Delta Programme

Report and findings of the Delta Programme 2018 Signal Group

including fact sheets and references

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July 2017

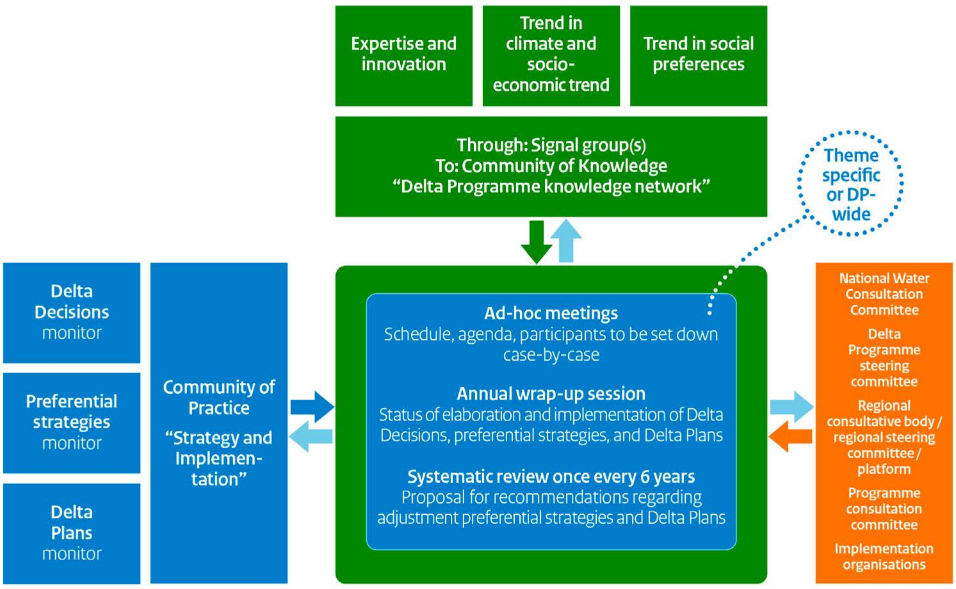
1. Introduction

Why a Signal Group?

The Delta Programme is based on an adaptive approach. This implies that a finger is kept on the pulse in terms of progress ("are we still on schedule?", the so-called Blue Line), and in terms of relevant external developments (the climate, socio-economic trends, knowledge, societal preferences and developments) ("are we still on (the right) track?", the so-called Green Line) (see Figure 1). By reference to the Green Line, we can determine whether we need to adjust the course or the pace of the Delta Programme. The Signal Group plays a monitoring role in this respect.

The Delta Programme Signal Group is charged with the following duties:

- Mapping out the external developments that could constitute reason for a reconsideration of the Delta Decisions, preferential strategies, and Delta Plans, or an adjustment of their implementation,
- Indicating when adjustment would be called for: in the context of the 6-year systematic reviews of the Delta Programme (the first of which is scheduled for 2019/2020), or ahead of schedule. The latter can be the case if the development identified is expected to have a major impact on the Delta Decisions, regional preferential strategies, and Delta Plans, if such impact is expected to manifest itself in the near future, and/or if such impact is relatively certain.



Relevant developments and impacts comprise:
- *Physical and socio-economic conditions* in the Netherlands or abroad, such as the development of the wind climate in relation to storm surges in the Wadden Sea and IJsselmeer lake, the long-term trend in extreme river discharges, the rising sea level, regional population growth, and regional depopulation;
- *Knowledge development*, such as the "proven strength" of dykes, insights into the stability of ice caps, or factors determining regional climate sensitivity. This also encompasses innovations, such as the market introduction of cheaper dyke improvement technologies, and new insights dictating an adjustment of the premises underpinning the Delta Decisions, preferential strategies, and Delta Plans, whether incorporated into underlying models such as the National Water Model or not;
- *Political developments and societal preferences*, such as the value that society (and politics) attaches to, e.g., nature, sustainability, and flood risk management, as well as policy decisions.

Information on the above developments and impacts can be generated through model simulations or be derived from authoritative reports.

How does the Signal Group work, who are the members?

