

Landfill Management in the Netherlands

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Introduction

The main objective of COCOON is to develop, integrate and improve relevant policy instruments for landfill management. As part of the COCOON project the Dutch landfill management policy is evaluated. In this current document we have tried to highlight the most relevant policy developments in the Netherlands for the COCOON project partners. This document was drafted by Witteveen+Bos on behalf of the Directorate-General for Public Works and Water Management of The Netherlands (*Rijkswaterstaat Leefomgeving*).

To provide a snapshot view of Dutch policy developments over the years, with regard to landfill management, a desk study and interviews with policymakers and a landfill operator were conducted. The following persons were interviewed for this report:

- Mr A. Bruurs, Ms M. Jochemsen, Mr E Van den Berg, Mr J. Ditters and Mr J. Voesenek; all policymakers at the Province of Noord-Brabant
- Mr H. Scharff, senior advisor at Afvalzorg (landfill operator).

In this report we have chosen to translate the name of the Dutch Acts and regulations to English. For clarity purposes, first the translation is mentioned followed by the Dutch name in brackets in *italics*. For example: Soil Protection Act (*Wet Bodembescherming*). An overview of all the legislation mentioned in this report is provided in chapter 7, with both the English translation, the Dutch name and abbreviation.

An overview of the references that were used to write this report are listed in chapter 8 and referred to as follows in the text of this document [reference X] in case of a website and [author, date] in case of a report.

On the following page an executive summary of the project is provided.

Executive Summary

The Netherlands has seen a major decrease in the amount of waste landfilled (chapter 1). Dutch legislation stimulates recycling. Landfilling is allowed only as a last option, if no other options are feasible. The current paper addresses the various reasons, including regulations, taxes and bans, for the decrease in landfilling over the last decades. A few characteristic elements of the Dutch waste management policy are the waste management hierarchy principle, enforced landfill bans for materials that can be treated or recycled, and the National Waste Stakeholders Council (chapter 2). This council facilitates the acceptance of new legislation as it is developed and discussed at a decentralized level involving all stakeholders (municipalities and provinces). The Netherlands distinguishes two types of landfills: sanitary Wm-landfills and former-landfills. The most important difference is that the former-landfills are landfills that were taken out of operation before 1 September 1996 and that the sanitary Wm-landfills have to comply with the Dutch Environmental Management Act (Wm). Therefore there are landfills that fall under the Environmental Management Act (sanitary landfills) and landfills that do not fall under this Act (mostly non-sanitary landfills).

The Netherlands has approximately 4,000-6,000 former-landfill sites (chapter 3). To obtain a national overview of the actual risks posed by these former-landfills the “NAzorg VOormalige Stortplaatsen (NAVOS)” programme was initiated in the 1990s. The results showed an insufficient thickness of the top-covering in 90% of the sites but in most cases this did not pose risks. Many of these former-landfill sites were already in use as nature or for agricultural or leisure activities, or have been redeveloped since. At approximately 60-80 sites (remediation) measures were taken to prevent the spread of contamination and to mitigate human and/or ecological risks. Remediation measures were executed under the Soil Protection Act. For former-landfills no national legislation was in place, some provinces developed their own Provincial Environmental Regulations to deal with these former-landfills.

All landfills in operation after 1980 have to meet stringent regulations and have (partly) been (re)constructed as a sanitary landfill (chapter 4). From 1 September 1996 aftercare of landfills became mandatory. While the landfill site is in operation the site operator (owner) is responsible, the specific compliance regulations are listed in the Environmental Management Act. The province is responsible for the aftercare of these sanitary Wm-landfills upon closure. Currently there are 19 operational sanitary Wm-landfills. A dedicated fund is in place to finance the aftercare, which is established and managed by the province and funded by the landfill operator.

There is no specific policy in place with regard to mining of landfills neither is new policy development taking place. There has been a debate about whether mining of sanitary Wm-landfills in the Netherlands is (economically) feasible. Over the past few years several lab-experiments, pilot and full-scale landfill mining projects have been conducted (chapter 5), but not on a national level therefore little information is available. From the information that is available one can conclude that in successful projects the main aim was remediation

or redevelopment of the site. Recycling of raw materials was at the most a secondary activity/goal, but financially not feasible.

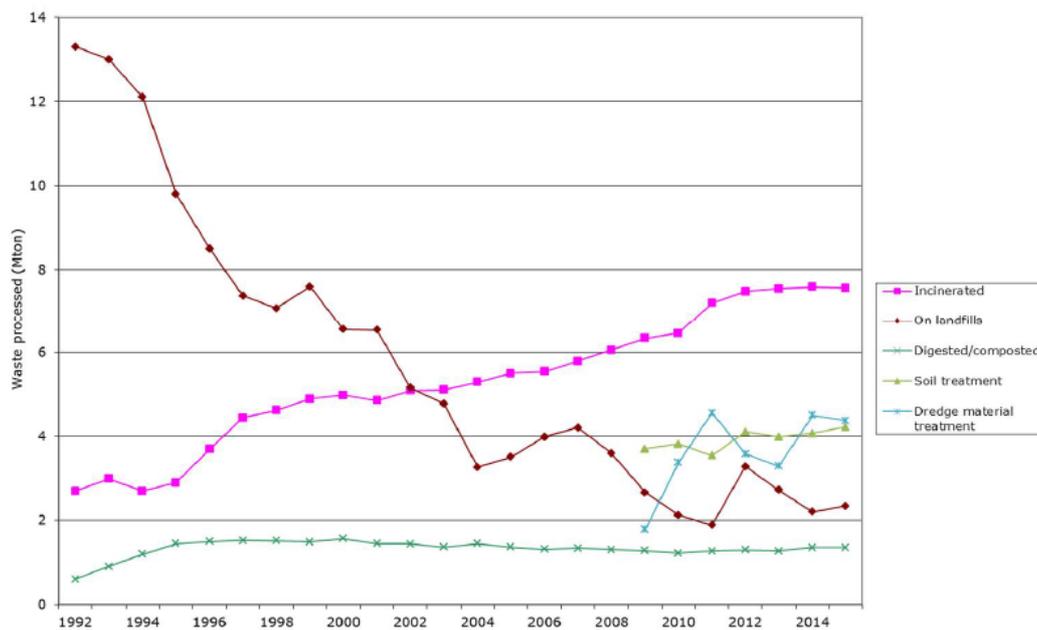
The final chapter in this paper describes the lessons learned and gives an overview of the policy needs for the future. For more detailed information we refer to chapter 6. One aspect addressed is the aftercare of sanitary Wm-landfills. Currently one of the most important policy developments is the project 'Introduction Sustainable Landfill Management'. This is a research project that focusses on a sustainable method for closure and aftercare of landfills. In light of this research programme a number of landfill sites have been given temporary permission to deviate from (current) regulations, with respect to capping of the landfill with an impermeable layer, until the results from the pilots are evaluated.

1. Waste management in the Netherlands

Dutch legislation stimulates recycling. Landfilling is allowed only as a last option, if no other options are feasible. This paper addresses the various reasons, including regulations, taxes and bans, that resulted in a decrease in landfilling over the last few decades in the Netherlands.

This current chapter provides some facts and figures on waste management in the Netherlands, highlighting the trends with regard to landfilling and recycling of waste material. Furthermore an overview is provided of publicly available data, specific for landfills. In the following chapters information is provided on the developments in landfill policy that resulted in a decrease of waste ending up in landfills.

The Netherlands produces 60 million tonnes of waste per year of which approximately two million tonnes (2-3% of total waste) cannot be recycled or incinerated and ends up in a landfill [references 11 and Scharff 2014]. Figure 1 provides an overview of the processed volumes of waste landfilled, incinerated and composted in the Netherlands since 1992. This figure shows that over the years there has been a major decrease in the amount of waste that ends up in landfills [reference 11].



*Data for soil and dredge material treatment are available since 2009

Figure 1. Overview of amounts waste per waste management technique in the Netherlands from 1992-2015 [Reference 11]. Note: the landfilled waste includes usefully applied material at landfill sites (in 2015 that was 0.4 Mton).

A major decrease in amount of waste disposed in landfills has been achieved from 35% in 1985 to 2% in 2014 [reference 1]. This trend was achieved by a reduction in the amount of both household waste and of waste from companies, industries and demolition waste, which is disposed at landfill sites. Furthermore for recycling purposes waste streams are collected separately [reference 1]. In 2014 the Netherlands recycled 82% of paper and cardboard and 94% of metals [reference 5]. In six years' time the recycling of plastic packaging has almost doubled.

