allocation and Groundwater Management

Water allocation and groundwater management are two key programs for reducing drought risk. In the case of the Netherlands, a low-lying country with abundant water resources and a relatively low drought risk, these programs are developed to the extent of the perceived risk. In the Netherlands, the main objective of water distribution and the daily management of the water system is to control water levels and salinity intrusion. The desired water levels of the water system are set in the NWP and the river basin plans. Rijkswaterstaat and the Water Boards manage an extensive system of water conveyances, pumps, and inlet facilities to maintain the desired water levels – Water Boards and Rijkswaterstaat prepare legislative Water Agreements managing the water conveyance between regional and main water system. The water levels are established with several purposes: to maintain the stability of the water infrastructure, to protect the foundations of buildings, to prevent subsidence, and to manage groundwater levels. For the low-lying part of the

Netherlands, freshwater levels are established for salinity control. The salinity in the system comes from saline groundwater as well as saltwater intrusion through sluices and ship locks.

#### Adaptable Water Allocation

The Netherlands does not have a system of usage rights or water entitlements. Both surface water and groundwater are publicly owned. Under normal conditions, there is enough surface water for users and there is no need for water allocation systems. Nearly all agriculture in the Netherlands is rainfed, with supplementary irrigation only in dry periods. Under normal conditions, there are no explicit limits on water extractions and there are no special extraction charges. The distribution of the water over the surface water system is based on the need for water level and saline intrusion control. In the case of severe droughts, restrictions are imposed on the use of surface water and groundwater. This will be described in Section 5.2.

#### Groundwater Management

The Water Act governs the use and management of groundwater resources in the Netherlands. The Act places the main responsibilities for groundwater management in the provinces in terms of strategic direction and in the Water Boards in terms of operational management. The management of groundwater aims at maintaining particular groundwater levels that are determined by policy decisions and that are made operational in Water Board regulations. Recently, initiatives to reduce land subsidence rates in the low-lying Netherlands have gotten more attention. The provinces also have the power to grant permits for the extraction or recharge of groundwater and to impose groundwater taxes. The Water Act mandates that the provinces maintain a register of groundwater extraction and recharge of water. Water Boards have additional regulations on groundwater use, especially for small water demands. On a regular basis, groundwater is used for drinking water supply and for industry. However, the main groundwater extraction in the Netherlands is done for agricultural purposes during dry periods.

The Netherlands does not currently implement stand-alone aquifer management plans. Nor has the country established groundwater organizations like those in more arid countries where over-extraction of groundwater is an important issue.

Conjunctive use of surface water and groundwater is hardly practiced in the Netherlands. The lower (western and northern) parts of the country use surface water while the higher (eastern and southern) parts use groundwater. Artificial groundwater recharge is widely practiced by drinking water companies for storage and quality improvement of the raw water source for drinking water production, in particular in the western part in the dune areas. For many years, greenhouse horticulture operations have used Managed Aquifer Recharge (MAR) systems to store water of good quality in the groundwater system for use when the water quality (in particular the salinity) of surface water is not good enough for their sensitive crops. Desalinization of (brackish) groundwater and the disposal of the resulting brine in the deeper subsurface provides farmers with very high quality water, ready to be used in greenhouse horticulture.

### 5.2 Floodplain Management

River and coastal floodplains are often convenient places for the establishment of cities, farms, and industries. Easily accessible waterways facilitate commerce, rich river floodplain soils increase agricultural production, and rivers offer readily available sources of freshwater. In addition, living close to rivers and beaches, and enjoying their natural beauty, is a powerful draw. These attributes have attracted people throughout the ages to rivers and coastlines around the world. The challenge is that floodplains are also prone to inundation, putting people and assets at risk.

Healthy watersheds and water resources infrastructure can both help reduce flood hazards on floodplains and shape floodplain physical characteristics. Floodplain management is fundamental in enabling people to live in harmony with river and coastal floods and in making room for the river and the sea while also reaping the benefits of living close to water (Browder et al., 2021).<sup>20</sup>

The land along the main rivers in the Netherlands is protected against floods by dikes, which restrict flooding to the floodplain areas between the dikes. In the Netherlands, the only natural floodplains exist in the most upstream part of the Meuse. Some minor floodplains are also found along smaller rivers. A system of ‘summer’ dikes within floodplains enables the use of the floodplains for agriculture during normal to low flow periods. The main dikes are called the ‘winter’ dikes. The provincial and municipal spatial plans inform the regulations

that define and restrict economic activities in the floodplains.