The Signal Group is composed of experts from several authoritative knowledge institutes that are of relevance to the Delta Programme. For the time being, these are the Royal Netherlands Meteorological Institute (KNMI), the Netherlands Environmental Assessment Agency (PBL), Deltares, Wageningen University & Research Centre (WUR), and Rijkswaterstaat-Water, Traffic, and Environment (RWS-WVL). At a later stage, the Netherlands Bureau for Economic Policy Analysis (CPB) and the Netherlands Institute for Social Research (SCP) may be approached. The staff of the Delta Programme Commissioner is responsible for the organisation and chairmanship of the Signal Group.

The institutes have delegated a highly qualified expert to represent them in the Signal Group.

On the basis of its members' expertise, the Signal Group explores potentially relevant developments, and identifies which of these could constitute reason for an adjustment of the Delta Programme. Annual consultations are held with the representatives of the Delta Programme themes and regions to interpret the signals, in terms of their potential impact on the preferential strategies. The actual translation into amended strategies or sets of measures is the responsibility of the sub-programmes and the associated consultation committees, if any. The outcomes of this process are presented in the annual Delta Programme.

The Signal Group commenced its duties in the autumn of 2016. This first report addresses:
- The method and indicators (and the associated requirements) that the Signal Group will potentially be using (Paragraph 2);
- The first harvest of signals relevant to these indicators (Paragraph 3);
- The actions proposed for 2018 (Paragraph 4).

2. Monitoring method, points of attention for a monitoring system

In the trial year 2017, the Signal Group practised the compilation and application of a monitoring indicating system. To this end, we first examined what we want to know. Which developments are relevant to the expediting, slackening, or adjustment of the preferential strategies of the Delta Programme? And in which changes is this reflected? What are good indicators for such changes and their impact on the water system? This has subsequently been translated into what exactly we want to gauge in order to get timely and reliable signals.

What do we want to know?

The Delta Decisions and the preferential strategies of the Delta Programme are aimed at an adaptive approach to water taskings and climate change. These taskings are dictated by several “drivers”, such as climate change, socio-economic developments, and third-party actions. These drivers subsequently prompt changes in the water systems and impact operational functions. New knowledge can modify the insights into such changes, new technologies can affect the impact of such changes on operational functions or prompt new measures, and in addition, linkage opportunities may open up. Whether these developments and effects are socially acceptable and/or must lead to action depends on the prevailing policy frameworks and societal preferences. Such frameworks and preferences may also change over time, e.g., the importance attached to nature or sustainability.

For that reason, the Signal Group targets changes in the following indicators that are, in fact, representative for the relevant developments, underlying premises, and their impact on the three issues referred to in Chapter 1.

1. Relevant “drivers” of developments: climate (progress of the climate agreements set down in the Paris treaty, physical indicators), soil subsidence, demographics, developments relating to new construction/urbanisation/land use, impact of Water Assessment on spatial plans, quality of disaster control, financial capacity of the district water boards, scope of European collaboration. The developments may involve various scale levels: regions, the Netherlands, international catchment areas, Europe, or the global level. The scale level may also be significant in the purview of a good ratio between the large variations in the measurement series (the “noise”) and the trend one aims to detect (the “signal”).

2. Effects of these “driver” developments on the parameters that dictate the Delta Programme water taskings in terms of:
   a. “load” (sea level rise, storm frequencies, extreme discharges, frequency and duration of periods of drought, frequency and intensity of downpours);
   b. “management” (required pump capacity, closing frequency of storm surge barriers, required dyke improvements / river widening, closing off water intake);
   c. “damage/impact on consumers” (blocking of shipping traffic, agricultural damage, waterlogging).

3. Relevant premises in the underlying models of the Delta Programme, which have been used to determine the water taskings and which underpin the strategies (in particular, the delta model, e.g., with respect to Lobith discharge and upstream flooding, Rhine tributaries discharge distribution), storm surge duration, utilisation of superelevation of dykes, costs/benefits, discount rate, robustness allowance in dyke designs).

4. Societal preferences, such as the importance attached to sustainability, nature, and water awareness (especially in political and administrative circles).

This information must be tailored to the regional level (preferential strategies), the supra-regional level, or the national level (Delta Decisions).[1]

What do we want to measure?