From 1980/1985 onward all operational landfills were constructed as sanitary landfills and had to comply with the Directive Controlled Landfilling (*Richtlijn Gecontroleerd Storten*). In 1993 a decree Landfill and Soil Protection (*Stortbesluit bodembescherming*) was issued. This decree described the measures required for the construction of a landfill, where the aim is to isolate, control and monitor the landfill. From 1st September 1996 aftercare was mandatory for all landfills.

The Netherlands distinguishes between two types of landfills: Wm-landfills (*Wm stortplaatsen*) and former-landfills (*voormalige stortplaatsen*). The difference between these two types is explained in more detail in chapters 3 and 4. The most important difference is that the former-landfills are landfills that were taken out of operation before 1 September 1996 and the Wm-landfills have to comply with the Dutch Environmental Management Act (*Wet Milieubeheer*). Therefore there are landfills that fall under the Environmental Management Act (sanitary landfills, in exploitation after 1 September 1996) and landfills that do not fall under this Act (mostly non-sanitary landfills, out of operation before 1 September 1996). Wm-landfills comply with the EU Directive 1999/31/EC (*'Richtlijn 1999/31/EC van de Raad van 26 april 1999 betreffende het storten van afvalstoffen'*).

1.1 Publicly available information on landfills in the Netherlands

An overview of the location of all landfills in the Netherlands is shown in figure 2. This overview was created based on x,y coordinates and addresses both sanitary Wm-landfills and former-landfills, using publicly available data provided by the national government (Rijkswaterstaat).

As is clear from the figure, not all information in the document was accurate. Table 1 shows that in 10% of the former-landfills, actual location information was missing. Furthermore detailed information on type and volume of landfilled material is not available on national level, this information is available at the provincial or municipal authority.

For more site specific information an overview of all sanitary Wm-landfills, categorized per province, can be found on the website of Bodemplus (see appendix I of this document). The website provides information on the address, operator, operational status and whether hazardous waste was landfilled [reference 23].

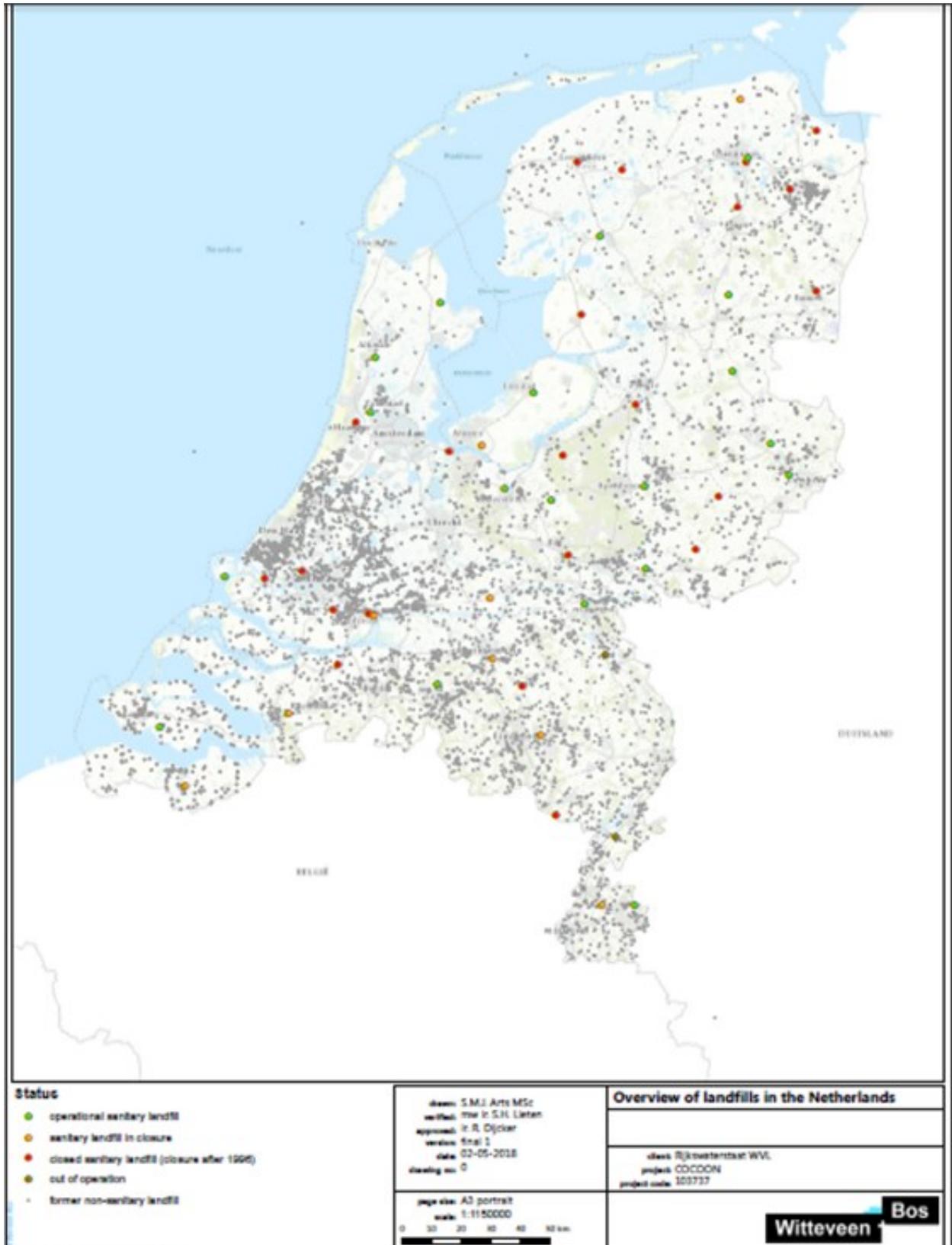


Figure 2. Overview of all former-landfills (*voormalige stortplaatsen*) and closed and operational sanitary Wm-landfills (*Wm stortplaatsen*) in the Netherlands.

Table 1 Number of sites with data on x,y coordinates

	nr sites data available	information on coordinates available	usable
Former-landfills (voormalige stortplaatsen)	7183	6402	6402
Sanitary Wm-landfills (Wm stortplaatsen)	70	64	70
Totaal	7253	6466	6472

With regard to former-landfills, consultation with experts and information from literature showed that more detailed information is available, but these databases are not centralised, they are managed by each individual authority. For former-landfills this information is available at a regional level. Each province or large-municipality is responsible for the data management of former-landfills. This is commonly compiled in a soil information system or GIS-application. Some provinces/municipalities have shared the data publicly, for example on the provincial Georegister website [reference 15], a portal of publicly available GIS information. The provinces of Groningen, Gelderland, Overijssel and Noord-Holland (4 of 12) have provided their data on this website. As an example in figure 3 a map and screenshot are shown of results from a search on the Georegister website. Other authorities have shared information on their own (provincial) GIS-information portal. In appendix I an overview is provided of relevant websites where this information can be found, for each individual province separately.



Titel	Bronhouder	Groepen
<input checked="" type="checkbox"/> Gesloten stortplaatsen (Omgevingsvisie 2016-2020)	Provincie Groningen	
<input checked="" type="checkbox"/> Gesloten stortplaatsen (Omgevingsverordening 2016)	Provincie Groningen	
<input checked="" type="checkbox"/> Milieu- Bodem Stortplaatsen Nazorg Wm, provincie Gelderland	Provincie Gelderland	
<input checked="" type="checkbox"/> Milieu- Bodem Inpassing stortplaatsen, provincie Gelderland	Provincie Gelderland	
<input checked="" type="checkbox"/> Stortplaatsen	Provincie Overijssel: team Beleidsinformatie	
<input checked="" type="checkbox"/> Voormalige stortplaatsen (Navos-locaties)	Provincie Noord-Holland	
<input checked="" type="checkbox"/> Milieu- Bodem Voormalige stortplaatsen (NAVOS), provincie Gelderland	Provincie Gelderland	

Figure 3. Results from Georegister data for amongst others the provinces of Groningen, Gelderland, Overijssel, Noord-Holland [reference 15].

2. Development of landfill management policy in the Netherlands

In this chapter the legal framework of landfill policy in the Netherlands is described. Typical elements of the Dutch waste management policy are stated and an overview of the waste management policies is provided and its role in reducing the amount of waste ending up in landfills. Furthermore an overview is provided of the rules applicable per landfill type (former and sanitary Wm-landfills) and the actors involved.

