# Policy evaluation Sand Engine 2021

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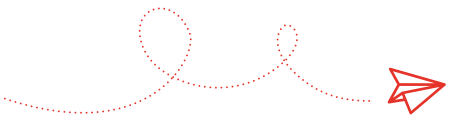

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# Management summary

The shallow coastal zone in the Netherlands is mainly composed of sandy sediment. The amount of sand determines the location of the coastline, with the beach and dunes behind it offering nature values and safety. The amount of sand constantly changes due to supply and discharge, waves and tidal currents. In net terms, in many places along the Dutch coast there is not enough sand to maintain the coastline, making coastal maintenance necessary. These shortages will increase in the future due to a rising sea level. It is common practice in the Netherlands to maintain the coast with sand placed on the coastline by dredging vessels (also known as 'sand replenishment'). This fits in with Dutch policy of working with sediment as far as possible and making use of natural processes, according to the "Building with nature" design philosophy. A faster rising sea level will probably require maintenance with more and possibly larger replenishments. With the Sand Engine, knowledge is acquired about large-scale replenishments that will prepare Dutch coastal policy for the future.

The Sand Engine project combines several policy goals:

1. *Stimulating natural dune growth in the coastal area from Hoek van Holland to Scheveningen. This dune growth serves various functions, namely safety, nature and recreation.*
2. *Generating knowledge development and innovation to answer the question of to what extent this form of coastal maintenance can provide added value for recreation and nature.*
3. *Adding attractive recreational and natural areas to the Delfland coast.*

Regular sand replenishments are primarily aimed at maintaining the coastline and guaranteeing water safety in the long term. The Sand Engine project is also aimed at knowledge development (e.g. can this type of nourishment be used more often in the future?) and the creation of a nature reserve and recreation area. Moreover, large-scale replenishment can be cheaper and less damaging to the ecology than repeated regular replenishment. This evaluation examines the three policy goals and how the management of the Sand Engine has contributed to achieving them. Although this policy evaluation will take place in 2021, the Sand Engine is still in full development. That dynamic will ensure that the Sand Engine will also lead to new insights in the years ahead.

### Coastal protection

One of the aims of the Sand Engine is to make a long-term contribution to coastal safety. Safety on the Delfland coast was already in order thanks to the reinforcement of the dunes in 2010. The Sand Engine has led to additional coastal reinforcement and extended the life span of the coastal reinforcement.

A gradual growth has taken place of the dunes / sea strip of the Sand Engine. It concerns a considerable volume (700,000 $m^3$ landward of the Sand Engine). Because of the design of the Sand Engine with a lagoon and a dune lake the additional dune growth as a result of the Sand Engine over the last 10 years has been less than anticipated. The formation of vegetation and embryonic dunes has increased since 2016, but at the moment it does not contribute significantly to further reinforcement of long-term coastal safety.

The development over the next few years is uncertain and could accelerate (further) because:

- By catching sand, the lagoon and the dune lake become smaller and smaller. This increases the chance for drifting sand to reach the dunes.
- Dune development has an erratic pattern, partly due to the influence of storms. It is conceivable that after years of little development, vegetation and dunes suddenly appear rapidly.
- Dune growth as a natural process shows a growth curve: in the first five years, one hectare of new dune was created, which is less than expected. Development has been faster since 2016. Especially on the south side of the Sand Engine, embryonic dunes are forming in places where vegetation is starting to grow.

**Knowledge and innovation**

The Sand Engine project has proved to be a breeding ground for a broad knowledge base on innovative, sandy solutions through an effective combination of monitoring (the 'what') and scientific research (the 'how'). Several knowledge institutions and researchers are or have been active on the Sand Engine and many insights have been gained over the past 10 years. The NatureCoast and NEMO programmes have been described as very valuable and unique collaborations between knowledge institutions and disciplines.

The export value of the Sand Engine is still small, because of the limited number of locations worldwide where a Sand Engine-like solution has a chance of success. With the exception of the project in Bacton, England, no comparable large-scale replenishment has been carried out (yet). In spite of this, the Sand Engine delivers a lot of value in terms of knowledge and innovation. Insights from the monitoring and innovative measuring methods can be applied in other coastal protection projects - there's no need to build an exact copy of the Sand Engine in order for it to be of value for the development and export of knowledge. On a strategic level, the Sand Engine has kickstarted a new way of thinking about sandy strategies, which has been an inspiration for other (sand replenishment) projects at home and abroad.

**Nature and recreation**

The added value of the Sand Engine for nature and recreation is of a temporary nature: the Sand Engine is designed to (almost) disappear in the long term, and so these functions will. This is where this policy objective differs from the 'permanent' policy objective of knowledge and innovation.

In terms of landscape and dynamics ('naturalness'), the Sand Engine is a very valuable area. For the time being, the Sand Engine adds little to the diversity of plant species, under the influence of unfavourable conditions - such as dry soil, salty sea wind and drifting sand - but also during periods of drought. The greatest natural value seems to come from the fact that the Sand Engine has a positive effect on benthic life and resting/fertilising birds. Both are connected because shorebirds (and fish) feed on benthic organisms. The Sand Engine has potential as a habitat for coastal breeding birds.

However, these birds are very sensitive to disturbance, making the combination of recreation and nature difficult to reconcile in this respect.

The Sand Engine clearly attracts recreational users, and specific target groups: while the Sand Engine is less popular with beach tourists, the area attracts people looking for space, tranquillity and nature. Due to favourable conditions (no direct open connection with the sea), the Sand Engine lagoon has a strong attraction for kite surfers.

It has been shown that the Sand Engine has a positive effect on the perception of visitors. Because of its recreational function, the Sand Engine also represents a considerable economic value. However, only part of the economic value can be attributed to the Sand Engine, because the Sand Engine has not demonstrably led to an increase in the number of visitors (compared to before 2011) and it is uncertain how future-proof that value is.

**Management**

In the area of beach and bathing safety, cooperation between managing organisations, such as the local rescue teams, went well and the risks were well manageable. It can be said that this contributes to the value of the Sand Engine as a recreational area. At the same time, recreation puts pressure on the Sand Engine as a nature area. The decision not to apply recreational zoning has not proved beneficial to nature. Motorized traffic and cleaning work also put pressure on the development of vegetation and dunes. Although additional agreements were made about this early on in the management phase, in order to give nature as much room as possible to develop. Lessons have thus been learned in this area and the management has proved adaptive, thus contributing to the formation of vegetation and dunes.

Risks to vegetation foreseen in the N2000 Solleveld area seem (for the time being) either not to occur, or to be manageable. There is a certain degree of effect on sand spray and salt spray, but so far this has not had a major impact on the vegetation present. The risk to drinking water production at Solleveld (threat of salt increase and pollution) has been prevented by a management measure, the construction of a drainage system.

A point of attention in the management is the control and coordination between authorities, such as the municipalities involved, rescue teams, Zuid-Hollands Landschap, etc. Although this has not led to any problems or incidents, it does constitute a risk for the future. Namely, that suboptimal choices are made in management. In summary, the conclusion is that management does not stand in the way of achieving the policy goals. In addition, by means of an overarching management strategy and more clarity on agreements, management can be deployed more actively to achieve the policy goals.

**Recommendations**

On the basis of the sources studied and interviews conducted (see appendix), the researchers come to five recommendations.

1. *Draw up a vision for the future of the Sand Engine.* The Sand Engine will disappear in the long term, just as it has been designed. That need not be negative, but it will mean that the nature

and recreational value will also disappear. And coastal protection will require a follow-up to the Sand Engine. This could be regular replenishment, or another large-scale replenishment. The recommendation is to draw up a vision for this, so that the future management of the Sand Engine after 2021 can already anticipate on the time after the "planned life span" of the Sand Engine. Rijkswaterstaat and the province of Zuid-Holland will have to take the lead in this.

2. *Continue to disseminate the lessons learned from the Sand Engine (internationally).* Not only because this will create opportunities for Dutch market parties, but also because parts of the Sand Engine could be suitable for coastal protection issues abroad. In addition to actively communicating the instrument, promoting it also means continuing to bundle knowledge from various separate pilots (Sand Engine and comparable projects) and scaling up its application (via public-private partnerships) to a broader coastal policy.
3. *Evaluate the current monitoring programme (the MEP).* Monitoring of the Sand Engine has provided a lot of insight into the developments over the past 10 years. Given the scope and importance of the monitoring programme, it makes sense to evaluate it. Research how the results can be optimally translated into practical knowledge for managers and policy makers and, in addition, test the monitoring programme against its scientific added value.
4. *Continue to monitor the Sand Engine.* The Sand Engine has not yet been 'fully developed' and the dynamics can provide ever-changing insights about, for instance, dune growth or swimming risks. Monitoring will remain relevant for the time being. However, choices must be made regarding the depth of the research financed by the government and, in any case, continue to monitor matters that are *necessary* for the continued development of knowledge about the Sand Engine. Also consider where and how monitoring is currently organised, and investigate whether this can be effectively combined.
5. *Reassess the management agreements and record them in the long term, in line with the future vision from recommendation 1.* Have Rijkswaterstaat and the province of Zuid-Holland, as joint commissioners, draw up a vision of how the various management elements can be coordinated: who is in charge and who plays what role? Appoint a clear point of contact and consider introducing (more) structure in the coordination between authorities. Recalibrate (or renew) management agreements. Although the greatest morphological changes have occurred in the first few years of the Sand Engine project, the dynamics are still unpredictable. Because of this dynamic, close monitoring of beach and swimming safety will continue to be necessary.