The Signal Group uses a monitoring system to timely identify whether the Delta Programme needs to be adjusted. This system is composed of indicators that provide univocal, validated, and timely information. The information to be collected must meet specific requirements to this end:

- Univocality implies a good “signal-noise” ratio (for example, the frequency of extreme discharges measured is too low to warrant accurate information on trends in extreme discharges; consequently, you will need to gauge less extreme discharges occuring with a higher frequency, or extreme discharges in other catchment areas in Northwest Europe, or to
- model results);
- Certainty: the extent to which a potential trend is based on a combination of observations, forecasts, and plausible explanations is proportional to the certainty of its occurrence;
- Validated sources: this implies that the new data or knowledge originates from authoritative institutions or research programmes subject to peer review.
- Timeliness implies that the signals are early enough to allow sufficient time to expedite/slacken measures, or to switch strategies. It should be noted in this respect that the planning and realisation of water-related measures usually takes more than 10 years.

The challenge is to compile a good set of indicators that collectively produce timely and reliable signals. The indicators used in 2017 constitute a first set, that will be further improved in 2017-2018.

1 Supra-regional indicators pertain to, e.g., societal preferences such as the value that society (and politics) assigns to, e.g., nature, sustainability, flood risk management. Indicators relating to societal preferences are not taken into consideration in this first round; they will be addressed in the preparations for Delta Programme 2019.

3. Initial findings

Based on the method and requirements outlined above, the Signal Group has made a first selection of indicators that may be relevant to the Delta Programme with a view to potential adjustment. This selection has been supplemented with the outcomes of a Delphi analysis conducted in parallel.[2] Subsequently, the existence of potentially relevant signals relating to these indicators was explored. Such signals have been identified with respect to the following topics:

- **Worldwide, the sea level is rising more than has been assumed in the delta scenarios, but this additional rise is not yet manifest along the Dutch coast.**
- Wave heights are increasing more than originally assumed, resulting in more frequent or increased coastal erosion.
- The frequency of persistent patterns of atmospheric low pressure systems is increasing, involving prolonged excessive precipitation.
- Hurricane remnants reach the North Sea more frequently, potentially involving storm surges and precipitation.
- The winter discharges of the Rhine and Meuse are increasing more than assumed in the delta scenarios.
- The summer discharges of the Rhine and Meuse are falling more than assumed in the delta scenarios.
- **Supercells/cluster downpours are occurring more frequently, causing more frequent and more severe urban flooding.**
- Urban heat is less manifest than assumed in the delta scenarios.
- Discharge to the IJssel is increasing vis-à-vis the discharge distribution set down in policy.
- The water temperature of the Rhine and Meuse is increasing.
- The increasing use of IT in operations expands the options but also entails operational risks.

The two signals printed in bold have a potentially large impact on the Delta Programme. Worldwide observations are available regarding the accelerated sea level rise, but, on account of the relatively short measurement series of satellite observations they are, as yet, insufficiently reliable to establish such acceleration with any degree of certainty. Such acceleration cannot yet be observed along the Dutch coast. However, new insights and measurements are available regarding the accelerated loss of land ice on Antarctica, making a reasonable case for the acceleration trend. The increase in supercells/cluster downpours is already manifest in measurement series; the models indicate that this trend is likely to continue. In addition, there is a plausible causal explanation for this (change in) trend. Ergo, the (change in) trend is quite certain.

On account of the "impact" and "plausibility" reasons, the Signal Group has decided to describe these two signals in further detail (see Appendix Fact Sheets), to review their consequences with the Delta Programme regions and themes, and to have the following statement incorporated in Delta Programme 2018:

"The initial overview drawn up by the Signal Group shows two potentially important developments:

- *potential acceleration in sea level rise;*
- *increasingly more severe downpours, causing damage due to precipitation, hail, and gusts of wind (supercells).*

Measurements and new research indicate that the sea level is rising more rapidly than has been assumed in the delta scenarios. This still needs scientific confirmation by the IPCC. In 2021, the KNMI will need to translate this into new forecasts for the Dutch coast. In anticipation, the Signal Group is exploring and mapping out the potential consequences for the Delta Programme. The results will be presented in Delta Programme 2019. The increase in severe downpours is already manifest in measurements and forecasts for the future, and bears physical explanation. This development constitutes one of the justifications for the Delta Plan on Spatial Adaptation, and will be accommodated in the Climate-proof City focus area."