In the 1970s there were over 1600 operational landfills, this number dropped to approximately 200 in 1980s and to 80 in 1992. Currently only 19 landfills are operational. A number of regulatory interventions has led to this decrease.

A few characteristic elements of the Dutch waste management policy are:

- Order of preference for waste management (waste management hierarchy, “*Ladder van Lansink*”)
- Stringent waste treatment standards; landfill bans in place for materials that can be treated/recycled with best available technique
- National Waste Stakeholders Council (*Afval Overleg Orgaan*)
- Planning on national level
- Producer responsibility
- Use of various (economic) instruments to stimulate prevention of waste and stimulate recycling.

These elements form the basis of the Dutch waste management policy [[reference 24](#)]. An overview of the most relevant Dutch legislations and guidelines with respect to landfilling and landfill management are:

- 1980: Directive Controlled Landfilling (*Richtlijn Gecontroleerd Storten*)
- 1985: Second Directive Controlled Landfilling (*Tweede Richtlijn Gecontroleerd Storten*)
- 1990s: Introduction of the Environmental Management Act (*Wet Milieubeheer*) and the Soil Protection Act (*Wet Bodembescherming*)
- 1993: Decree Landfill and Soil Protection (*Stortbesluit Bodembescherming*) implemented
- 1994: Mandatory separate collection of organic household waste (food and garden waste)
- 1995: Decree Landfill and Waste Disposal Bans (*Besluit stortplaatsen en stortverboden afvalstoffen*) introduced for 35 waste categories
- 1995: Introduction of landfill tax
- 1996: Closure of all non-sanitary landfills
- 2003: Ministry for Housing, Spatial Planning and the Environment draws up a National Waste Management Plan (*Landelijk Afvalbeheer Plan (LAP)*) every six years
- 2010: Implementation of (compulsory) separate collection of plastics
- 2012: Landfill tax abolished
- 2014: Landfill tax reintroduced
- 2017: Release of LAP3 (National Waste Management Plan 3).

2.1 The early days, policy development

In the 1980s the incident at the village of Lekkerkerk, breach of a water supply line due to soil pollution, was big news. A whole neighbourhood of 300 houses, was built on a heavily polluted old landfill site. This was the first major incident of soil contamination at a former-landfill site in the Netherlands [reference 25]. This incident resulted in a snowball of actions which resulted in a whole new legislation and created public awareness on uncontrolled waste dumping and its impact on public health.

The Dutch approach in waste management is primarily based on prevention, recycling and removal of materials in order to avoid creating waste. Furthermore it stimulates re-use. Removal from the recycling chain is a last resort. This approach is described in the waste management hierarchy principle (*'Ladder van Lansink'*), as shown in figure 4 [reference 24]. It was passed as a resolution by the Dutch Lower House (*Tweede Kamer*) in 1979 and incorporated into legislation by 1994. This concept was also adopted in the EU Waste Framework Directive in 1975. In the waste management hierarchy the order of preference is described. As an example the recovery of usable and valuable raw materials and generation of energy by incinerating residual waste is preferred above landfilling. Landfilling is only allowed for waste for which recovery or incineration is technically or economically not feasible. The 'waste management hierarchy' describes landfilling as the least desirable option in waste management.

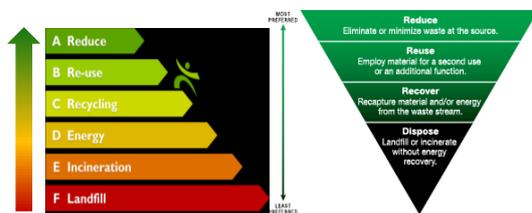


Figure 4. Order of preference in the waste management hierarchy (*Ladder van Lansink*) [reference 24]

One of the most important success factors for the realisation of a successful waste management system in the Netherlands was the 'National Waste Stakeholders Council' (*'Afval Overleg Orgaan'*), which was operational during the 1990s. All actors of the waste management system (national, local/regional responsible authorities and waste management agencies) were a member of this council and all possible legislative measures were first discussed and approved in this council before being discussed in the Dutch parliament. This resulted in a constructive dialogue and support for implementation and compliance of the legislation by all stakeholders, upon implementation. This is in line with the long tradition in the Netherlands of consultation and cooperation between government bodies, citizens, and civil society organisations. Consensus is a vital element in the political culture of decision-making in the Netherlands [reference 4].

In the 1990's the Dutch government started taking measures/action at contaminated sites that caused human, environmental or ecological risks. Furthermore funds were developed for aftercare measures (*nazorg*) at contaminated sites. On 1st March 1993 the Environmental Management Act (*Wet Milieubeheer*) replaced the existing 'Nuisance Act' (*'Hinderwet'*), the Wastes Act (*Afvalstoffenwet*) and the Chemical Waste Act (*Wet Chemische Afvalstoffen*).

This former law (Nuisance Act) was in place since 1875 and described the rules for businesses/activities that could cause risk, damage or 'nuisance' to the environment. The Environmental Management Act set out an integrated approach to environmental management in the Netherlands and provided the legal framework by defining the roles of national, regional and municipal government [reference 4]. Besides the already existing responsibility for operational landfills, the national government passed on the responsibility for former-landfill sites to the regional authorities. Due to this decentralisation, now the provinces are the competent authority and have the jurisdiction for the landfill management (see §2.3).

The decree Landfill and Soil Protection (*Stortbesluit Bodembescherming*), issued in January 1993, describes the measures required at the time of construction of a landfill. The aim is to isolate, control and monitor the landfill, this is known as an ICM-measure (*IBC-maatregel*). Rules and regulations for aftercare/monitoring of landfill sites after closure, are outlined in the Environmental Management Act. This part of the Act, in force since 1999, is applicable to all landfills operational after 1st September 1996.

In 1994 the Dutch Waste Management Association organised a contest to generate concepts for future landfill management [VA, 1994; ref 37]. In 1997 the Dutch Sustainable Landfill Foundation was established. Between 2000 and 2005 three concepts were tested on full-scale. Consecutively the feasibility of applying similar approaches to existing landfills was tested. As a result, in 2010, the Ministry of Infrastructure and Water Management started the project 'introduction of Sustainable Landfill Management' [reference 13] and acquired support from competent authorities and landfill operators.

Another successful intervention that resulted in a reduction of the amount of waste ending up in landfills, was the gradual introduction of specific bans on the landfilling of specific materials. The decree for Landfill and Waste Disposals Bans (*Besluit stortplaatsen en stortverboden afvalstoffen*) was introduced in 1995. The decree included bans for a number of waste materials for which a best available treatment technology was available. It prohibited the landfilling of materials if recycling was a viable option. The bans gradually extended from 35 (in 1995) to 64 waste categories, currently 61 bans are in place and are enforced [Scharff, 2014; ref 22].

In 2002 the National Waste Management Plan (*Landelijk Afvalbeheer Plan (LAP)*) was introduced [reference 9]. Every 6 years the plan is revised and a new plan is formulated. The 3rd plan has been released in December 2017.

The first National Waste Management Plan set the framework of future waste management policy in the Netherlands and introduced the management of waste policies under a national perspective. The second National Waste Management Plan introduced a target to increase the recycling of household waste to 60 % by 2015. There are also specific regulations in place for waste from companies, industries and specific types of wastes. Circular economy and waste to material are the leading principals in the third plan.

Another (EU) policy intervention which is in place, prohibits the export of waste for incineration or landfilling, with an exemption for waste for energy recovery. Waste generated in the Netherlands, which can't be reused or incinerated, must be landfilled in the Netherlands. Exceptions are made only if it appears that landfills outside the Netherlands are the only processing possibility for that particular waste [Scharff, 2014; ref 22].

Besides these laws and regulations, financial instruments were implemented by the national government; for example taxes on landfilling and 'Pay-as-you-throw' (*Diftar*) schemes in the collection of household waste. Landfill taxes were introduced in 1995. In 2002, there was a steep increase of the tax level which kept increasing marginally the following years. A sharp increase in 2010 made the landfill tax in the Netherlands the highest in Europe. Struggling waste incineration facilities also resulted in a decrease in landfilling and an increase in incineration. By 2012, this tax was abolished due to it being rendered administratively bothersome. However this abolition did not lead to an increase in landfilling (of combustible waste or biodegradable municipal waste), as can be seen in figure 5 [Scharff, 2014]. In 2014 the tax was reintroduced.