# 1. Introduction

## 1.1 The Sand Engine as large-scale sand replenishment

The shallow coastal zone in the Netherlands is mainly composed of sandy sediment. The amount of sand determines the location of the coastline, with the beach and dunes behind it offering nature values and safety. The amount of sand constantly changes due to supply and discharge, waves and tidal currents. In net terms, in many places along the Dutch coast there is not enough sand to maintain the coastline, making coastal maintenance necessary. These shortages will increase in the future due to a rising sea level. It is common practice in the Netherlands to maintain the coast with sand placed on the coastline by dredging vessels (also known as 'sand replenishment'). This fits in with Dutch policy of working with sediment as far as possible and making use of natural processes, according to the "Building with nature" design philosophy. A faster rising sea level will probably require maintenance with more and possibly larger replenishments. With the Sand Engine, knowledge is acquired about large-scale replenishments that will prepare Dutch coastal policy for the future.

The national government has the task of protecting the country against floods from the sea, and pursues policy on this. Dikes, dams and dunes provide that protection. To offer sufficient protection to the hinterland, the dunes must contain sufficient sand, and the entire coastal base[1] must remain in balance with the rising sea level. The central government therefore carries out so-called 'sand replenishments' on a regular basis in order to provide the coast with extra sand and to keep the coastline where it was in 1990 (as laid down in Derde Kustnota 2000: “Traditie, Trends en Toekomst”). The sand is collected from the deeper parts of the North Sea. Replenishment currently takes place about every five years in places where there is a lot of erosion. By that time, a new replenishment is needed to keep the coastline in place.

But this is not without its drawbacks. Dredging up sand (from the deep North Sea) and repositioning it (near the coast) disrupts nature and benthic life. For the quality of flora and fauna, it is better to keep the frequency of replenishments at a minimum. "Building with nature' is the design philosophy that utilises natural processes in the design of hydraulic solutions.[2] It is a pilot for a large-scale replenishment. This means applying a larger quantity of sand in one go, after which nature - via waves, currents and wind - spreads the sand further along the coastline. The intended benefit to nature is that it will need to be replenished less frequently and that the area can be left in peace for a longer period.

The Sand Engine pilot combines several policy objectives. Regular sand replenishment is primarily aimed at maintaining the coastline and guaranteeing water safety in the long term. The Sand Engine project is also aimed at knowledge development (e.g. can this type of nourishment be used more often in the future?) and the creation of a nature reserve and recreation area. Moreover, large-scale replenishment can be cheaper and less damaging to the ecology than repeated regular replenishment.

1 This is the zone within which the sand on the coast moves in about 200 years. The boundaries of the coastal base lie seaward at NAP -20m and landward where the dunes merge into the hinterland.

2 See www.ecoshape.org for other examples of "Building with Nature" projects.

An important precondition for the construction of the Sand Engine was that it was an *additional* coastal protection measure (not a replacement for existing coastal reinforcement plans).[3]

## 1.2 Dynamics of the Sand Engine

The Sand Engine was realised in 2011 by replenishing 21.5 million $m^3$ gross and[4] 18.7 million $m^3$ net of sand. This is far more than the volume of sand used in regular replenishment. Of the total sand volume, approximately 16.6 million $m^3$ was used for the island and 2.1 million $m^3$ for two replenishments to the south and north of the Sand Engine. The expected life span of the Sand Engine when it was constructed was 20 years. Nowadays a longer life span is expected. In the long run a more or less smooth coastline will develop, but that will take at least a couple of decades.[5] The image on the right [6] shows the Sand Engine after construction in 2011.


Under the influence of waves, currents and wind, the sand moves from the head of the Sand Engine along the coast, in northern and southern direction. In the first three years of the Sand Engine, the erosion was the strongest. And especially in the winter months, during storms. Analyses have shown that waves in particular have an important influence on the distribution of the sand. Waves that arrive on the Sand Engine at an angle create a strong current, which transports the sand to the flanks of the Sand Engine. Most of the waves arrive at the Sand Engine from a southerly direction, causing most of the sand to be deposited on the northern side. This can be seen in the position of the Sand Engine, which after construction has shifted more and more in the direction of Kijkduin/Scheveningen[7]:

3 Ambitieovereenkomst Zandmotor (2008).
4 Dredging always involves a loss of sand, so the amount of sand applied is less than what has been extracted from the sea.
5 MEP Report 2021 (Deltares).
6 MEP Report 2021 (Deltares).
7 MEP Report 2021 (Deltares).


In the ten years since its construction in 2011, some 500 metres of coastal decline have taken place, measured at the point of the Sand Engine that lies furthest out to sea.[8]

The 'dune lake' and the 'lagoon', which were in the original design, still exist. Because sand is blown into them, the wet surface of both decreases. The 'spit' is the elongated sandbar on the northwest side of the Sand Engine, which is partly submerged at spring tide. A 'gully' has formed through the spit, which grows longer and shallower over the years, closing off the lagoon from the North Sea. At present, the lagoon is even completely devoid of any exchange of water with the sea.[9] Other important developments are the formation of sand banks and cliffs.

## 1.3 Evaluation of policy and management objectives

The Sand Engine has an extensive monitoring and evaluation programme, the MEP. In it, all parts of the Sand Engine are evaluated. In addition, the contract for the Sand Engine monitoring stipulated that an interim policy evaluation would be carried out after 5 years and a final evaluation after 10 years.[10] This report contains the results of the latter policy evaluation.

8 MEP Report 2021 (Deltares).
9 MEP Report 2021 (Deltares).
10 Transfer and assignment of Sand Engine monitoring from DG RWS Jan Hendrik Dronkers to HiD R. Hillen, dated 28 February 2012.

The 2016 interim evaluation outlines the extent to which the Sand Engine's goals are being achieved. The researchers state that the concept of the Sand Engine as a multifunctional form of coastal maintenance seems to have been successful. The coastal development is proceeding as expected in 2016 (although the dune growth is modest), a dynamic nature area with various habitats has been created, as a recreational area the Sand Engine is widely used and highly valued, and the pilot has given an impulse to the development of knowledge and its application in other coastal protection projects. The evaluation resulted in a number of recommendations for the continuation of the project, focusing on monitoring, organisation and socio-economic aspects, among other things.

The Sand Engine is dynamic: nature's forces change its shape, and with it the functions (nature, recreation) of the area. That is why it is important to monitor and periodically evaluate it. The aim of this policy evaluation is to find out whether the Sand Engine has proved a success, what lessons can be learned for future coastal protection policy in the Netherlands and what recommendations can be made for the continuation of the monitoring and management conducted around the Sand Engine. The success of the Sand Engine is linked to the three policy goals set at the start of the pilot project:

1. *Stimulating natural dune growth in the coastal area from Hoek van Holland to Scheveningen. This dune growth serves various functions, namely safety, nature and recreation.*
2. *Generating knowledge development and innovation to answer the question of to what extent this form of coastal maintenance can provide added value for recreation and nature.*
3. *Adding attractive recreational and natural areas to the Delfland coast.*

After the Sand Engine's construction, a management objective has also been formulated: *The collection of sufficient and adequate information to be able to manage the Sand Engine and its surroundings properly.*[11]

## 1.4 Approach to policy evaluation and reading guide

### Approach

The development of the Sand Engine is intensively monitored under the coordination of Deltares. An extensive plan for the monitoring and evaluation programme (MEP) was drawn up at the start in 2011.[12] In it the three policy objectives and the management objective were subdivided into concrete sub-questions and various underlying hypotheses which are tested in the MEP. Some evaluation questions were modified after the 2016 policy evaluation, at the request of Rijkswaterstaat Water Verkeer en Leefomgeving (RWS WVL) as client, so that they became more testable. The MEP maps out developments in morphology, hydrodynamics and ecology, among other things, in detail, evaluating them for each component. In this evaluation it is an important source for answering the question whether the Sand Engine's goals have been achieved.[13] In addition to the technical-substantive aspects and the question whether the goals of the Sand Engine are achieved, the evaluation also pays

11 See among other things: Uitvoeringsprogramma Monitoring en Evaluatie pilot Zandmotor (Deltares et al., 2011).
12 Uitvoeringsprogramma Monitoring en Evaluatie pilot Zandmotor (Deltares et al., 2011).
13 Part of the monitoring is not the responsibility of RWS WVL. The province of Zuid-Holland is responsible for questions relating to recreation (in relation to nature), swimming safety, groundwater, measurements of overgrowth, beach management and the use/valuation of the Sand Engine. Dunea is monitoring the effects of the Sand Engine on groundwater.

attention to the socio-economic and social aspects and the Sand Engine as a policy project (among other things around the theme of collaboration). For this purpose, the earlier policy evaluation from 2016, project documentation from the client and insights from interviews were mainly considered.

The evaluation was carried out in a number of phases. In the first phase, the researchers studied a number of key documents, such as the MEP report 2016 and the MEP report 2021. Based on this, a knowledge document was then drawn up with points for attention for interviews. In the next phase, interviews were held with stakeholders, both public and private. This report contains a number of quotes from the interviews. Some of these are direct quotes from an interviewee, others are quotes collated by the authors of this report. The interviewees have been promised that quotations will not be traceable.