Between 1850 and 1960, the floodplains were reduced from about 80,000 hectares to 30,000 hectares, mainly because of urban expansion. This has reduced the storage capacity of the floodplains enormously. In 1993 and 1995, floods forced the evacuation of 200,000 people and threatened to devastate several regions in the Netherlands. These events, coupled with a growing understanding of the anticipated impacts of climate change, caused the Dutch government to increase the safety level of the river system. The new safety level spurred a program of measures costing about €2.2 billion that was implemented from 2006 to 2018. These measures included the objective of restoring the spatial quality and the ecological value of the river systems and the floodplains. The resulting Room for the River project was designed and implemented in close cooperation with all partners, including provinces, municipalities, the Water Boards, and Rijkswaterstaat. The measures in the project aim to lower the flood levels. They included moving levees back from rivers, creating and increasing the depth of flood channels, reducing the height of groins, removing obstacles, and constructing a ‘green river’ that can serve as a flood bypass.

Rijkswaterstaat, Water Boards, and provincial governments prepare flood hazard mapping for their particular areas of management. In 2001, Rijkswaterstaat, Water Boards, and provincial governments commissioned a Flood Risks and Safety in the Netherlands (FLORIS) study to better understand the consequences and the probability of flooding in the Netherlands. FLORIS was published in 2005. It informed flood mitigation regulations and strategies and established a common method to assess flood risks in the Netherlands. The study included hundreds of inundation scenarios with potential dike breaches as well as an assessment of dike failure probabilities. A similar nationwide flood hazard mapping study was commissioned in 2017 to update the flood risks in the Netherlands’ system of 58 levees. Provinces use the information generated by these mapping efforts for regional planning. The Ministry of Infrastructure and Water Management uses the analytical inputs for cost benefit and casualty risk analysis to underpin the new flood protection standards. Simulations of flooding patterns due to potential dike breaches are also an important tool for crisis management by waterboards and safety regions (as described in the next section).

20. Browder, Greg, Ana Nunez Sanchez, Brenden Jongman, Nathan Engle, Eelco Van Beek, Melissa Castera Errea, and Stephen Hodgson. 2021. “An EPIC Response: Innovative Governance for Flood and Drought Risk Management—Executive Summary.” World Bank, Washington, DC

## 6. RESPOND - Flood and Drought Response

The final cluster of program areas in the EPIC Response Framework focuses on responding to floods and droughts through effective early warning, responses to the events, and actions to be taken to recover in case an actual event has taken place.

The Water Management Center of the Netherlands (WMCN), under Rijkswaterstaat, is the central organization providing the information to manage the response to floods and droughts. WMCN cooperates closely with the regional divisions of Rijkswaterstaat, KNMI, the Water Boards, the Provinces, the Safety Regions, as well as the scientific community. The main tasks of the WMCN are providing information about present and predicted events (such as water levels, river discharges, and precipitation deficits), advising in crisis situations, and sharing knowledge. WMCN combines meteorological and storm surge information from KNMI (see Section 2.3) with actual and forecasted data on river discharges, water levels, and sea levels. WMCN is supported by three crisis-advice groups for coasts, rivers, and lakes. Those groups consist of staff members of government agencies and the scientific community that do monitoring and provide specific operational forecast information to be shared with WMCN partners.

The WMCN uses a four-color coding system (green-yellow-orange-red) to indicate the severity of the flood or drought event. Green indicates normal management while red indicates serious and exceptional situations that require major emergency responses. The color coding is used to determine the scale of the emergency response.

The color coding system of floods and droughts and the corresponding upscaling of activities are formalized in a road map that is regularly updated and authorized by the Steering Group Management of Water Crisis and Flooding (in Dutch, SMWO) in which all the major institutional stakeholders are represented (Rijkswaterstaat, Water Boards, Provinces, Safety region, Ministry of Infrastructure and Water management, and KNMI).