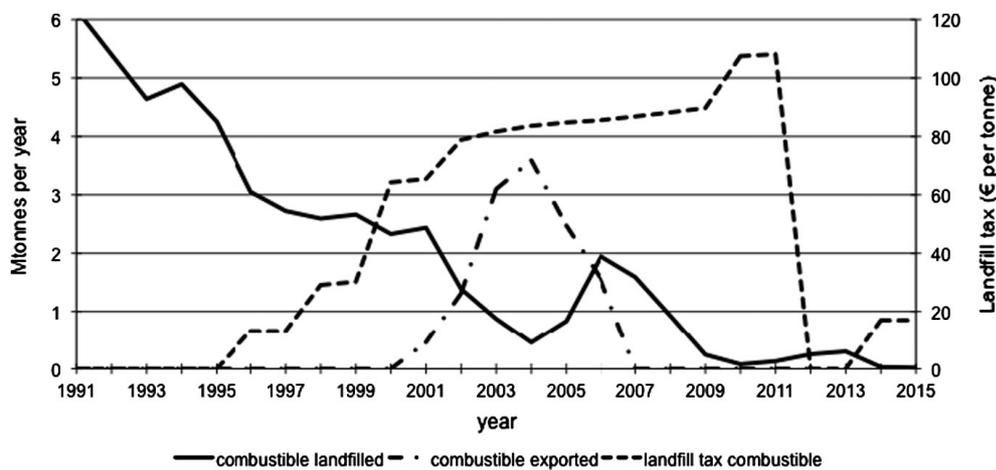


Figure 5. Development of landfill tax, landfilled and exported combustible waste in the Netherlands [Scharff, 2014].

2.2 Current status of policy developments

In 2016 the government issued a policy document in which it proposes a 100% Circular Economy in the Netherlands by 2050. In the transition agenda Circular Economy the ministries of Economic Affairs and Climate policy and Infrastructure and Water Management work together [reference 14]. One of the first milestones is a 50% reduction in the use of primary raw materials 2030. This should lead to an increase in re-use and recycling and a further decrease in landfilling.

Sanitary Wm-landfills

The law ‘Crisis and Recovery Act’ (‘Crisis en Herstel’ wet) and the revision of the decree Landfill and Soil Protection (Stortbesluit Bodembescherming) facilitated the implementation of a new landfill aftercare research project put forward by landfill operators: ‘Introduction Sustainable Landfill Management’ (*Introductie Duurzaam Stortbeheer (iDS)*).

A Green Deal between the Dutch waste management industry, national and regional governments and research institutes has led to the investigation of more sustainable landfill management solutions [reference 13].

“The Green Deal approach in the Netherlands is an accessible way for companies, other stakeholder organizations, local and regional government and interest groups to work with Central Government on green growth and social issues. The aim is to remove barriers in order to help sustainable initiatives get off the ground and to accelerate this process where possible. Central Government plays a key role in this area. Initiatives often start from the bottom up, in response to societal dynamics.”

<http://www.greendeals.nl/stortplaatsen-krijgen-water-en-lucht/>

The ‘Introduction Sustainable Landfill Management’ (iSLM) focusses on a sustainable method for closure of landfills. The project will investigate the possibilities for speeding up the processes of degrading, stabilizing or otherwise rendering harmless the contaminants in a landfill. It is a strictly supervised research programme into sustainable landfill management. It focuses on creating more sustainable landfills in which a less complex (and less expensive) system of final sealing and aftercare activities will suffice. In 2016 this ten year programme commenced at three pilot sites:

- Noord-Brabant (Bergen op Zoom, landfill Kragge II)
- Noord-Holland (Hollands Kroon, landfill Wieringermeer)
- Flevoland (Almere, landfill Braambergen).

iSLM is the most important development on landfill management policies for sanitary Wm-landfills in the Netherlands. Currently, a number of other landfill sites have been given temporary permission to deviate from current rules, with respect to capping of the landfill with an impermeable layer, until the results from the pilots are evaluated. This may possibly lead to new regulations.

Artikel 14d

1. De stortplaatsen waarop aan de bovenkant van de gestorte afvalstoffen geen bovenafdichting hoeft te worden aangebracht die tegengaat dat water in de gestorte afvalstoffen infiltreert, zijn, voor zover het de gedeelten betreft die zijn weergegeven in bijlage 3:
 - a. Braambergen te Almere;
 - b. Boeldershoek te Hengelo/Enschede;
 - c. Elhorst Vloedbelt te Borne;
 - d. Haps te Cuijk;
 - e. Kragge II te Bergen op Zoom;
 - f. Nauerna te Zaanstad;
 - g. De Sluiner te Voorst;
 - h. Spinder te Tilburg;
 - i. Wieringermeer te Hollands Kroon;
 - j. Zweekhorst te Zevenaar.

Figure 6. Screenshot from decree Landfill and Soil Protection, in which the exemption for other operational landfills is mentioned [reference 26].

Former-landfills

For former-landfills, currently these developments are taking place¹:

1. As described in the Covenant Soil and Subsurface (*Convenant Bodem en Ondergrond*) 2016-2020 (art. 9), the government agreed to investigate possibilities to reduce/optimize aftercare for contaminated sites (including former-landfill sites).
2. The Dutch government is working on a new legislation, the 'Environment and Planning Act' (*'Omgevingswet'*), which will be implemented in the near future (expected 2021). In this new Act the municipalities become the (sole) authority for soil protection. This implies that provinces will no longer be the competent authority for former-landfill sites. On a national level dialogues are taking place to ensure a smooth transition of specific dossiers and responsibilities.

2.3 Actors and the competent authorities

Environmental management policy is related to spatial planning and directed at creating a healthy environment with clean air, water and soil by regulating emissions from road transport, industry and other sources. While national policy on environmental issues is the responsibility of the ministry, the provinces are responsible for translating these guidelines into the regional context [reference 16]. The 12 regional (provincial) governments in the Netherlands develop regional policy and draw up regional plans. The regional authorities are responsible for granting environmental permits and stipulating (emission and noise) limits [reference 16].

With regard to (operational) sanitary Wm-landfills the Ministry of Infrastructure and Water Management (*Ministerie van Infrastructuur & Waterstaat*) is responsible for policy and legislation. The Directorate-General for Public Works and Water Management (*Rijkswaterstaat Leefomgeving*) is responsible for the implementation of this policy. The province is responsible for licensing and enforcing permits. While the landfill is operational the site operator (owner) is responsible and the Environmental Management Act legislation is enforced by the province.

¹ note: the Environmental Management Act and the Soil Protection Act do not apply to these landfills

The province is also responsible for the (financial) management of the aftercare-fund and the management of the aftercare of sanitary Wm-landfills upon closure.

In case the soil or groundwater surrounding a (non-sanitary) former-landfill site is polluted by the landfill, then the owner of the site is responsible. This is in accordance with the Soil Protection Act. In this case the Soil Protection Act is enforced and the provinces or large municipalities are the competent authorities. For redevelopment activities at former-landfills no national legislation is in place. Therefore some provinces developed their own specific Provincial Environmental Regulations to facilitate redevelopment of former-landfill sites. In the Interregional Working Group-BOOG (*BOdemOntwikkelGroep*) provinces align specific regulations for facilitating redevelopment of former-landfill sites with the overall soil remediation policy. See chapter 4 for more information.

Figure 7 gives an overview of the actors involved and the competent authorities per landfill type and shows the relevant legislation, which is specified separately for sanitary Wm-landfills and for former-landfills. In chapters 3 and 4 more detailed information is given on these two types of landfills.