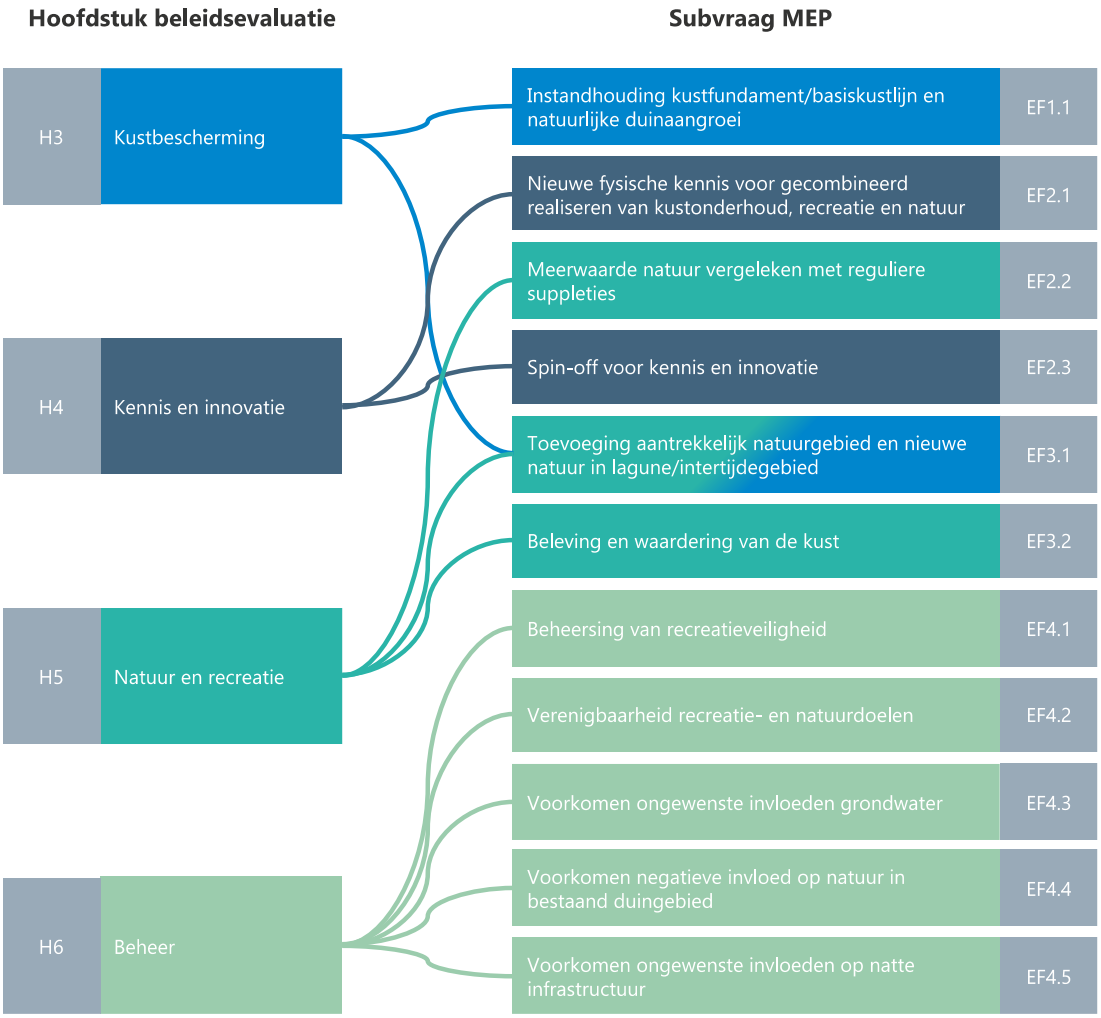
Finally, the insights from the document study and the interviews were brought together and, based on a synthesis by the research team, translated into conclusions and recommendations. RWS WVL is the commissioning party for this final evaluation and was involved in the review of interim products and analyses.

**Reading guide**

Chapter 2 discusses the Sand Engine as a project: its realisation, the appreciation of those involved and the project organisation. The subsequent chapters will discuss the substantive policy goals: coastal protection (chapter 3), knowledge and innovation (chapter 4), nature and recreation (chapter 5). The extent to which the Sand Engine's management objective has been realised is presented in chapter 6. The conclusions and recommendations follow in chapter 7.

The appendix to this report contains a list of consulted documents and stakeholders.

As mentioned, the policy goals and management goal of the Sand Engine have been subdivided in the MEP into several sub-questions in order to operationalise them for the monitoring. The figure below gives an overview of where the sub-questions from the MEP come up in this policy evaluation (in Dutch). Because the policy objectives of the Sand Engine are central to this evaluation, the chapter structure follows these objectives. The researchers have found it logical for the readability of this report to sometimes let the sub-questions land in another chapter, as can be seen in the following illustration.


Hoofdstuk beleidsevaluatie
Subvraag MEP
H3
Kustbescherming
H4
Kennis en innovatie
H5
Natuur en recreatie
H6
Beheer
Instandhouding kustfundament/basiskustlijn en natuurlijke duinaangroei
EF1.1
Nieuwe fysische kennis voor gecombineerd realiseren van kustonderhoud, recreatie en natuur
EF2.1
Meerwaarde natuur vergeleken met reguliere suppleties
EF2.2
Spin-off voor kennis en innovatie
EF2.3
Toevoeging aantrekkelijk natuurgebied en nieuwe natuur in lagune/intertijdegebied
EF3.1
Beleving en waardering van de kust
EF3.2
Beheersing van recreatieveiligheid
EF4.1
Verenigbaarheid recreatie- en natuurdoelen
EF4.2
Voorkomen ongewenste invloeden grondwater
EF4.3
Voorkomen negatieve invloed op natuur in bestaand duingebied
EF4.4
Voorkomen ongewenste invloeden op natte infrastructuur
EF4.5

# 2. Sand Engine as a project

## 2.1 The process by which the Sand Engine was created

The realization of the decision to construct the Sand Engine is described in detail in "Het verhaal van de Zandmotor".[14] In this publication, various perspectives are presented: from representatives of different governmental organizations, to private parties and several environmental organizations. It does justice to the various images of (the realization of) the Sand Engine project.

When these images are juxtaposed, the impression of coincidence can arise: the Sand Engine was built because it was possible at the time. But dismissing it as a coincidence does insufficient justice to the complexity of the decision-making process. A well-known theory in administration science is the creation of a so-called "*policy window*".[15] This refers to the moment when a policy or project proposal suddenly becomes possible. This is the case when three streams come together: there is an existing problem, there is a possible solution, and there is political-administrative room to embrace the policy or project proposal. The Sand Engine is an example of what such a *policy window* can look like:

- **Problems** were identified by various parties, although different parties emphasized different problems. There was a (statutory) need for coastal reinforcement, as the Delfland coast had been identified as one of the "Weak Links" in the Dutch coastal defences. Before the Sand Engine was constructed, this entire coastal section was therefore reinforced. The Sand Engine was never intended as a reinforcement measure (which is why it has been given a pilot status), but as a possible solution for coastal maintenance in the longer term, in the context of rising sea levels. There was also a need for more recreational area in the southern part of the province.
- There was a possible **solution**, namely the Sand Engine. This solution had not yet been tested in practice, but could offer an answer to the problems mentioned.
- **Political-governmental space** was created, partly as a result of the financial crisis that started in 2008. The Crisis and Recovery Act was adopted, for example, which meant that procedures could be completed more quickly. There was a great deal of willingness to invest, if this meant that employment could be safeguarded. The costs could be limited, because it was possible to follow in the slipstream of the construction of Maasvlakte 2, and because of favourable market conditions such as low fuel prices and under-utilisation of dredging capacity. For these reasons, there was also (political) willingness to accept uncertainty and construct the Sand Engine.

In short, the Sand Engine could be constructed in 2011 because the circumstances permitted it at the time. But it was not a coincidence.

14 Het verhaal van de Zandmotor. Het turbulente proces van een innovatie binnen het waterbeheer bezien vanuit verschillende invalshoeken (Jan Baltissen, 2015).
15 This theory has been developed and described in several publications by John W. Kingdon.

## 2.2 Rating by stakeholders

The interviews conducted show that the Sand Engine is generally regarded as a success story. Most of the interviewees indicated that, with the benefit of hindsight and under similar circumstances, they would opt to build a 'Sand Engine' again. Depending on the role of the interviewee in question, the success is linked to policy goals (coastal protection, knowledge and innovation, nature and recreation), but in almost all cases there are also some comments. We will look at this in more detail in Chapter 3.

The interviewees describe a number of success factors that have led to the realization of the Sand Engine (in the way it has been done). Reference has been made to the 'open' formulation of the Ambitieovereenkomst, respect for the dynamics and uncertainty of the Sand Engine, and the removal of resistance in the decision-making process prior to the Sand Engine.

*"The Ambitieovereenkomst in 2008 was very important for the realisation of the Sand Engine. It wasn't immediately solution-oriented ('we're going to build a Sand Engine'), as is often the tendency. But the agreement contained broad ambitions that the parties involved wanted to fulfil together. The various designs were then tested against those ambitions."*

*"The original idea was: we lay down a lot of sand that can develop spontaneously. And then came the consultation rounds with residents and the politicians got involved. A design threatened to emerge that would not work. Namely, a dynamic nature process with all kinds of demands being made in advance. Fortunately, that didn't turn out so well in the end."*

*"It is very important that you get all parties on board right away. Nature organisations, for example, met with some resistance in the beginning, because they feared that certain animal species would die. WNF was also involved at the time and they convincingly put forward the benefit to nature. The overcoming of resistance went very well in this project, where positive influence of national organisations and a good atmosphere in consultations were success factors."*

In addition, the driving role of EcoShape and some politicians have been mentioned as motivators for the realization of the Sand Engine.