The Road Maps for Floods and Droughts provide the following information:

- A description of the water management organizations dealing with floods and drought
- The color coding, indicating the upscaling of the crisis, criteria for scaling up and scaling down, and roles and

mandates of organizations involved

- The network scheme of information flows among organizations.

In case of floods or droughts, WMCN activates other organizations (such as LCO and LCW, see below) to handle the crisis. In the organizations involved in the response a distinction is made between the WRM organizations (such as Rijkswaterstaat and the Water Boards) and the generic DRM organizations (Safety Regions and Interdepartmental Coordination Commissions). The roles of the generic crisis organizations become more important if the situation worsens.

### Recovery After a Flood or Drought Event

The response activities in the Netherlands on floods and droughts focus on preparation and on the actual response to the event. These are described in sections 5.1 and 5.2 below.

Insurance against extreme weather events is possible but not popular. A general compensation mechanism is arranged in the Law on Compensation Damage due to Disasters. This is a general law for disasters (including earthquakes, hailstorms, and major accidents) which also provides compensation for freshwater flooding (but not for coastal flooding) and extreme droughts. Funds come from the national government. Provinces and municipalities implement the law based on the conditions as specified in the law. Compensation can only be provided after the national government has declared the specific region as a disaster area. In case of droughts, this will only be done in extreme drought situations (1 in 10 years or higher). 'Normal' droughts are considered to be occupational risks for farmers. Damages during the (near-) flooding events of 1993 and 1995 and the flood of July 2021 were compensated under this law.

### 6.1 Flood Emergency Response

The main organization for flood management is the National Coordination Commission for Flood Risk (Landelijke Coördinatiecommissie Overstromingsdreiging or LCO) in which all water managers (at the national, provincial, and water board level) are represented. LCO plays a crucial role in providing early warnings for increased flood risks and providing information to potential flooded areas.



Water level in river Rhine, during the 2022 drought, Arnhem, the Netherlands.

The basic information for flood emergency responses as provided by the WMCN to the LCO are the actual and predicted states of the system, including precipitation, water levels, storm surges, and river discharges. This information, together with assessments of potential failures of certain important infrastructure (such as dikes), determine the color coding:

- Green: normal management
- Yellow: (expected) water levels higher than normal, standard measures taken – yearly event
- Orange: (expected) water levels increase, additional measures are taken (such as permanent dike surveillance), use functions are limited, and major measures are prepared – 1 in 5 year event
- Red: serious and extreme situation (expected) with national security impacts; major measures taken (such as precautionary evacuation) – 1 in 20 (or 1 in 100) year event (depending on region).

The road map for flood management describes the responsibilities and activities of all partners, including communications with the public.

### Recovery and Insurance

Insurance against floods has historically not been possible in the Netherlands. This is because the damages from coastal or river flooding due to infrastructure failure were considered too high for insurance companies to cover, even with re-insurance mechanisms. Recently some insurance against flooding has been made available, though severe restrictions apply, such as a maximum limit on insured assets in a region. The insurance premiums depend on the flood risks faced by the assets as estimated by Rijkswaterstaat. Flood insurance is not popular as most people do not consider flooding as a high risk they should be prepared for, and the Government is not currently implementing any incentives or other forms of support for the purchase of flood insurance.

## 6.2 Drought Response System

The WMCN uses the following basic information for classifying drought events: the amount of discharge from the Rhine and Meuse, precipitation deficits, groundwater levels, salinity levels, and measures of water shortages used by the Water Boards. As drought is a slow process, this information is shared with all interested parties on a bi-weekly basis, with the frequency of information exchange increasing if conditions worsen.

The main organization for drought management is the National Coordination Commission for Water Distribution (Landelijke Coördinatie-commissie Waterverspreiding or LCW) in which all water managers at national, provincial, and water board levels are represented. At the regional level, drought meetings (Regionaal Droogte-Overleg – RDO) take place between regional divisions of Rijkswaterstaat and the Water Boards. When water shortages occur, the crisis management moves up to the Management Team Water Shortages (MTW) and inter-departmental coordination (ICCb) takes place. At the highest crisis level, the Ministry Commission of Crisis Control (MCCb) takes charge. The linkage between the WRM organizations and DRM organizations (see Section 2.1.2) is illustrated in Figure 8.