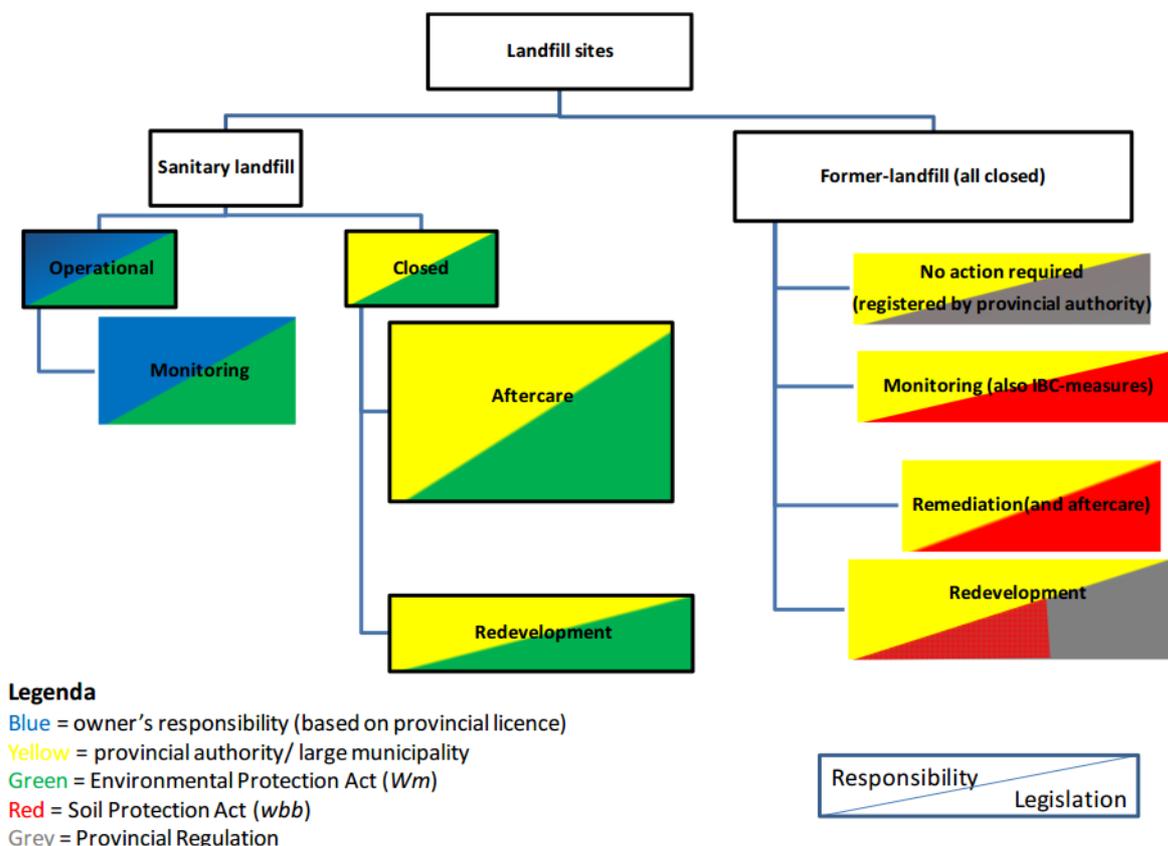


Figure 7. Responsible actor, competent authority and relevant sites legislation specified for landfills in the Netherlands.

3. Former-landfills (non-sanitary landfills)

Chapter 3 focusses on the former-landfills in more depth, describing the followed approach, policy developments, redevelopment strategies and future policy needs.

In the Netherlands there are 4,000-6,000 former-landfill sites with a total area of approx. 8000 ha. These sites are called former-landfills as they haven't received any new waste material after 1st September 1996; they were closed before this date at the latest. Many of these sites are non-sanitary landfills, though some were constructed under sanitary conditions. Some are illegal dumpsites while others were authorised by the municipalities. Some were mono-landfills while others were landfills for household waste and construction waste.

3.1 Followed (investigation) approach

A broad preliminary investigation was conducted to collect information on the existing landfills in the Netherlands; starting with the VOS project (*Verkennend Onderzoek Stortplaatsen*). This investigation predominantly focussed on the location of landfill sites and provided an estimate of the financial consequences of non-sanitary landfills. To obtain a national overview of the actual risks posed by these former-landfills, in the 1990s the 'Aftercare former-landfills' (*NAzorg VOormalige Stortplaatsen*, NAVOS) programme was initiated. This NAVOS-programme was commissioned by the Consultation Committee of Governing Bodies ('*DUIV overleg*'). Members of this committee are amongst others the association of provinces (*IPO*), association of Dutch municipalities (*Vereniging Nederlandse Gemeenten (VNG)*) and the union of water boards (*Unie van Waterschappen*). In the NAVOS-programme the human and ecological risks were investigated. The programme focussed primarily on the organization and the funding for monitoring of these former-landfills and secondarily on formulating feasible (remediation) options. Aspects that were studied were amongst others the degree of dissemination of groundwater contamination, thickness of the top cover layer and natural attenuation processes. The research took place between 1995-2004 and the results are described in various NAVOS reports.

The results showed that in 90% of the former-landfill sites the top layer was of insufficient thickness compared to what was required according to the Soil Protection Act. In most cases however no unacceptable risks occurred/were foreseen. The results from the NAVOS operation also showed that only in 6% of the former-landfill sites the groundwater was (heavily) contaminated. In most of these cases (>90%) this was caused by metal leachate (arsenic, cadmium, nickel and zinc) and in 3% by volatile organochlorides and aromatics. Furthermore, it became evident that the metal contamination at many former-landfills was probably related to the natural abundance of metals in the surrounding area, due to the geography of the area (predominantly in the provinces of Noord-Brabant and Limburg). At 80 sites measurements were conducted to determine whether natural attenuation processes were occurring. A number of additional investigations were conducted by the individual provinces or other appropriate (remediation) measure were taken to prevent the spread of contaminations and to mitigate human and/or ecological risks.

Results showed that in 70% of the sites the natural attenuation processes resulted in no spread of contamination. In 30% of the sites the natural attenuation processes weren't sufficient and thus spread of (predominantly) metal occurred. In 30% of the landfill sites additional measures were required, this included further monitoring as well as remediation actions (in many cases the thickness of the top cover was insufficient). In figure 8 an example of the results for the province of Noord-Brabant are given [NAVOS-report 2005, ref 17].

	NAVOS 1		NAVOS 2		NAVOS 3	
	aantal	%	aantal	%	aantal	%
>T-waarde	101	19	95	19	46	13
>I-waarde	151	29	137	27	159	43
totaal onderzocht	521	100	502	100	368	100

Figure 8. An example of results for contamination of groundwater near former-landfill sites in the province of Noord-Brabant (600 sites investigated). T-waarde and I-waarde are Dutch pollutant reference and target values [reference 17].

The final report of the NAVOS-programme contains recommendations on how to deal with these former-landfill sites. The recommendations mainly focus on the organization and financing of aftercare, as this was the main assignment that the Consultation Committee of Governing Bodies gave to the steering group and core group of NAVOS. The advice was based on extensive environmental investigation which was conducted in all provinces for a duration of three years. The results showed that the problem was far less- in terms of financial contributions needed- as compared to the initial estimate [NAVOS-report 2005, ref 12].

3.2 Subsequent policy developments

At this point in time (NAVOS-programme) no specific legislation was in place for former-landfills. Therefore a number of provinces developed their own legislation for these sites. These Provincial Environmental Regulations were based on the Soil Protection Act and/or the Environmental Management Act and were predominately for the management and redevelopment of former-landfill sites; in other word to stimulate landfill management. These regulations are also applicable for initiatives for the redevelopment of sanitary Wm-landfills. Examples of Provincial Environmental Regulations are: 'Provinciale Milieuverordening Noord-Brabant, 2010', 'Beleidsnota Bodem, 2012, Gelderland', 'Uitvoeringsprogramma voor de ondergrond, Overijssel', 'Beleidsregels hergebruik voormalige stortplaatsen, 2007, gemeente Groningen' [RHDHV, 2015, ref 2].

As mentioned above different provinces dealt with former-landfills differently. In the textbox, two examples of different policy approaches are given: respectively the province of Noord-Brabant and the province of Gelderland. Both these approaches provided a framework for management and redevelopment of former-landfill sites.

Two different policy approaches for landfill management. Both approaches provided a framework for the management and redevelopment of former-landfill sites.

Provincial Environmental Regulation province of Noord-Brabant

In the Provincial Environmental Regulation of the province of Noord-Brabant, activities at a former landfill site are prohibited. They have a “No, but Yes if certain (precautionary) measures are taken” policy. This means that no activities are allowed without prior permission of the province. The province puts some precautionary measures in place. These measures are site specific and can range from prohibition of pumping up groundwater, application of a clean top layer, extensive or intensive groundwater monitoring, no excavation activities etc.

In other words the province actually stimulates redevelopment by allowing activities under site specific precautionary measures; and by providing exemptions. These exemptions give the province the possibility to enforce certain necessary measures that need to be taken to avoid human, ecological or environmental risks occurring. The provincial website provides detailed information on the requirements for redevelopment of such sites.

Provincial Environmental Regulation province of Gelderland

The province of Gelderland has classified the landfill material as part of the soil matrix and therefore considers contaminated landfill sites as sites that need to be treated under the Soil Protection Act. However the province wants to develop former landfill sites by stimulating and facilitating the redevelopment. In the Provincial Environmental Regulation ‘Beleidsnota Bodem 2008, De Gelderse wegwijzer door bodemland’ the province has formulated specific policy for the remediation and redevelopment of former landfills. The regulations are based on the Soil Protection Act.