*"A platform like Ecoshape is very important for initiatives like the Sand Engine to get off the ground. It provides a safe (pre-competitive) environment to seek cooperation, in the ideal composition of public and private parties."*

*"As far as I am concerned, it will come as soon as possible." (Jan Peter Balkenende during a meeting of the Innovation Platform in Scheveningen, 4 February 2008."*[16]

## 2.3 Project organisation and dynamics

Especially in the preparation and construction phase, the Sand Engine had a layered project structure, with various consultations and about 20 organisations playing a role. The decision to establish the project structure was made when the Ambitieovereenkomst was signed in March 2008 (see Article 8 of that document). The agreement was signed by the Province of South Holland, the (then) Ministry of Transport, Public Works and Water Management, the municipalities of Westland, The Hague and Rotterdam, the Delfland Water Board and the South Holland Environmental Federation. In the Ambitieovereenkomst, the following agreements were made about the project organisation:

16 https://www.parool.nl/nieuws/kabinet-achter-plan-eiland-in-noordzee~b126ab49/.

- In the development phase of the Sand Engine concept, the Province of South Holland is acting as director and initiator. In the implementation phase, this role will pass to Rijkswaterstaat.
- There will be a steering committee responsible for monitoring goals, preconditions and starting points, and it will be empowered to take decisions at certain times.
- A project group will prepare the work of the steering committee from an administrative point of view. In the development and implementation phase, the province provided the core team for this project group; from 2012, the project group was led by Rijkswaterstaat.

All of the above parties are represented in the steering committee and project group. In addition, working groups have been set up, for example on certain management functions (such as beach and swimming safety) and on the various research programmes. In this project organisation, the environmental impact assessment (EIA) process was completed in 2009. As of the tender (May-September 2010, awarded in December 2010), the project was taken over by Rijkswaterstaat. Between March and November 2011, the Sand Engine was constructed off the Delfland coast, between Ter Heijde and The Hague.

Many interviewees observed a similar pattern in the dynamics of the project. Before the Sand Engine was constructed, there was a great deal of energy involved in the project and the EIA procedure was carried out energetically. The Province of South Holland had an important driving role in that phase. There was also a lot of involvement in the years after construction, especially because of the novelty and the rapid changes of the Sand Engine, which had to be coordinated and responded to. The interviewees state that the project dynamics diminished afterwards, without making value judgments. This picture is in line with the 2016 policy evaluation, which notes that a number of consultation structures eventually transitioned into an informal (non-structural) setting.

# 3. The Sand Engine for coastal protection

## 3.1 Policy objective and sub-objectives

The first policy objective of the Sand Engine is: "To stimulate natural dune growth in the coastal area between Hoek van Holland and Scheveningen for safety, nature and recreation".

Contributing to coastal safety in the long term is central to this policy objective and relates to the Sand Engine's coastal protection function by strengthening the existing dunes and developing new (embryonic[17]) dunes. The Sand Engine's contribution to nature and recreation is not only related to the development of the dunes, but also to the construction and layout of the entire Sand Engine.[18]

In the EIA for the Sand Engine[19], an estimate of the increase in dune area was given for each design studied at the time. For the chosen design - "Hook North" - the expectation was that in 20 years about 28 to 33 hectares of dunes would be created, compared to about 16 to 17 hectares in the reference alternatives.

## 3.2 Results

Dunes are formed and strengthened by the wind picking up sand on the Sand Engine and transporting it landwards. Most of this sand lands on the first dune row and only a limited amount on the dunes behind it. The amount of transported sand per year is higher than at the rest of the Delfland coast, but the growth rate of existing dunes is not higher than at other places. The reason is that a lot of sand is caught 'on the way' in the lagoon and the dune lake.[20]

Although most of the dynamics in the development of the Sand Engine was in the first five years, this does not apply to the development of new dunes. In the first five years one hectare of new dunes was created, which is less than expected.[21] One reason for this was the short measurement period in which the dunes could have developed, in combination with the fact that it was decided not to plant marram grass. After all, dunes need plants (particularly marram grass) in order to grow, and the same plants benefit from leaving sand behind. Dunes and vegetation reinforce each other, and this growth process can take decades.[22] The shared use (use by cars for all kinds of work) of the beach has also been cited as an important cause of a brake on the development of embryonic dunes, see chapter 6.

The picture of dune growth in recent years is more positive: development has accelerated since 2016. In 2018 there were approximately 6 hectares of embryonic dunes, in 2020 this has increased to approximately 13 hectares. Especially on the south side of the Sand Engine embryonic dunes are formed in places where vegetation starts to grow. In the middle and northern parts, it has occurred

17 Dunes are embryonic when they are in the early stages of dune formation.
18 Beleidsevaluatie Zandmotor 2016 (Anantis, Royal HaskoningDHV).
19 Projectnota/MER: Aanleg en zandwinning Zandmotor Delflandse kust (2010).
20 MEP report 2021 (Deltares).
21 MEP report 2016 (Deltares).
22 MEP report 2021 (Deltares).

even less, mainly due to recreational pressure and because the Sand Engine has been constructed high up here.[23]

The MEP also takes a broader look at the development of the (amount of) sand present in the area, the so-called 'sediment balance'. Net, in the area on and around the Sand Engine about 60% of the eroded sand can still be found. This is much less than after the first five years, when almost all the sand (about 95%) from the Sand Engine was still present within the monitoring area. The lion's share of the sand has spread along the coast, but a limited amount has been transported towards the dunes.

## 3.3 Conclusions on coastal protection

One of the aims of the Sand Engine is to make a long-term contribution to coastal safety. Safety on the Delfland coast was already in order thanks to the reinforcement of the dunes in 2010. The Sand Engine has led to additional coastal reinforcement and extended the life span of the coastal reinforcement.

A gradual growth has taken place of the dunes / sea strip of the Sand Engine. It concerns a considerable volume (700,000 $m^3$ landward of the Sand Engine). Because of the design of the Sand Engine with a lagoon and a dune lake the additional dune growth as a result of the Sand Engine over the last 10 years has been less than anticipated. The formation of vegetation and embryonic dunes (especially since 2016) have not yet contributed significantly to the further strengthening of long-term coastal safety.

The development over the next few years is uncertain and could accelerate (further) because:

- By catching sand, the lagoon and the dune lake become smaller and smaller. This increases the chance for drifting sand to reach the dunes.
- Dune development has an erratic pattern, partly due to the influence of storms. It is conceivable that after years of little development, vegetation and dunes suddenly appear rapidly.
- Dune growth as a natural process shows a growth curve: in the first five years, one hectare of new dune was created, which is less than expected. Development has been faster since 2016. Especially on the south side of the Sand Engine, embryonic dunes are forming in places where vegetation is starting to grow.

23 MEP report 2021 (Deltares).

# 4. The Sand Engine for knowledge and innovation

## 4.1 Policy objective and sub-objectives

The second policy objective of the Sand Engine is: "To generate knowledge development and innovation to answer the question to what extent coastal maintenance can generate added value for recreation and nature". In the MEP, this policy objective has been operationalised in sub-questions about the physical knowledge gained for the joint realisation of objectives (coastal maintenance, nature, recreation), the knowledge about the added value for nature (specifically: sediment and soil composition) compared to regular replenishment and the spin-off of the Sand Engine for knowledge and innovation. The focus in this policy evaluation is on the latter: the degree to which the Sand Engine is a breeding ground for applied and scientific research, and the extent to which there is a spin-off of knowledge and innovation for sandy strategies at home and abroad.

## 4.2 Results

The Sand Engine was set up as a pilot project of serious proportions. Expectations were formulated about what the project would yield, but due to its innovative character, there were also many uncertainties. It was therefore decided to monitor and evaluate the pilot project extensively. In addition to the ten-year MEP, two scientific research programmes – NEMO[24] and NatureCoast[25] – were running, involving knowledge institutions TUDelft, Utrecht University, Twente University, Wageningen University, VU University Amsterdam and the Netherlands Institute for Ocean Research (NIOZ). Knowledge partners see a nice interaction between the two projects: while the MEP mainly measures *what* happens, the scientific part is needed to explain *why* it happens. The "ownership" of the knowledge programme lay (primarily) with Rijkswaterstaat and the Province of South Holland; the municipalities were less involved.

Interviewees express their appreciation for the role played by EcoShape and Rijkswaterstaat in the initiative to apply for the ERDF subsidy that made it possible to set up the NatureCoast programme on a grand scale. The NatureCoast programme was described as innovative because it was multidisciplinary and the combination of disciplines and themes was necessary to explain things. From a scientific perspective, a number of interviewees regret that the programme could not be continued after 2016, as the Sand Engine has a (much) longer lifespan and is still producing new knowledge.