2 See DP2018, Paragraph 2.2.2.

4. What next?

In its second year, supplementary to the actions ensuing from the first two signals, the Signal Group will continue to develop the monitoring method and the required indicators into a proposal for a monitoring programme. Information regarding these indicators can originate from:

- New calculations (including the biannual National Water Model forecasts);
- Reports and scientific articles containing new knowledge or insights (e.g., from IPCC, KNMI, PBL or NKWK focus areas);
- Pilots (involving new technologies);
- Measuring programmes.

For each indicator, the proposal for the monitoring programme will indicate what will be measured / studied / collected, by which party (at which location and with which frequency), whether such efforts are already under way or are new, and how the efforts will be funded.

Delta Programme | Signal Group fact sheet

High end scenario for sea level rise by 2100

Rob van Dorland (KNMI), Marjolein Haasnoot (Deltares), Sybren Drijfhout (KNMI), and Laurens Bouwer (Deltares)

What do we see with respect to sea level rise?

Signs can be observed that indicate that as a result of increased melting and ice cliff collapse of Antarctic ice, by 2100 and beyond, the sea level may rise considerably more rapidly than was concluded in the fifth IPCC assessment report (2013).

Are there measurements, forecasts, and causal explanations?

Recent observations suggest that at several locations on the West Antarctic ice cap, an instability has set in that in a few decades' time will cause the ice to melt and break up at an accelerated pace. These processes have already been implemented in various ice cap models, as a result of which the volume of ice in these models is decreasing more rapidly compared to the models that have been used for the IPCC report (2013).

The question is how exactly these processes will need to be parameterised in the models. A model study conducted by DeConto and Pollard[1] has taken account of two processes that as yet have not been taken into consideration in other models. This generates much more extreme values in terms of sea level rise. A strong point in this study is that it enables explanation of estimated variations in the sea level in palaeo climates up to three million years ago.

A team of KNMI scientists (Le Bars et al.[2]) have taken this study as their point of departure for a further elaboration into probabilistic scenarios for global sea level rise by 2100 under the highest emissions scenario RCP8.5), and based on the premise that the processes that, according to this study, are breaking down the Antarctic ice cap provide a realistic picture of

1 DeConto, R.M and D. Pollard, 2016: Contribution of Antarctica to past and future sea-level rise. Nature, 531, 591-597.
2 Le Bars, D., S. Drijfhout and H. de Vries, 2017: A high end sea level rise probabilistic projection including rapid Antarctic ice sheet mass loss. Environmental Research Letters.

the upper limit of the sea level rise to be expected, and therefore can serve as the point of departure for an extreme sea level rise scenario.

Within what time frame and with what probability?

Under the lowest emissions scenario (RCP2.6, corresponding to the 2-degree target), DeConto and Pollard do not observe any substantial differences in the contribution of the Antarctic ice cap to global sea level rise vis-à-vis the IPCC report (2013). However, this outcome has been criticised by other scientists, because in this model, the Antarctic ice cap appears in balance with the current ocean-atmospheric forcing, whereas this is actually not the case. By virtue of the Paris agreement (2015), the IPCC will present figures in 2018 on the sea level rise under the 1.5 degrees target. Yet further research is needed to provide a realistic picture of the contribution of the Antarctic ice cap under such an emissions scenario.

Based on the premises of DeConto and Pollard, there is a 5% probability that the sea level will rise by some 2.5 to 3 metres by 2100. A rough estimate based on this study is a sea level rise of approx. 18 metres by 2500.

The above figures pertain to the global average. The sea level rise values for the Dutch coast have not yet been calculated.

Does this deviate from the delta scenarios?

The calculated upper limits are considerably higher than those listed in the IPCC report. They also exceed the 1.15 metres of the worst-case scenario calculated by the Royal Netherlands Meteorological Institute KNMI in 2008 on behalf of the Delta Committee (Veerman scenario).