In case the disposed waste resulted in contamination of surrounding soil or groundwater then the Soil Protection Act was applicable. Therefore the monitoring of contaminated former-landfill sites is in accordance with the Soil Protection Act.

3.3 Redevelopment of former-landfill sites

The results from the NAVOS operation showed that in most cases these sites didn’t pose an environmental risk. At the sites that posed a risk, in most cases this was due to an insufficient thickness of the top-covering. Many of the former-landfill sites were in use as nature or agricultural land etc. or have been redeveloped since. In the Netherlands this is common practice.

As an example, in the province of Noord-Brabant of the 600 sites approximately 75% were already in use before the NAVOS operation commenced. The province has exemptions in place at 70 sites. Here (redevelopment) activities are allowed if certain precautionary measures are taken (see boxed section). At 30 sites only registration of the site was required and redevelopment activities weren’t impeded at all.

In most cases (in most provinces) redevelopment of former-landfills occur, however in many cases the monitoring obligation from the Soil Protection Act requires that upon reuse of the site the monitoring must be continued until a stable final situation has been demonstrated. This is one of the additional measures the authority can put in place when providing a permit for redevelopment of the site.

The website www.nazorgstortplaatsen.nl gives an overview of some landfill management projects at former-landfill sites (and sanitary Wm-landfill sites). In figure 9 a screenshot of the website is provided. This website is managed by the interregional working group BOOG.

The screenshot shows a website interface with a vertical navigation menu on the left and a main content area on the right. The menu includes items like 'Navos', 'Juridisch kader', 'Achtergronddocumenten', 'Archief', 'Praktijkvoorbeelden', and a section for 'Wet milieubeheer stortplaatsen' with sub-items 'Algemeen', 'RINAS', 'Risicomodel', 'FAQ', 'Achtergronddocumenten', and 'Archief'. The main content area displays six project cards, each with a title, a brief description, a 'meer info' link, and a representative image. The projects are: Gemeente Dordrecht (Polder Stedijk), Gemeente Eersel (Recycling), Gemeente Katwijk (Sport op de Stort), Provincie Flevoland (Park Residentie Dronten), Provincie Overijssel (3 praktijkvoorbeelden herontwikkeld), and Provincie Zeeland (Werk met werk maken).

Figure 9. Examples of redevelopment of former-landfills (voormalige stortplaatsen) [reference 3].

3.4 Future policy needs

With the introduction of the new legislation the 'Environment and Planning Act' (*Omgevingswet*) 26 Acts will be harmonized into one national framework policy. The framework of the Soil Protection Act will be incorporated in this future framework of the Environment and Planning Act, thereby replacing the Soil Protection Act. As a consequence of this, the responsibility of former-landfills will be transferred from the provinces to the municipalities. In the new 'Environment and Planning Act' the municipalities can determine their own ambitions with regard to landfill management.

The main challenge in the future will be to manage, secure and safeguard all the data collected and to ensure the transfer of knowledge. Currently the provinces manage these databases in accordance with the Soil Protection Act, in the future the municipalities will. This asset-management may be an issue facing the future of landfill management.

In spatial planning projects, it can be necessary/desirable to reallocate landfill material within a former-landfill site. However, currently there is a lack of clarity as to whether this is allowed (by law). There is a need for more clarity on this matter.

Furthermore minimizing the monitoring requirement at ICM-sites (Isolate, Control and Monitor sites) is an aspect that needs to be addressed and looked into.

4. Sanitary Wm-landfills

Chapter 4 focusses on the sanitary Wm-landfills in more depth. The followed approach, applicable regulations, aftercare policy, redevelopment strategies and future policy needs are described. Currently there are 19 operational landfills in the Netherlands. An overview of the capacity per province is given below. All these landfills are sanitary landfills.

Provincie	Netto gestort (Mton)			Totaal op de stort gebracht ¹ (Mton)			Restcapaciteit ² (10 ⁶ m ³)			Ingerichte capaciteit (10 ⁶ m ³)	Capaciteit in procedure (10 ⁶ m ³)
	2013	2014	2015	2013	2014	2015	2013	2014	2015	2015	2015
Groningen	0,06	0,05	0,05	0,11	0,06	0,13	0,4	0,4	0,4	0,4	-
Friesland	0,08	0,12	0,18	0,09	0,14	0,21	1,6	1,8	1,8	0,7	-
Drenthe	0,01	0,01	0,02	0,09	0,02	0,03	5,7	4,6	4,6	0,5	-
Overijssel	0,03	0,02	0,02	0,06	0,03	0,03	6,2	6,2	6,1	2,8	-
Gelderland	0,55	0,42	0,39	0,61	0,51	0,43	4,4	4,0	3,8	1,9	-
Flevoland	0,24	0,12	0,10	0,24	0,15	0,11	3,3	3,2	3,2	0,6	-
Utrecht	0,27	0,33	0,26	0,29	0,37	0,31	1,7	1,4	1,3	1,3	-
Noord-Holland	0,25	0,26	0,41	0,32	0,31	0,45	1,5	1,8	3,1	2,3	-
Zuid-Holland	0,26	0,22	0,25	0,56	0,23	0,27	1,7	1,7	0,2	0,2	-
Zeeland	0,12	0,11	0,12	0,15	0,15	0,15	1,0	1,0	0,9	0,4	-
Noord-Brabant	0,13	0,18	0,13	0,18	0,21	0,19	7,4	7,3	7,2	1,4	-
Limburg	0,01	0,04	0,04	0,03	0,04	0,05	3,1	3,1	3,0	0,1	-
Capaciteit op plank ³	-	-	-	-	-	-	8,8	7,1	8,3	-	-
Nederland	2,02	1,87	1,98	2,73	2,20	2,34	46,8	43,5	43,8	12,6	-

Figure 10. Current landfill capacity in the Netherlands [reference 11].

4.1 Followed approach and applicable regulations

All landfills in operation after 1980 have to meet stringent regulations and have been (re)constructed as sanitary landfill sites (licence-conditions). All landfills in operation after 1st September 1996 have to meet stringent regulations for aftercare. These landfills are carefully constructed with an impermeable layer (or an equivalent) to protect the underlying soil and groundwater. Furthermore the landfill is sealed with a soil and a surface sealing to prevent water infiltration, limited air emissions is a secondary result/side effect. Residual water is collected and treated if necessary, and often landfill gas is collected and used as bio-energy. The regulations for sanitary landfills are part of the Environmental Management Act.

Operational landfills are evaluated every year, since 1991, with a nearly 100% response. A yearly questionnaire is conducted by the Working Group on Waste Registration (*Werkgroep afvalregistratie*), in which several interest groups participate. The Working Group on Waste Registration consists of members of the Ministry of Infrastructure and Water Management, Directorate-General for Public Works and Water Management, the Ministry of Economic Affairs and Climate Policy, the Dutch Waste Management Association (*Vereniging Afvalbedrijven*), Interprovincial Consultation Committee (*IPO*).

Yearly reports are publicly available, that provide a survey of the annual amount of waste processed by landfills, waste incinerators, vegetable-fruit-garden waste digesters, composting installations and treatment of soils and sludge material.

The monitoring of these landfills is conducted as described in the National Waste Management Plan (*Landelijk Afvalbeheer Plan*) [[reference 9](#)].

While the landfill site is operational the site operator (owner) is responsible, regulations are listed in the Environmental Management Act. The province imposes these regulations in a licence. The province is responsible for the aftercare of sanitary Wm-landfills.

4.2 Aftercare upon closure

In accordance with the Environmental Management Act (title 15.11), before closure of a sanitary Wm-landfill the owner needs to provide an ‘Aftercare Plan’ (nazorgplan) to the province as competent authority. Both the technical as well as the financial section of the aftercare plan are reviewed by the province. The province can (completely or partially) approve or reject the aftercare plan. On the basis of her judgement the province determines the ‘target ability’ (*doelvermogen*) on which she bases the tax levy (*belastingaanslag*).

After approval of the plan and the closure of the landfill, the province becomes administratively, financially and organizationally responsible for the aftercare of the site. From then onward the province is responsible for the risks that may occur (in the future) at the landfill site or in its direct surrounding. The approved aftercare plan describes the aftercare measures and financial management of a landfill after closure.

An excerpt from the Environmental Management Act (art. 8.49 *Wet Milieubeheer*) that describes aftercare is shown below (figure 11). In the Netherlands the aftercare period is not limited in time. The EU Landfill Directive states in art. 13 that aftercare should be *for as long as may be required by the competent authority* (see figure 12).