*"The great thing about NatureCoast was that all disciplines and themes were represented in one programme. That was rare in the past and really was an added value of NatureCoast. The interaction between disciplines was also necessary to be able to explain things properly."*

*"It is important that parties reserve time at the start of the research to influence the research and its direction and to indicate what they want out of it. When researchers are up to speed, they are oil tankers and difficult to change course. The province*

24 A European research project to gain insight into the interaction between dunes, beach and coastal foundation. Three PhD students and three postdocs were involved.
25 An interdisciplinary research programme investigating how currents, morphology, dune formation, ecology, hydrology and governance interact, and ultimately shape the coastal landscape. This involved 12 PhDs and three postdocs.

*was well involved in the research part. Their ideas and questions were certainly well addressed. We saw the municipalities less."*

The knowledge and innovation function of the Sand Engine has, potentially, an impact on coastal protection at the operational (concrete) and strategic (abstract) levels at home and abroad. The following picture emerges from the document study and interviews with stakeholders regarding the extent to which this impact is already visible.

**Operational**

- The Sand Engine, as an instrument – a large-scale replenishment developed by nature – has so far received little follow-up. There is one project that is comparable to the Sand Engine in terms of methodology (Bacton, United Kingdom), although it is less complex in design and scope.[26] An important reason is that the number of locations worldwide where a replenishment of this magnitude would be promising is very limited. There are locations with coastal erosion, but only a limited number where the idea of large-scale replenishment fits in with the physical conditions (enough sand, no large waves), governmental context (preference for short-term measures, restrictions on funding) and socio-economic wishes (development of recreation and tourism).[27]

  *"The exportability is partly determined by the division of responsibilities. In the Netherlands, coastal protection belongs to Rijkswaterstaat and the Water Boards. In many other countries, the ownership belongs to a hotel or a local government, for example. And a local government doesn't want to make investments if the benefits largely accrue to its neighbours."*

- Another question is whether certain insights have been gained in MEP and/or scientific research and applied in regular coastal replenishment or innovative national and international coastal protection projects. This specifically concerns technical insights, such as the role of the lagoon and the dune lake as a sand trap or the effect of storms on morphological development. Abroad, work has been done on Sand Engine-like solutions, using morphological models to predict the life span and spread of sand.[28] Experiments were also carried out with innovative measuring techniques, which will be more widely applicable to coastal maintenance in the future, such as measuring the coast using drones and computer models for landscape development.[29]

  *"Some things you really have to try in order to learn from them. Take dune growth. In the first five years, not much happened there, but recently it has become more and more common. But more importantly, we have gained insight into the whole dynamics of dune growth, and this is now being increasingly considered in other projects."*

26 Although the sand replenishment at Bacton was inspired and made possible by the Sand Engine – see below – and is a large-scale replenishment by British standards, it involves a much smaller amount of sand and with a primary focus on coastal protection.
27 Onderzoek naar de economische en sociale meerwaarde van de Zandmotor (Ecorys, 2020).
28 MEP report 2021 (Deltares).
29 MEP report 2021 (Deltares).

**Strategic**

- The Sand Engine can be seen as an ambassador for the concept of "Building with Nature". Interviewees indicate that the Sand Engine has greatly broadened the thinking on innovative sandy strategies, and has raised awareness of the fact that other objectives (than coastal protection) can be linked to sand replenishment. The Sand Engine pilot project has had a driving role for projects such as Hondsbossche Duinen and Amelander Zeegat, and the sand resplenishment near Bacton (United Kingdom). Interviews show that the Sand Engine has not only been an inspiration but also a precondition for the Bacton sand replenishment.

  *"In the United Kingdom, there is a strong focus on maximising (social) returns and, as a result, there is much less room (and less budget) for innovation. There is room for it in the Netherlands. The Sand Engine as 'tried and tested innovation' has laid the foundation for the project at Bacton."*

  *"The value of the Sand Engine for the market parties involved is great. For the knowledge and experience gained from the collaboration. But also for the story: that these kinds of solutions will really be needed in the future and that they are capable of shaping them well. Clients both at home and abroad are increasingly asking for this."*

- It is indicated that a pilot such as the Sand Engine is not only successful if the project is repeated at other locations. It is also about applying the knowledge gained in 'regular' projects.
- At the same time, a number of discussion partners note that the Sand Engine has not yet led to an upscaling of alternative sandy strategies for the whole of the Netherlands. They would like to see a step being taken in terms of governance to give "Sand Engine-like" solutions a place in the regular coastal care.

  *"The Sand Engine, Hondsbossche Duuinen and Amelander Zeegat. All interesting projects, but separate pilots. And they were also organised as separate pilots. You organise pilots so that you can eventually incorporate them into your policy. But we are apparently not yet able to translate the various pilots into an upscaling of the concept.*

  *"It would be nice if the Sand Engine were embedded in a larger story. How can the Sand Engine be used as a vehicle for upscaling? The ministry has not yet given this point much thought. One idea might be to review the earlier Ambitieovereenkomst, recalibrate it and see who would be prepared to put their signature on it again. This would require a party to be a clear enabler of the process, as EcoShape was at an earlier stage. "*

## 4.3 Conclusions on knowledge and innovation

The Sand Engine project has proved to be a breeding ground for a broad knowledge base on innovative, sandy solutions through an effective combination of monitoring (the 'what') and scientific research (the 'how'). Several knowledge institutions and researchers are or have been active on the Sand Engine and have gained many insights in the past 10 years. The NatureCoast and NEMO programmes have been described as very valuable and unique collaborations between knowledge institutions and disciplines.

The export value of the Sand Engine is still small, because of the limited number of locations worldwide where a Sand Engine-like solution has a chance of success. With the exception of the

project in Bacton, England, no comparable large-scale replenishment has been carried out (yet). In spite of this, the Sand Engine delivers a lot of value in terms of knowledge and innovation. Insights from the monitoring and innovative measuring methods can be applied in other coastal protection projects - there's no need to build an exact copy of the Sand Engine in order for it to be of value for the development and export of knowledge. On a strategic level, the Sand Engine has kickstarted the thinking about sandy strategies, which has been an inspiration for other (sand replenishment) projects at home and abroad.

# Intermezzo: added value of the Sand Engine

Following the 2016 policy evaluation, two investigations into the added value of the Sand Engine were started, at the recommendation of an International Audit Committee set up at the time. These studies had not been assigned to the MEP. Besides further knowledge development, the purpose of these was to share and reflect on the knowledge about the value of Sand Engine in an international perspective. Describing the added value of the Sand Engine will ultimately help in the policy decision on long-term coastal maintenance with multiple functions. This knowledge is important in an international context in order to be able to realize similar concepts as the Sand Engine.

The first study concerned the socio-economic value of the Sand Engine and was conducted by Ecorys (2020). This study mainly looked at the economic (recreational) value, the business case of the Sand Engine compared to regular replenishments and the added value for nature. The other study, conducted by Deltares (Heleen Vreugdenhil et al., 2021), looked at 'social' value in terms of art and culture, archaeology and palaeontology, education, economics and spatial planning.

**Socio-economic value**

The socio-economic value from the Ecorys study, as a result of nature and recreation, is discussed in chapter 5, as this is one of the policy objectives of the Sand Engine. The business case of the Sand Engine will be given separate attention below.

The total construction costs for the Sand Engine amounted to about €70 million (excluding VAT)[30], of which about €50 million was for depositing the sand.[31] The amount not spent on construction went largely to monitoring and evaluation. This was paid for with government funds, EU subsidies and by EcoShape. Rijkswaterstaat funded approximately 5/6$^{th}$ of the construction and the Province of South Holland 1/6$^{th}$.

A relevant policy question is whether construction of the Sand Engine will ultimately be cheaper than repeated replenishments. At the moment this is still unclear and something that should be further investigated. As follows from this policy evaluation, the Sand Engine now has a longer lifespan than expected, which potentially increases its cost-effectiveness. However, the costs of replenishments also strongly depend on factors as the type of replenishment, the scale, the location and market circumstances (capacity at dredging companies, current sand and fuel prices). Therefore, it cannot be said beforehand whether a large replenishment is always more cost-effective than repeated replenishments, or vice versa.

**Social value**

Besides the economic costs and benefits, there are also social effects in a broader sense. The Sand Engine is seen as an 'icon' within hydraulic engineering, a breeding ground for artistic and cultural expressions, and an exceptional site for archaeology and palaeontology. The area also offers many opportunities for education.[32] This was not foreseen beforehand.

30 Onderzoek naar de economische en sociale meerwaarde van de Zandmotor (Ecorys, 2020). This is approximately equal to the reported amount of €85 million including VAT.
31 Hoe bruikbaar is de Zandmotor? (Rijkwaterstaat et al., 2014)
32 Maatschappelijke meerwaarde van de Zandmotor (Deltares, 2021).

# 5. The Sand Engine for nature and recreation

## 5.1 Policy objective and sub-objectives

The third policy objective of the Sand Engine is as follows: "To add an attractive recreational and natural area to the Delfland coast".

Beforehand, no concrete targets were set for the development of flora and fauna, fitting the idea of letting the Sand Engine 'free' in its development. Naturally, positive nature effects were expected. For example, the lagoon enclosed by the hook is protected against waves and currents, so natural conditions here are relatively calm and other benthic animals and ecology could develop, the large surface area of the hook and the dune lake are potentially favourable as resting places for marine mammals and birds, and there is room for plants on the beach and in the dunes. At the same time, there were concerns about possible negative effects on nature in the underlying Natura 2000 area of Solleveld. These possible effects were therefore closely monitored.