The color coding for drought is as follows:

- Green: no shortages, normal management
- Yellow: shortages are imminent; LCW convenes, advises, and coordinates Rijkswaterstaat, Water Boards, Provinces, and RDO; measures are prepared – 1 in 2 year event
- Orange: actual water shortages; MTW takes over with LCW in an advising role; measures are implemented, including the enforcement of the priority list of water use – 1 in 5 year event
- Red: crisis water shortage (expected); the DRM organization takes over, WRM organizations continue to fulfil their responsibilities – 1 in 10 (and up to 1 in 20) year event.

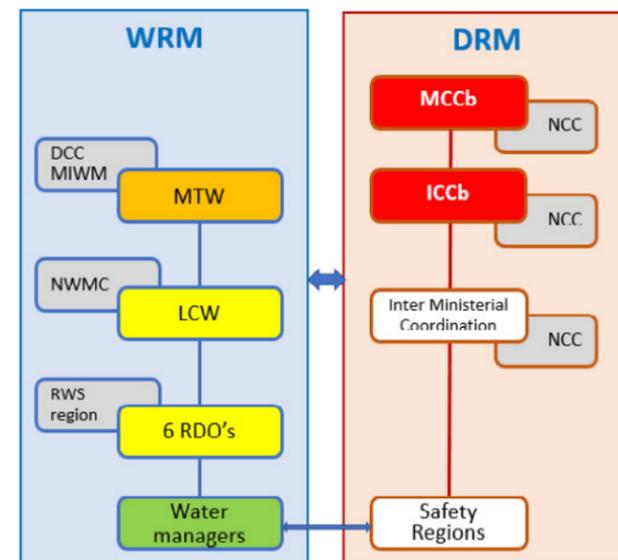


Figure 8. Organization structure and upscaling for WRM and DRM in drought management in the Netherlands

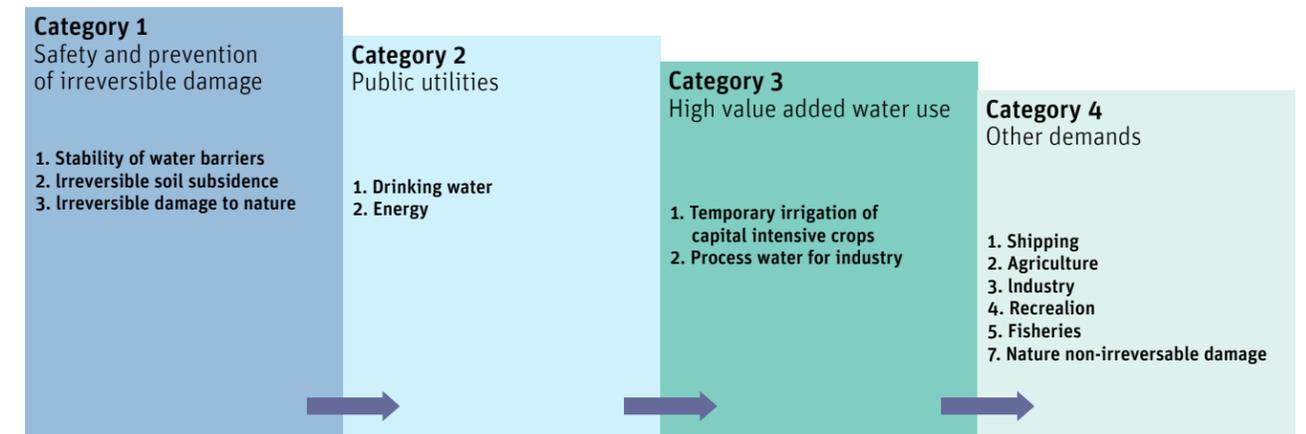


Figure 9. Pre-defined priority list of water use in case of shortage



River Meuse during the 2021 floods in Maastricht.