Wm Artikel 8.49

1. Met betrekking tot een gesloten stortplaats worden zodanige maatregelen getroffen dat wordt gewaarborgd dat die stortplaats geen nadelige gevolgen voor het milieu veroorzaakt, dan wel, voor zover dat redelijkerwijs niet kan worden gevergd, de grootst mogelijke bescherming wordt geboden tegen die nadelige gevolgen.

Figure 11. Excerpt from Environmental Management Act [28].

In order to finance the aftercare, the provinces manage an ‘Aftercare Fund’ (*Nazorgfondsen*) in which the provincial levies from landfill owners is deposited; this is regulated in the Environmental Management Act (title 15.11). The tasks of the province as competent authority include the approval of aftercare plans, approval of final top cover, calculation of the aftercare costs, manage the aftercare fund, provide a closure statement and manage aftercare activities.

In accordance with Dutch legislation, upon closure, the administrative, financial and environmental responsibility is transferred from the site owner to the regional authority or the province (art. 8.47). Whereas according to the EU Landfill Directive the site owner is responsible for the costs for a period of at least 30 years (art. 10) (figure 12).

4.3 Redevelopment of sanitary Wm-landfill sites

European Directive 1999/31/EU Article 13 (Closure and aftercare procedures)

After a landfill has been definitely closed, the operator shall be responsible for its maintenance, monitoring and control in the aftercare phase for as long as may be required by the competent authority, taking into account the time during which the landfill could present hazards. For as long as the competent authority considers that a landfill is likely to cause a hazard to the environment and without prejudice to any Community or national legislation as regards liability of the waste holder, the operator of the site shall be responsible for monitoring and analysing landfill gas and leachate from the site and groundwater regime in the vicinity of the site in accordance with annex III'. The EU-directive 1999/31/EU (article 10) has set a time frame of 30 years for aftercare payed and executed by the site owner independent of whether risks occur.

European Directive 1999/31/EU Article 10 (Cost of the landfill of waste)

Member States shall take measures to ensure that all of the costs involved in the setting up and operation of a landfill site, including as far as possible the cost of the financial security or its equivalent referred to in Article 8(a)(iv), and the estimated costs of the closure and after-care of the site for a period of at least 30 years shall be covered by the price to be charged by the operator for the disposal of any type of waste in that site. Subject to the requirements of Council Directive 90/313/EEC of 7 June 1990 on the freedom of access to information on the environment(9) Member States shall ensure transparency in the collection and use of any necessary cost information.

Figure 12. Excerpt from EU Landfill Directive 1999/31 EU

Currently operational landfills are often prepared in such a manner that redevelopment is possible. Sanitary Wm-landfill sites are popular with real estate developers and builders as a possible location for area development (e.g. leisure purposes such as golf courses, solar energy parks etc). Whether extra incentive is attractive to redevelop these sites depends among other things on the location and the kind of the initiative. The aftercare, upon formal closure of the site, is managed by the province as the competent authority. Upon redevelopment, the aftercare activities need to be continued/conducted, in accordance with the Environmental Management Act and if applicable Provincial Environmental Regulations.

An example of a redeveloped sanitary Wm-landfill site is Hollandsche Brug (Naarden). The landfill has been closed, the closure procedure is divided into six steps, after which responsibility will be transferred from the site owner to the province). The landfill site has been redesigned and is part of recreational area Naarderbos with a 18 hole golf course, walking, cycling and horseback trails and a habitat corridor [[reference 36](#)].

4.4 Future policy needs

Protection of the environment is the fundament of Dutch legislation with regard to landfills. Therefore sanitary Wm-landfills have been carefully constructed to protect the soil, groundwater and air. An effective but expensive solution, that requires continuous aftercare. It is undesirable to transfer risks, aftercare and costs to future generations. For this reason the Dutch government closely follows national and international developments concerning the reduction of risks and costs at landfill sites. The mining of raw materials and the redevelopment of landfill sites are part of this approach.

During the financial crisis discussion about aftercare and the (interest rate provision of) financial funds of landfills became a topic of discussion in the Netherlands. This triggered the Dutch waste management industry, national and local governments and research institutes, to investigate a more sustainable and efficient solution. This resulted in the Green Deal Sustainable Landfill Management (abbreviated in Dutch as iDS). This is a strictly supervised research programme which is currently being conducted at three landfill sites. Besides these three landfills there are a number of other sanitary Wm-landfill sites which are qualified for a similar sustainable management if the research programme is successful at the three designated sites and legislation has been adjusted accordingly.

This financial insecurity led to the decision of the Ministry of Infrastructure and Water Management to start an evaluation of the financial paragraph of the aftercare regulation in the Environmental Management Act. The 'Aftercare scheme' is currently being evaluated by the Ministry.

A challenge for the future is to try and reduce the timeframe and costs of aftercare at these sites (see §2.2). Currently the aftercare of sanitary Wm-landfills is not limited in time. The province remains responsible and must ensure no adverse effects occur to humans nor the environment. Furthermore there is no validated procedure that helps to demonstrate that no negative effects occur at a landfill site. Possibly the iSLM research programme will contribute to a cost-effective approach that will not burden future generations.

Currently Denmark is developing a procedure to demonstrate no negative effects occur at a site. At this moment this is not available in any European country. The Dutch National Institute for Public Health and the Environment (RIVM) in cooperation with the Energy research Centre of the Netherlands (ECN) have proposed an assessment system to test whether waste water from sustainably managed landfills does not cause damage to soil and groundwater [[reference 32](#)]. This will also be tested in the iSLM pilot.

5. Landfill Mining

What is the relationship between landfills and the circular economy? This chapter addresses landfill management in context of the circular economy. It describes recent experiences with landfill management strategies like landfill mining and touches up on aspects like strategic temporary storage.

5.1 Circular Economy and resource management

In 2016 the government issued a policy document in which it proposes a 100% Circular Economy in the Netherlands by 2050 [reference 11]. One of the first milestones is a 50% reduction in the use of primary raw materials by 2030. This should lead to an increase in re-use and recycling and a further decrease in landfilling. Currently only material that is not recyclable is landfilled. This however results in modern landfills being sinks for residues or 'hazardous material' from the recycling process, that can't be put to use. This would imply that sanitary Wm-landfills can't be mined for valuable resources. However, landfills can serve as strategic temporary storage facility for materials for which currently no recycling options are available but technologies are being developed/foreseen. These waste streams could prove valuable in the near future [Scharff 2014, ref 33]. From a circular economy perspective strategic storage might be considered a more interesting option than incineration (with energy recovery).

Former-landfills may serve as (urban) mines for resources as they may contain materials for which appropriate recovery technologies are available now, but were not available in the past and were thus landfilled.

5.2 Strategic temporary storage

There are various materials for which currently no financially and/or technically feasible recycling option exists, but for which a shortage is expected in the near future. Therefore in cases where potential reuse (in the near future) is expected, temporary storage might be an interesting solution. Such a strategic (temporary) storage is not a new concept. In the Netherlands it was proposed under the name Megastratem in 1994 [VA, 1994; ref 37].

The aim of strategic storage of materials is storage and conservation of the resources. The operation of the landfill must ensure that the resources are preserved. If (hazardous) waste streams are mixed in a landfill then it is often impossible (technically and financially) to, recover these at a later stage. As a temporary storage materials can for example be stored in separate compartments at a landfill site. The materials can be stored under conditions similar to a mono-landfill with full environmental protection measures. Biodegradable materials however need to be processed on shorter notice and cannot be considered suitable materials for strategic storage. A current example of a waste stream where strategic temporary storage might be interesting is ashes from thermal treatment of sewage sludge. These contain high levels of phosphate.

The EU Waste Framework Directive specifies 'storage of waste pending any other recovery operation' as a recovery and not a disposal operation [EC, 2008; ref 30]. Many EU member states, including the Netherlands do not allow storage longer than three years. Storage is only allowed under safe storage conditions that ensure no human nor environmental risks. This means measures are needed and additional costs may need to be made.

5.3 Enhanced Landfill mining examples in the Netherlands

During the last few years several lab-experiments, pilot and full-scale landfill mining projects have been conducted in the Netherlands. Many of these mining projects have been initiated and performed by landfill operators and local authorities. As a consequence there is no national overview of these projects and lessons learned, as the information is not always publicly available. However, in a recent desk study performed on behalf of the Ministry of Infrastructure and Water Management a number of landfill mining pilots have been listed and evaluated [RHDHV, 2015; ref 2].