The attraction that the Sand Engine would have for recreational users was also unknown. Positive effects were expected, however, because the shortage of recreational space in the southern part of the province was one of the reasons for siting the Sand Engine at its current location.

## 5.2 Results nature

### Development of vegetation

Interviewees, and especially nature organisations, describe the Sand Engine as an area of great value in terms of landscape and dynamics ('naturalness').

> *"There are a lot of gullies and sand banks. Many dune lakes have been created and have disappeared again. A wonderfully dynamic process."*

After a few years vegetation formation was already observed on the Sand Engine, including sea kelp, rush grass and marram grass. But from the monitoring it appears that the development of the number of species of plants on the Sand Engine is still limited, but that this was not to be expected on this term either. Also, the drought in recent years limited (not only on the Sand Engine) the development of vegetation.[33]

However, new (embryonic) dunes have been growing (especially since 2016), creating a habitat for new vegetation.

### Development of species

The Sand Engine increases the habitat and the diversity of habitats for fish, various species of shorebirds and marine mammals. In theory, the Sand Engine should also lead to less disturbance of the benthic animal community due to the lower frequency of replenishment. The most important insights into the development of animal species after 10 years of the Sand Engine are:

33 MEP report 2021 (Deltares).

- The number and diversity of benthic animals increased in comparison to a measurement made in 2010. This applies especially to the flanks, the relatively sheltered zone north of the Sand Engine and in the lagoon. New habitats have arisen here that were not there before the Sand Engine was constructed.
- Especially its size makes the Sand Engine a suitable resting and foraging area for birds. Due to the larger surface area of the new beach zone, larger numbers of gulls, terns and waders have been observed.[34] However, the number of shorebirds has declined since 2017.[35] The Sand Engine has the potential to be an excellent habitat for breeding shorebirds, such as the rare Great Ringed Plover and Kentish Plover. Due to human disturbance – mainly walkers, kite surfers and people walking their dogs – there are few breeding birds on the Sand Engine: none at all in the first five years, after which there have been a number of observations.[36]
- The number of (juvenile) fish cannot be stated because there was too much variation in the measurements and the monitoring was only carried out in the first few years.
- Marine mammals are often observed, but in small numbers. Despite the relative calm, there seem to be too many visitors to create a safe environment for marine mammals.[37]

## 5.3 Results recreation

From the start, the Sand Engine gave a different impulse to recreation. Frequent guests are kite surfers, hikers and people walking their dogs. The arrival of kitesurfers, who make use of the relatively calm water in the lagoon, came as a surprise. There is now also a kite surfing school on the Sand Engine. A development in recent years has been that people are increasingly spreading their visits over the day and more into the evening hours. This requires extra efforts from supervisory bodies. There are also fewer bathers. This has to do with the intended dynamic development of the Sand Engine: by spreading sand along the coast, the distance to the sea increases in more places (except at the height of the Sand Engine itself); there are many places for beach visitors that are more accessible than the Sand Engine.

The perception of the Sand Engine is predominantly positive. Initially there were low expectations about the intended result of the Sand Engine among local residents, especially in the municipality of Westland, but now there is a mostly positive attitude about the nature and recreational possibilities. Although it is not yet possible to speak of a feeling of 'connection' among local residents. This was confirmed in the interviews. The Sand Engine has added value for visitors in terms of experiencing nature and on the whole the Sand Engine seems to have a (small) positive effect on the popularity of the coastal zone.

*"In the early years, we had to deal with dangerous sea currents, the pavilion owners who were troubled by the shifting sand and an unexpectedly high influx of visitors who had to be guided in the right direction. That was a challenge, but now the dust has settled and it is above all a nice crowd puller."*

34 Onderzoek naar de economische en sociale meerwaarde van de Zandmotor (Ecorys, 2020).
35 MEP report 2021 (Deltares).
36 MEP report 2021 (Deltares).
37 MEP report 2021 (Deltares).

On average, there are 395,000 *visits* to the Sand Engine each year – the number of unique *visitors* is lower because of repeated visits – which together provide approximately €3.7 million in direct spending (mainly in the hospitality sector). In addition, an estimate of €0.7 million is linked to residential tourism (overnight stays). The employment that can be linked to activities around the Sand Engine is approx. 63 labour years. It should be noted, however, that the estimated economic value, viewed on a national scale, mainly concerns redistribution effects (spending that is made elsewhere in the Netherlands, but still within the Netherlands). It is also important to note that recreational preferences on the Sand Engine can change over time. Silting up the lagoon will put pressure on its function as a kite surfing location. At the same time, the experience of nature could increase in the future.

## 5.4 Conclusions on nature and recreation

The added value of the Sand Engine for nature and recreation is of a temporary nature: the Sand Engine is designed to (almost) disappear in the long term, and so these functions will. This is where this policy objective differs from the 'permanent' policy objective of knowledge and innovation.

In terms of landscape and dynamics ('naturalness'), the Sand Engine is a very valuable area. For the time being, the Sand Engine adds little to the diversity of plant species, under the influence of unfavourable conditions - such as dry soil, salty sea wind and drifting sand - but also during periods of drought. The greatest natural value seems to come from the fact that the Sand Engine has a positive effect on benthic animal life and resting/foraging birds. Both are connected because shorebirds (and fish) feed on benthic organisms. The Sand Engine has potential as a habitat for breeding shorebirds. However, these birds are very sensitive to disturbance, making the combination of recreation and nature difficult to reconcile in this respect.

The Sand Engine clearly attracts recreational users, and specific target groups: while the Sand Engine is less popular with beach visitors, the area attracts people looking for space, tranquillity and nature. Due to favourable conditions, the Sand Engine lagoon also has an unexpected attraction for kite surfers.

It has been shown that the Sand Engine has a positive effect on the perception of visitors. Because of its recreational function, the Sand Engine also represents a considerable economic value. However, only part of the economic value can be attributed to the Sand Engine, because the Sand Engine has not demonstrably led to an increase in the number of visitors (compared to before 2011) and it is uncertain how future-proof that value is.

# 6. Management of the Sand Engine and the dunes of Solleveld

## 6.1 Description of management tasks

In addition to the three policy objectives, there is also a management objective. This was added after the Sand Engine's construction and reads: "*The collection of sufficient and adequate information to be able to manage the Sand Engine and its surroundings in a good way.*" In the MEP the management objective has been operationalized in sub-questions about the extent to which recreational safety could be managed, the compatibility of recreational and nature objectives, the prevention of undesirable groundwater influences, the prevention of new dune area on the nature values on existing nature area and the effects on the wet infrastructure.

The policy evaluation of management has a substantive and an organisational aspect. Content-wise, it concerns firstly the management of risks in the area, and secondly the question whether the management contributes to achieving the policy goals (realising water safety, generating knowledge, developing natural and recreational areas). In organisational terms, it concerns collaboration between the various authorities that play a role in management.

The basis for the management of the Sand Engine is in the Beheerovereenkomst pilot Zandmotor (2010). This agreement stipulates that the Province of South Holland is primarily responsible for the day-to-day management. The management is outsourced but paid for by the Province of South Holland. The management tasks can be divided into three categories:

- *Supervision and beach surveillance*. Agreements on this can be found in the cooperation agreement on beach and swimming safety for the Sand Engine pilot project. The parties involved are the Haaglanden Safety Region, municipalities and voluntary rescue teams. The municipalities receive a subsidy for surveillance (The Hague) and support for rescue teams (Municipality of Westland).
- *Nature and recreation management*. This task – supervision and provision of information for visitors, cleaning, monitoring of flora and fauna, and special (ad hoc) management measures – has been entrusted by the province to Zuid-Hollands Landschap.
- *Nature management of the Solleveld dunes*. Dunea performs this management task, as laid down in a covenant with the province. The purpose of the covenant is to lay down the agreements between the parties concerning the responsibility for the construction, management and monitoring of the geohydrological measure and the financing of those aspects.

Section 6.2 deals with surveillance and beach monitoring, section 6.3 with the management of nature outside the Sand Engine and section 6.4 with the compatibility of nature and recreation management.

## 6.2 Beach and bathing safety

A recent evaluation for the province[38] shows that the monitoring of swimming and beach safety has gone well. In 2011, the Sand Engine was not yet open to the public. The following two years a (partial) ban on swimming applied due to dangerous currents, but as of 2014 this no longer applied. The number of incidents involving swimmers has been relatively small in recent years. In 2020, there was a sharp increase in incidents, but this was the case along the entire coast, due to the combination of warm weather (crowds), offshore wind and the presence of many channels. Risks materialised (including, for example, the formation of quicksand), but these were largely foreseen and it was therefore possible to respond well to them. In addition, (following an incident involving people getting trapped at high tide) signs have been placed at each entrance showing a walking route to prevent people getting trapped.

Ultimately, the swimming risks are relatively limited because risks appear to occur mainly in poorly accessible areas or during extreme weather (when there are few beach users), and are mainly attributable to kite surfers.[39][40]

The arrival of the Sand Engine has given an impulse to the collaboration between the voluntary rescue teams of Monster, The Hague and 's-Gravenzande.[41] In the past there was little need for cooperation, but now there is because the Sand Engine extends over a larger area. Valuable knowledge has been exchanged between the parties and the collaboration has contributed to the desire to further professionalise the rescue teams. In the context of the professionalisation of rescue teams, the Province of South Holland has also invested in the development of an app that paints a picture of potentially dangerous swimming situations.