In the case of actual shortages, actions are taken in the water distribution system, such as allocating water to specific regions or decreasing flushing, and a pre-defined priority list of water use is applied as illustrated in Figure 9.

### Recovery and Insurance

The economic damages of a drought are considered to be a professional risk for the agriculture, shipping, public water supply, and industry sectors, and thus these sectors are not



generally compensated by the government. Insurance against droughts in agriculture is available but is not very popular. The reasons are the high costs of insurance and the large own risk. Droughts, however, have increased in frequency in recent years. That might change the thinking of both the government and private parties on recovery activities for drought. After the drought of 2018, for example, the government started to provide subsidies for drought insurance.

### 6.3 Disaster Risk Financing

According to a 2021 study commissioned by the European Commission '[t]here is currently no EU Member State with a comprehensive disaster risk financing strategy.' The study adds that the building blocks for a sound national disaster risk financing strategy in member countries are normally scattered around different sectors, such as disaster risk management, environment, and agriculture. National budgets contain provisions for disasters, but these are mainly stable, predictable, and contained expenditures for risk assessments, prevention, and preparedness, and to a certain extent emergency response. An analysis of past spending patterns for disasters shows that the spending focuses mostly on low-impact high-frequency disasters, with few arrangements made to deal with high-impact low-frequency events.<sup>21</sup>

In the Netherlands, the main instrument for disaster risk financing is the Calamities and Compensation Act (Wet Tegemoetkoming Schade bij rampen en zware ongevallen, in short: WTS) which provides the legal basis for disaster loss compensation up to a total of €450 million for uninsurable disasters such as major floods.

The EU is leading the path towards disaster risk financing with initiatives promoting climate action and resilience. Several existing European financing schemes have been activated and others have been established to provide funds that supplement national funds for DRM or climate action. EU funding is conditional and covers only part of the disaster cost; disbursement can take time due to specific procedural steps. However, tackling the future impacts from natural disasters will require member states to take steps towards more comprehensive disaster risk financing.

21. Radu, Diana (2021) Disaster Risk financing: Main Concepts & Evidence from EU Member States. European Commission



Canal in Delft, South Holland, Netherlands

# 7. Assessing the Netherlands Flood and Drought Risk Management System

EPIC Response Framework can help countries to systematically assess their flood and drought risk management systems and identify areas where flood and drought risks management programs and the collaboration between them can be strengthened.

Recognizing that program development is an evolutionary process, the EPIC Response Framework distinguishes four levels that indicate the development level of a program. The general categories of these four levels are shown in Table 1. The EPIC Response Framework has developed generic evolution tables that describe these four levels for each of the programs. These specific generic tables can be used to help evaluate the status of a program (Browder et al. 2021).<sup>22</sup>

The Netherlands hydro-climatic risk management system, as described in previous sections, has gone through these four levels of development. The evolution of the system was often triggered by major events, such as the Storm Surge Flood of 1953. That flood led to the Delta works. Similarly, the river floods of 1997 triggered the Room for the River Project and the Delta Programme, along with associated institutional changes. Moreover, the periodic updates of the NWP and NSS allow for incremental changes based on the performance of the flood and drought risk management systems. Climate change now is a major factor to be considered in further development of the risk management system, updating the flood risk management system, and further developing the drought risk management system.

Table 2 presents an assessment of the Netherlands Flood and Drought Risk management system. The main purpose of the table is to illustrate the evolution of the EPIC Response Framework programs and to generate a discussion on how to strengthen the overall flood and drought risk management system in the Netherlands. The scores are based on expert opinion and can be subject to discussion.

After the application of the EPIC Response framework, it can be concluded that the Netherlands is mostly advanced with respect to flood risk management, but that further devel-

opment of the risk framework is possible, especially in those programs related to drought risk management, such as conjunctive water management and allocation.