Existing Dutch policy studies assume a sea level rise of less than 1 metre. Three studies assume a rise of between 1 to 6 metres. No studies exist into the consequences of a sea level rise of more than 6 metres.

Such high estimates for an extreme scenario are in line with other international findings. The latest scenario developed by the National Oceanic and Atmospheric Administration (NOAA) in the United States, and the scenario that a British team has developed in the purview of planning the flood defence system in the river Thames have already arrived at such high figures, although unlike the KNMI study, they were not based on model calculations.

Does this lead to an adjustment of the preferential strategies?

Many Antarctic models arrive at lower estimates, simply because the dynamic processes described by DeConto and Pollard have not been taken into account yet. In order to assess the solidity of DeConto and Pollard's findings, and consequently also that of the extreme sea level scenario published by the KNMI researchers, it is crucial for these missing processes to be incorporated into other models as quickly as possible. The KNMI continues to closely monitor the developments and intends to conduct its own ice sheet model studies. In parallel to these studies, Deltares and KNMI, in concert with the Delta Programme regions and themes, will develop a more concrete picture of what these new insights may entail for the Delta Decisions and preferential strategies, building on the Hackathon conducted by Deltares.[3] The outcomes of this in-depth elaboration will be included into Delta Programme 2019.

3 Deltares has set up a hackathon to map out the potential impact of an extreme scenario. See https://www.deltares.nl/app/uploads/2017/04/Hackathon-resultaten-rapport.pdf (in Dutch).

Delta Programme | Signal Group fact sheet

Increase in extreme downpours

Rob van Dorland (KNMI) and Geert Lenderink (KNMI)

What do we see with respect to measurements and forecasts relating to extreme downpours?

Signs can be observed that indicate that extreme precipitation in the Netherlands is increasing due to higher temperatures. Extreme downpours are increasing in terms of both frequency and intensity. There are indications that higher air humidity as a consequence of a warmer climate is resulting in the formation of larger clusters of downpours, including so-called "supercells" that may give rise to extreme downdraft winds and hail.

Tables 1 and 2 give an indication of the expected increase in precipitation volumes in 2 and 24 hours at return frequencies of 2, 10, 50, and 100 years in the current climate (2014) and in 2050, based on existing precipitation statistics and climate projections.

Return frequency in years	In 2014	In 2050 (highest scenario)
2	24 mm	27 mm
10	36 mm	42 mm
50	49 mm	59 mm
100	56 mm	67 mm

Table 1: 2-hour precipitation intensity in mm at four return frequencies in the current climate and in 2050 (highest value in the four KNMI'14 scenarios)

Return frequency in years	In 2014	In 2050 (highest scenario)
2	42 mm	49 mm
10	59 mm	68 mm
50	77 mm	90 mm
100	85 mm	100 mm

Table 2: 24-hour precipitation intensity in mm at four return frequencies in the current climate and in 2050 (highest value in the four KNMI'14 scenarios)

Of note is the fact that the Netherlands and surrounding countries have recently already seen actual precipitation intensities in the range of 100 mm per hour:

- Apeldoorn: 120 mm in 75 minutes (2009)
- Herwijnen: 94 mm in 70 minutes (2011)
- Deelen: 75 mm in 60 minutes (2014)
- Munster: 220 mm in 90 minutes (2014)
- Copenhagen: 150 mm in 120 minutes (2011)

This involved extreme events of short duration. Further research will be conducted into the driving mechanisms of such “supercells”/clusters of downpours. On account of the brief duration (< 2 hours), the specific mechanism, and the recent date (> 2010), this phenomenon is not yet clearly visible in the existing precipitation statistics, and does not (yet) warrant linking to return frequencies.

Are there causal explanations?

Based on measurement data recorded since 1951, we have established an increase in precipitation intensity in severe downpours of approx. 12% per degree (Lenderink et al.[1]). This occurs in particular with dew point temperatures[2] over 16 degrees Celsius. This phenomenon can also be observed at other locations in the world (Westra et al.[3]).