## 6.3 Nature outside the Sand Engine

The Sand Engine borders the Natura 2000 area 'Solleveld & Kapittelduinen'. Natura 2000 areas are strictly protected, for example against undesirable external influences. After exploring the possible influence of the Sand Engine on the natural values in this area, it was decided to carefully monitor the following effects:

- Changes in the amount of 'sand spray'
- Changes in the amount of 'salt spray'
- Changes in vegetation and the presence of breeding birds
- Waterlogging due to groundwater rise
- Undesirable impact on wet infrastructure

38 Terugblik 10 jaar Zandmotor – Strand en zwemveiligheid 9 strandseizoenen (Royal HaskoningDHV, 2021).
39 MEP report 2021 (Deltares).
40 Terugblik 10 jaar Zandmotor – Strand en zwemveiligheid 9 strandseizoenen (Royal HaskoningDHV, 2021).
41 Terugblik 10 jaar Zandmotor – Strand en zwemveiligheid 9 strandseizoenen (Royal HaskoningDHV, 2021).

### Sand spray

The Sand Engine allows a considerably larger quantity of sand to be sprayed into the dune area behind it. This 'sand spray' is favourable for nature development in the habitat type 'Grey Dunes'[42], but too much of it covers the vegetation and is actually detrimental. In the 2016 interim MEP report, there was no clear effect – negative or positive – of the sand spray on nature in Solleveld.[43] In 2021 the picture is unchanged, which is attributed to the active management taking place in the area.[44]

### Salt spray

Wind transports salt particles into the dune area. This is called 'salt spray'. These particles are important, because they prevent the development of sea buckthorn scrub and thus ensure the preservation of the habitat type Grey Dunes. The surf is the most important source of the salt, and the distance to the dunes determines the amount of salt spray. By constructing the Sand Engine this distance was increased and there was the concern that less salt would be blown in. After 10 years of the Sand Engine a decrease in salt spray seems indeed to be the case, but many measures have been taken to counteract encroachment (partly already before the construction of the Sand Engine), such as grazing and the construction of small ridges. This makes it difficult to establish a link between salt spray and vegetation (as well as between sand spray and vegetation).[45]

### Vegetation and breeding birds

There are no clear changes in vegetation visible in Solleveld that are related to the construction of the Sand Engine. This observation should be qualified by the fact that in 2010 (just before the Sand Engine was built) the sea strip was reinforced. This makes it difficult to distinguish any negative effects of the Sand Engine in a general sense. On the strengthening of the sea strip, more roughening has taken place landward of the Sand Engine, which indicates that there is an influence of the Sand Engine. Because this doesn't belong to the N2000 boundary, this is not a negative effect of the Sand Engine on Solleveld.

### Wetting

Rain sinks into the sand towards the groundwater. Fresh groundwater is lighter than salt groundwater and will float on top of it, forming a 'freshwater lens'. The Sand Engine expands the area where a freshwater lens can form and changes the flow of groundwater. This is a risk to the production of drinking water in the dunes, because the watershed would be situated to the west of an area where contaminants may be present in the soil, thus creating a risk of contaminated (and saline) water flowing to Dunea's drinking water production. This risk was recognised at the start of the Sand Engine project and a drainage system was installed to prevent any negative impact on the drinking water

42 Grey dunes form the largest part of the Dutch dune landscape. These are areas of great biodiversity. Low grasses, herbs, mosses and lichens are the dominant vegetation. The relative importance of the Netherlands for this habitat type in Europe is large to very large.
43 MEP report 2016 (Deltares).
44 MEP report 2021 (Deltares).
45 MEP report 2021 (Deltares).

extraction.[46] This averted the risk, but it cannot be determined whether the groundwater level would have risen without intervention.[47]

**Wet infrastructure**

Beforehand, a risk was estimated that the Sand Engine, because of silting up, would possibly have a negative influence on the ports of Rotterdam and Scheveningen, and on the Delfland pumping station. So far, this seems to be hardly the case.[48]

## 6.4 Compatibility of nature and recreation

The Sand Engine is about more than coastal protection. It was set up as a pilot project with room for the development of nature and for recreation, in addition to the importance of coastal safety. As the previous chapters have shown, progress is also being made in each area. The extent to which this is the case depends, among other things, on the choices made in the design. To some extent, there is a trade-off between objectives. The lagoon, for example, has so far been extremely suitable for recreation (kite surfing) but catches sand and is therefore less favourable for dune formation.

*"The multifunctional nature of the Sand Engine is part of the Building with Nature philosophy, but then you also have to accept the tension between goals."*

In addition to design choices, this also applies to management choices. There are especially examples of nature conservation and development objectives that are less easy to achieve because there are also recreational objectives and the management is geared towards these:

- The Province of South Holland and Rijkswaterstaat have decided not to apply zoning – in other words, protected nature and recreation zones – to the Sand Engine. This would have been favourable from the point of view of nature. Dune and vegetation development do not seem to be significantly affected by the presence of visitors. The disturbance of breeding birds by people (and dogs) is present, although due to increasing vegetation this is now less than in the first five years, when no breeding birds were observed.[49] This would probably have been better developed through zoning. It is interesting that it was decided at the start[50] that there would be recreational zoning on the Sand Engine, but that this never happened. The reason was that people did not want to install fences and expected that zoning would take place automatically. The decision not to zone was reconsidered at a later point in time (after the recommendation from the 2016 policy evaluation), but it was decided not to do so after all: it would lead to a break in trend for monitoring and management, and this was seen as undesirable.

46 Agreements on this have been laid down in a covenant between Dunea and the Province of South Holland. The costs of the measure are covered by the province.
47 MEP report 2021 (Deltares).
48 MEP report 2021 (Deltares).
49 MEP report 2021 (Deltares).
50 In the 'Protocol van beheersmaatregelen, taken en verantwoordelijkheden op de Zandmotor'.

*"The Sand Engine is so popular that rare species of breeding birds cannot find a place there. If you want to achieve that, you really have to close off a section, and that hasn't happened. On the other hand, if you want to make a Sand Engine for breeding shorebirds, you have to do it in a place where nobody comes. Not off the coast of The Hague, where it's difficult to keep recreational users out of the area anyway.*

- Nature organisations have indicated that they have problems with the unnecessary miles that 4x4s of authorities make in the area. This harms dune formation. Where embryonic dunes are now forming, cars drive around them. On the one hand, this is favourable, because traffic is increasingly concentrated on a limited number of lanes, but on the other hand, it is unfavourable because there is even less chance of new dunes forming in those places. During consultation between local authorities, driving by workmen has been discussed several times and agreements have been made to centralise the traffic flows more.
- Finally, the cleaning of the beach by the so-called 'beach cleaners' has also been mentioned as undesirable for the development of vegetation. Agreements about this were made early after the Sand Engine's construction. Zuid-Hollands Landschap cleans up the waste by hand and only deploys the beach cleaners of the Municipality of Westland when there is no other option, on busy days.

## 6.5 Control and coordination

The 2016 policy evaluation notes that management is "well organized". However, interviews conducted in the context of the current policy evaluation also reveal a different opinion. Several interviewees feel that management is rather fragmented – many different parties each with a relatively small management task – and that collaboration between authorities, as well as with commissioning parties, had been limited in recent years. It should be noted, however, that this situation is not necessarily unique to the Sand Engine: almost everywhere Rijkswaterstaat maintains the basic coastline, the Water Board maintains the defences, the site manager or the drinking water company maintains the dunes and the municipality maintains the (recreation) beach. A number of interviewees nevertheless indicated that they miss central management control. They need a clear point of contact, an overarching management strategy and clear long-term agreements.

*"It is a patchwork of managers in this area. The management tasks of each manager are quite limited, which is one of the reasons why nobody really feels responsible for control or coordination."*

To start with the latter – long-term agreements – the researchers see the following problems and possible solutions:

- Firstly, there are many staff changes at all parties and management agreements have (informally) evolved in recent years. This makes it difficult for new people to trace all agreements made in the past. In this evaluation study, no signals have come to light that something is going wrong because of this, or has gone wrong in the past.[51] But there is a risk that this will once happen. That risk is fairly easy to mitigate by keeping a central document

51 With the possible exception of "...the 'stone incident', in which the Province of South Holland dammed up a trench on its own initiative for safety reasons" (Policy evaluation 2016).

with agreements, communication lines and responsibilities and, for example, updating it annually.

- Secondly, the management agreements are not entirely synchronous. Some agreements are renewed every year (implicitly or explicitly), others are multiannual. Some agreements are accompanied by a transfer of resources, others are not. And those resources are sometimes transferred in the form of a subsidy, sometimes in the form of an assignment. Again, this is not necessarily a bad way of working, but it would be better to summarise all management agreements and to strive for more synchronisation of management agreements. The synchronisation of agreements is, of course, not a goal in itself; sometimes there are good reasons for this. The plea of a number of discussion partners is therefore to make conscious choices as to how the various management agreements relate to each other.

Such long-term agreements can be embedded in an overall management strategy. At the moment, management is experienced by some interviewees as ad hoc: when problems arise, they are solved. By adopting a more proactive strategy, management can be used (even) more effectively as an instrument for achieving policy objectives.