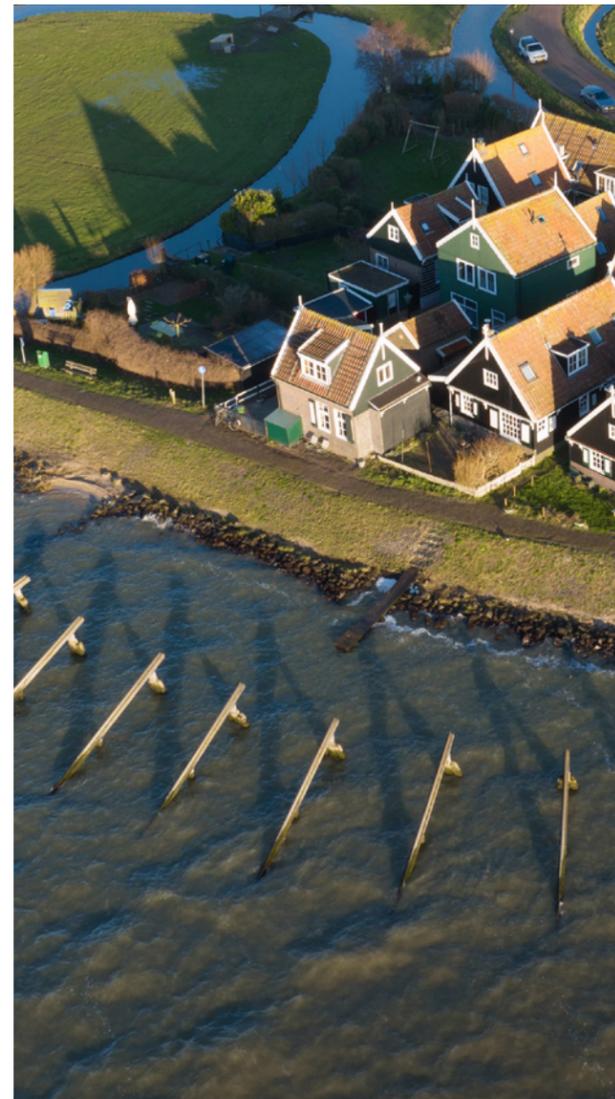


Table 1. Four development levels of a program

Nascent	Engaged	Capable	Effective
No legal framework or formal program. Ad hoc approach	Legal framework authorizes the program, but program not yet operational	Program is operational but still in early stages of implementation	Legal framework has been refined based upon experience, with mature program implementation

Table 2. Expert-based assessment of the Netherlands Flood and Drought Risk Management System

	Program area	Nascent	Engaged	Capable	Effective
<b>Enable</b>	WRM Framework				Major components of program area in place
	DRM Framework				Major components of program area in place
	Flood Risk Framework				Major components of program area in place
	Drought Risk Framework		Some components of program area in place	Major components of program area in place	Some components of program area in place
	Whole of Society Approach			Some components of program area in place	Major components of program area in place
	NMS/NHS Governance			Major components of program area in place	
	Hydro-met Services		Some components of program area in place	Major components of program area in place	Some components of program area in place
<b>Planning for mitigation</b>	RB-Plans incorporating flood and drought risk			Major components of program area in place	
	Irrigation water supply mitigation plans		Major components of program area in place	Some components of program area in place	Some components of program area in place
	Public water supply mitigation plans			Some components of program area in place	Major components of program area in place
	Coastal zone management plans		Major components of program area in place	Some components of program area in place	Some components of program area in place
<b>Investments</b>	Healthy watersheds			Major components of program area in place	Some components of program area in place
	Infrastructure investment policies				Major components of program area in place
	Flood control safety				Major components of program area in place
<b>Controlling</b>	Water allocation		Some components of program area in place	Major components of program area in place	Some components of program area in place
	Conjunctive groundwater management		Major components of program area in place	Some components of program area in place	
	Floodplain management			Major components of program area in place	Some components of program area in place
<b>Respond</b>	Flood emergency response				Major components of program area in place
	Drought response system			Major components of program area in place	Some components of program area in place
	Disaster risk financing		Major components of program area in place	Some components of program area in place	

Some components of program area in place  
Major components of program area in place

22. Browder, Greg, Ana Nunez Sanchez, Brenden Jongman, Nathan Engle, Eelco Van Beek, Melissa Castera Errea, and Stephen Hodgson. 2021. "An EPIC Response: Innovative Governance for Flood and Drought Risk Management—Executive Summary." World Bank, Washington, DC

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