In a warming climate, moisture content in the atmosphere increases. This increase more or less equals the 6.5% per degree increase in the maximum volume of water vapour that the air can contain at a certain temperature (Clausius-Clapeyron equation). A 1 degree increase in air temperature will result in an approx. 1 degree increase in dew point temperature. This means that in a warmer climate, the number of summer events involving dew point temperatures of more than 16 degrees Celsius will increase, resulting in a higher probability of severe downpours. During severe downpours, vertical movements are stronger as well. As a result, more ambient moisture is absorbed, which can raise precipitation intensity by 12% per degree. In connection with the stronger vertical movements in the downpour, the probability of gusts of wind, downdraft winds, thunderstorms, and hail will increase (in terms of both hailstone size and frequency).

Furthermore, there are recent indications that the size of severe downpour clouds is increasing.[4] This means that the total volume of precipitation in these “supercells” may increase even more than the 12% per degree Celsius as stated.

1 Lenderink et al, 2011: Scaling and trends of hourly precipitation extremes in two different climate zones – Hong Kong and the Netherlands. Hydrol. Earth Syst. Sci., 15, 3033–3041.
2 Dew point temperature is defined as the temperature to which the air must cool down for condensation to occur. The higher the moisture content, the higher the dew point temperature.
3 Westra, S. et al., 2014: Future changes to the intensity and frequency of short-duration extreme rainfall. Rev. Geophys., 52, 522–555, doi:10.1002/2014RG000464.
4 Lenderink et al, 2017: Super Clausius-Clapeyron scaling of extreme hourly convective precipitation and its relation to large-scale atmospheric conditions. Journal of Climate, in review.

Although we have observed an increase in the number of extreme precipitation days in the coastal area and the central section of the country, and a negative trend at some locations in the eastern part of the Netherlands, the locations at which heavy clusters of downpours occur are highly random in nature. The hourly extremes radar images for the period 1998-2008 show quite a bit of scatter, in contrast to the daily extremes. This may be attributed to the limited span of the data set (11 years), but it could very well be that there are no or few regional differences in extreme hourly precipitation.

Within what time frame and with what probability?

For the future, we expect the trend towards heavier downpours will continue, because dew point temperatures over the 16 degrees Celsius threshold will be increasingly common during the summer.

To what extent does this deviate from the delta scenarios?

The KNMI'14 climate scenarios for the Netherlands already mention the trend of more severe summer downpours. The study into the increasing frequency of large clusters of downpours is new. The first results show that the increase in waterlogging and especially urban flooding is higher than foreseen in the KNMI'14 climate scenarios.

Is there reason for adjusting the preferential strategies?

The KNMI continues to monitor the developments closely, and also intends to conduct further research into the precipitation intensity, gusts of wind, thunderstorms, and hail in supercells. In addition, research is required to determine regional differences and their causes, if any, such as the effects of land-sea transition and of urban areas. The outcomes of such research will be discussed in the Signal Group and with representatives of the Delta Programme in order to determine whether and how this warrants adjustment of the preferential strategies.

Points of attention in relation to the preferential strategies:

- Problems with local drainage in sewer systems, particularly in urban areas;
- Damage and injuries due to downdraft winds, hail, and thunderstorms attendant on heavier downpours;
- Management issues for the district water boards during the summer.

Delta Programme

The Delta Programme is a national programme involving an innovative collaboration between the central government, the provinces, municipalities and district water boards, with input from civic society organisations, knowledge institutes, citizens, and the business community. The aim is to protect the current and future generations of the Netherlands against flooding, to ensure a sufficient supply of freshwater and to climate-proof our country in order to prevent major damage.

The Delta Programme Commissioner submits an annual proposal for the Delta Programme to the Minister of Infrastructure and the Environment, fosters the implementation of the Delta Programme, and monitors progress. The proposal comprises all the measures scheduled and provisions made to reduce floods, pluvial flooding and water shortages. The Delta Programme is presented to the States General every year on *Prinsjesdag*, the state opening of Parliament.

Eight areas are working on the further elaboration and implementation of the strategies outlined in the Delta Programme. These areas cover the entire country. They are:
- Rhine Estuary-Drechtsteden
- Southwest Delta
- IJsselmeer Region
- Rhine
- Meuse
- Coast
- Wadden Region
- Elevated sandy soils

www.rijksoverheid.nl/deltaprogramma
www.deltacommissaris.nl

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