*"The development of the Sand Engine was extremely fast in the beginning and slower in the last few years. But there are still constantly changing currents, mounds and therefore risks. It is important that management continues. A process of collaboration and continuation of the contracts must be set in motion quickly, because the 10-year contracts expire this year. Advice: immediately conclude longer-term contracts again and make clear agreements about cooperation in management.*

## 6.6 Conclusions on the management of the Sand Engine

In the area of beach and bathing safety, cooperation between managing organisations, such as the local rescue teams, went well and the risks were well manageable. It can be said that this contributes to the value of the Sand Engine as a recreational area. At the same time, recreation puts pressure on the Sand Engine as a nature area. The decision not to apply recreational zoning has not proved beneficial to nature. Motorized traffic and cleaning work also put pressure on the development of vegetation and dunes. However, additional agreements were made about this early on in the management phase in order to give nature as much room as possible to develop. Lessons have thus been learned in this regard and the management has proven adaptive, thus contributing to the formation of vegetation and dunes.

Risks to vegetation foreseen in the N2000 Solleveld area seem (for the time being) either not to occur, or to be manageable. There is a certain degree of effect on sand spray and salt spray, but so far this has not had a major impact on the vegetation present. The risk to drinking water production at Solleveld (threat of salt increase and pollution) has been prevented by a management measure, the construction of a drainage system.

A point for attention in the management is the direction and coordination between managers, such as the municipalities involved, rescue teams, Zuid-Hollands Landschap, etc. Although this has not led to any clear problems or incidents, it does constitute a risk for the future. Namely, that suboptimal choices are made in management. In summary, the conclusion is that management does not stand in the way of achieving the policy goals. In addition, by means of an overarching management strategy

and more clarity on agreements, management can be deployed more actively to achieve the policy goals.

# 7. Conclusions and recommendations

This concluding chapter answers the following three questions:

- Have the policy goals of the Sand Engine been achieved?
- Has the Sand Engine's management objective been achieved?
- What recommendations follow from the policy evaluation?

**Have the policy goals of the Sand Engine been achieved?**

The three policy goals of the Sand Engine have been formulated in a broad and general way. Partly because of the dynamic and unpredictable character of the Sand Engine, often deliberately no concrete targets have been attached to them. In the MEP, the policy goals have been subdivided into sub-goals and hypotheses, in order to be able to analyse in more detail whether the goals are reached.

With regard to the *first policy objective,* it can be stated that the Sand Engine, due to the large quantity of sand deposited, will make an extra contribution to a safe coast in the longer term. The stimulation of natural dune growth is proceeding at a different pace than expected. In the last five years the growth of new dunes has been faster than immediately after the Sand Engine's construction and there are circumstances that could ensure a (further) acceleration in this in the coming decade.

The *second policy objective* concerns the knowledge and innovation function of the Sand Engine. The combination of extensive monitoring and scientific research programmes has resulted in the acquisition of a great deal of knowledge that will be useful in other coastal protection projects. The tangible export value of the Sand Engine is limited, due to the limited number of locations worldwide where a Sand Engine-like solution has a chance of success. But the value that market parties derive from the Sand Engine is certain: on a strategic level the Sand Engine has a major impact, kickstarting a new way of thinking about sandy strategies. Dutch (market) parties can thereby position themselves abroad as innovative. This would not have been the case without the actual application of the Sand Engine in the Netherlands.

That the Sand Engine has added an attractive area for nature and recreation to the landscape *(the third policy objective)* is certain. Even though this is only temporary, because the Sand Engine will eventually disappear again, as was intended. The area is home to a large number and diversity of benthic animals and is a magnet for various species of shorebirds. The development of vegetation and establishment of breeding birds is still limited. Negative effects on nature in the dune area have hardly occurred. Recreational users, including kite surfers, know how to find their way to the Sand Engine and the visitor experience value is fairly high.

**Has the Sand Engine's management objective been achieved?**

What is true for the policy goals is even more true for the management goal of the Sand Engine. This objective has not been formulated in the same way everywhere. In terms of content, the question is whether risks in the area can be controlled and whether the management has contributed to achieving the policy goals. In organisational terms, it's about the collaboration between the various authorities.

In the area of beach and swimming safety supervision, collaboration between organisations went well and the risks were manageable. It can be said that this contributes to the value of the Sand Engine as a

recreational area. At the same time, recreation puts pressure on the Sand Engine as a nature area. The decision not to apply recreational zoning does not benefit the development of new nature. Motorized traffic and cleaning activities also put pressure on the development of vegetation and dunes. However, additional agreements were made early on in the management phase to give nature room to develop. Lessons have thus been learned in this regard and the management has proven adaptive, thus contributing to the formation of vegetation and dunes.

A point of attention in management is control and coordination between authorites. Although this has not led to any clear problems or incidents, it does constitute a risk for the future. Namely, that suboptimal choices are made in management. There is a need for continuation of the management agreements and a central management strategy.

**What recommendations follow from the policy evaluation?**

Based on the sources studied and the interviews conducted, the researchers arrive at five recommendations.

1. *Draw up a vision for the future of the Sand Engine.* The Sand Engine will disappear in the long term, just as it has been designed. That need not be negative, but it will mean that the nature and recreational value will also disappear. And coastal protection will require a follow-up to the Sand Engine. This could be regular replenishment, or another large-scale replenishment. The recommendation is to draw up a vision for this, so that the future management of the Sand Engine after 2021 can already anticipate on the time after the "planned life span" of the Sand Engine. Rijkswaterstaat and the province of Zuid-Holland will have to take the lead in this.
2. *Continue to disseminate the lessons learned from the Sand Engine (internationally).* Not only because this will create opportunities for Dutch market parties, but also because parts of the Sand Engine could be suitable for coastal protection issues abroad. In addition to actively communicating the instrument, promoting it also means continuing to bundle knowledge from various separate pilots (Sand Engine and comparable projects) and scaling up its application (via public-private partnerships) to a broader coastal policy.
3. *Evaluate the current monitoring programme (the MEP).* Monitoring of the Sand Engine has provided a lot of insight into the developments over the past 10 years. Given the scope and importance of the monitoring programme, it makes sense to evaluate it. Research how the results can be optimally translated into practical knowledge for managers and policy makers and, in addition, test the monitoring programme against its scientific added value.
4. *Continue to monitor the Sand Engine.* The Sand Engine has not yet been 'fully developed' and the dynamics can provide ever-changing insights about, for instance, dune growth or swimming risks. Monitoring will remain relevant for the time being. However, choices must be made regarding the depth of the research financed by the government and, in any case, continue to monitor matters that are *necessary* for the continued development of knowledge about the Sand Engine. Also consider where and how monitoring is currently organised, and investigate whether this can be effectively combined.

5. *Reassess the management agreements and record them in the long term, in line with the future vision from recommendation 1.* Have Rijkswaterstaat and the province of Zuid-Holland, as joint commissioners, draw up a vision of how the various management elements can be coordinated: who is in charge and who plays what role? Appoint a clear point of contact and consider introducing (more) structure in the coordination between authorities. Recalibrate (or renew) management agreements. Although the greatest morphological changes have occurred in the first few years of the Sand Engine project, the dynamics are still unpredictable. Because of this dynamic, close monitoring of beach and swimming safety will continue to be necessary.

# Annex - Sources

**Documents consulted (in chronological order)**

- Ambitieovereenkomst Zandmotor (intern projectdocument, 2008)
- Projectnota/MER: Aanleg en zandwinning Zandmotor Delflandse kust (DHV, 2010)
- Projectvoorstel EFRO (Rijkswaterstaat e.a., 2011)
- Uitvoeringsprogramma Monitoring en Evaluatie pilot Zandmotor (Deltares e.a., 2011)
- Hoe bruikbaar is de Zandmotor? (Rijkwaterstaat, 2014)
- Tussenevaluatie Monitoring Pilot Zandmotor, onderdeel duinen (Witteveen+Bos e.a., 2014)
- Het verhaal van de Zandmotor (J. Baltissen, 2015)
- A framework for sandy strategy development (Deltares e.a., 2015)
- Policy evaluation 2016 (Anantis e.a., 2016)
- Ontwikkeling van de Zandmotor (Deltares, 2016)
- De bruikbaarheid van het concept Zandmotor (Deltares, 2016)
- Natuurevaluatie 5 jaar Zandmotor (Stichting Ark, 2016)
- MEP rapport 2016 (Deltares e.a., 2016)
- Wat is de 'motor' achter de Zandmotor? (L. van der Klaauw, 2019)
- The Sand Motor: A Nature-Based Response to Climate Change (TUDelft, 2019)
- Vogelonderzoek De Zandmotor (Ecoresult, 2019)
- Onderzoek naar de economische en sociale meerwaarde van de Zandmotor (Ecorys, 2020)
- Voortgangsrapportage monitoring pilot Zandmotor 2017-2021 (Deltares e.a., 2020)
- Terugblik 10 jaar Zandmotor – Strand en zwemveiligheid 9 strandseizoenen (Royal HaskoningDHV, 2021)
- MEP rapport 2021 (Deltares e.a., 2021)
- Maatschappelijke meerwaarde van de Zandmotor (Deltares, 2021)

**Organisations consulted (in alphabetical order)**

- Boskalis
- Deltares
- Dunea
- Municipality of The Hague
- Municipality of Westland

- Delfland Water Board
- Ministry of Infrastructure and Water Management
- Province of South Holland
- Rijkswaterstaat
- Royal HaskoningDHV
- Stichting Ark
- Stichting Duinbehoud
- TUDelft
- Utrecht University
- uid-Hollands Landschap

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