A few examples of mining of both non- and- sanitary landfill sites are described below:

1. De Spinder (Tilburg): De Spinder is a regular operational Wm-landfill where tests were conducted to determine whether mining would be feasible. De results from 2008 showed that many of the mined fractions were too heavily contaminated for direct reuse of the material. The results thus showed that waste from this landfill was not suitable for mining resources (apart from a small fraction as iron). After separation of the streams (still contaminated) incinerate was possible financially not feasible [Jansen, 2010; ref 35].
2. De Sluiner (Wilp): initially the sanitary Wm-landfill was excavated in order to produce granulate, to increase the landfill capacity and to renovate old compartments. The additional income due to the increased capacity were sufficient to cover the costs of the mining project [RHDHV, 2015; ref 2]. De Sluiner has been granted topcover sealing exemption during iSLM-pilot phase.
3. Boeldershoek (Hengelo). A sanitary Wm-landfill, mining was feasible for flammable materials and metals, this led to tax-reduction [RHDHV, 2015; ref 2]. Boeldershoek has been granted topcover sealing exemption during the iSLM-pilot phase.
4. Benedeneind & Engelage (Veenendaal): A study concluded that complete removal with separation into partly reusable fractions was the preferred solution at two landfills in Veenendaal. The landfills were a major obstruction in a housing development plan. A subsidy from the province and the expected increase in the price of the land resulted in the complete removal of the landfills as an economically viable option. Mining has taken place and 80% of the excavated waste was reused. The presence of asbestos posed a problem. [Geusebroek, 2001; ref 34].
5. Kemperbaan (Tilburg): At this former-landfill mining was not feasible as there was too much non-reusable material present, furthermore remediation at the landfill was necessary [RHDHV, 2015; ref 2].

These, and others examples, showed that it is technically possible to mine a former landfill, but in successful projects the main aim was remediation or redevelopment. Recycling of raw materials was at the most a secondary activity/goal.

Only recycling is financially not feasible. Important factors that play a part in the success of these mining projects are: create space within the facility, available information on (recently) disposed waste, possibilities for redevelopment of the site and a refund of (landfill) taxes.

Important factors that were responsible for the failure of a mining project were: the presence of contamination (asbestos) and the limitations of available mining/separation techniques [RHDHV, 2015; ref 2]. Furthermore, a hurdle in landfill mining is that landfill taxes needed to be paid for (re)landfilling of the non-reusable/recyclable mined material.

6. Lessons learned and policy needs

This final chapter provides a summary of all the aspects that were described in chapters 1 to 5 of this document and tries to pinpoint/underline the policy gaps and address the policy needs for the future.

6.1 Waste management policy development

In the Netherlands landfill management is an integral part of landfill policy. For both sanitary Wm- and former-landfill sites there seem to be enough incentives for redevelopment of the sites.

With regard to the policy development of sanitary Wm-landfills, the Netherlands has followed a bottom up approach. In the 1980s the National Waste Stakeholders Council (NWSC) (*Afval Overleg Orgaan*) was established. In this council new legislation was discussed and developed at a decentralized level involving all stakeholders (municipalities and provinces). The NWSC facilitated the acceptance and implementation of new legislation. The NWSC has been mentioned as one of the main success factors in the development and subsequent implementation of landfill management policy.

6.2 Management of former-landfills

At former-landfills in the 1990s research has been conducted from an environmental risk- and financial management perspective. The results showed that risks were less severe than expected. Many of these sites were already in use or have been redeveloped since due to space shortage in the Netherlands.

There was no specific legislation in place for these former-landfills. A number of provinces developed their own legislation for these sites (Provincial Environmental Regulation). These were based on the Soil Protection Act and/or the Environmental Management Act and were predominately to stimulate landfill management.

With the introduction of the new legislation the 'Environment and Planning Act' (Omgevingswet) 26 Acts will be harmonized into one national framework policy. The framework of the Soil Protection Act will be incorporated in this future framework of the Environment and Planning Act, thereby replacing the Soil Protection Act. As a consequence of this, the responsibility of former-landfills will be transferred from the provinces to the municipalities. In the new 'Environment and Planning Act' the municipalities can determine their own ambitions with regard to landfill management. The main challenge in the future will be to manage, secure and safeguard all the data collected and to ensure the transfer of knowledge from provinces to municipalities and to future generations. Asset management may become an issue facing landfill management in the future.

6.3 Management of sanitary Wm-landfills

In the Netherlands the aftercare period for sanitary Wm-landfills is not limited in time. In order to finance the aftercare, the provinces manage an 'Aftercare Fund' (*Nazorgfonds*) in which the provincial levies from landfill owners is deposited as described in the Environmental Management Act (title 15.11). The aftercare of sanitary Wm-landfills is not limited to time. The province remains responsible for the environmental impact of the site. The tasks of the province as competent authority include the approval of aftercare plans, approval of final top cover, calculation of the aftercare costs, manage the aftercare fund, provide a closure statement and manage aftercare activities. In this aspect the Netherlands goes beyond the EU Landfill Directive, which states that the site owner is responsible for the costs for a period of at least 30 years.

6.4 Landfill mining

There is no specific policy in place with regard to mining of landfills neither is new policy development taking place. There has been a debate about whether mining of sanitary landfills in the Netherlands is worthwhile. A substantial number of pilots have been conducted with regard to landfill mining, but no projects on a national level therefore information isn't publicly available.

The enforcement at the entry points at landfills is very strict in the Netherlands. Currently most of the waste at landfill sites are residues from recycling processes, the value of this waste is low or heavily contaminated. The presence of asbestos, for examples, is a significant problem.

6.5 Policy needs and challenges for the future

There is a need for new techniques with which to diminish the need for aftercare and monitoring of landfill sites. The 'Introduction Sustainable Landfill Management' is the most important development on landfill management policies for sanitary Wm-landfills in the Netherlands. However to be able to conduct this research a temporary permission to deviate from current regulations, with respect to capping of the landfill with an impermeable layer, was necessary. The results from the pilots may lead to new regulations for all sanitary Wm-landfills if the pilots prove no risks for human health nor the environment.

According to Dutch legislation the aftercare of landfills must ensure no adverse effects for the environment. A challenge for the future is to try and reduce the costs of the aftercare at these sites.

Currently the financial paragraph of the aftercare regulation in the Environmental Management Act is being evaluated and an recommendation will be formulated for the minister of Infrastructure and Water Management.

7. Glossary

Legislation

- Soil Protection Act : Wet Bodembescherming (Wbb)
- Environmental Management Act : Wet Milieubeheer (Wm)
- Nuisance Act : Hinderwet
- Wastes Act : Afvalstoffenwet
- Chemical Wastes Act : Wet Chemische Afvalstoffen
- Directive Controlled Landfilling : Richtlijn Gecontroleerd Storten
- Decree Landfill and Soil Protection : Stortbesluit bodembescherming
- Environment and Planning Act : Omgevingswet
- Provincial Environmental Regulation: Provinciale Milieuverordening
- National Waste Management Plan : *Landelijk Afvalbeheer Plan (LAP)*
- Covenant Soil and Subsurface : *Convenant Bodem en Ondergrond*
- "Crisis and Recovery Act" : *'Crisis en Herstel' wet*
- Ministry of Infrastructure and Water Management : Ministerie van Infrastructuur & Waterstaat
- Ministry of Economic Affairs and Climate Policy : Ministerie Economische Zaken (EZ)
- Directorate-General for Public Works and Water Management (department physical environment): Rijkswaterstaat (afdeling Leefomgeving)
- Dutch Waste Management Association : Vereniging Afvalbedrijven
- Interprovincial Consultation Committee : Interprovinciaal Overleg (IPO)
- Dutch National Institute for Public Health and the Environment : Rijks Instituut voor Milieu (RIVM)
- Energy research Centre of the Netherlands : ECN
- Consultation Committee of Governing Bodies : 'DUIV overleg'
- Association of Dutch municipalities : Vereniging Nederlandse Gemeenten (VNG)
- Union of Water Boards : Unie van Waterschappen
- Interregional Working Group-BOOG : BODemOntwikkelGroep
- Working Group on Waste Registration : Werkgroep afvalregistratie
- National Waste Stakeholders Council : Afval Overleg Orgaan
- Dutch Lower House : Tweede Kamer der Staten Generaal
- 'Introduction Sustainable Landfill Management' (iSLM) : Introductie Duurzaam Stortbeheer (iDS)
- Sanitary Wm-landfills : Wm stortplaatsen
- Former-landfills : voormalige stortplaatsen
- 'Aftercare former-landfills' (NAVOS) : NAzorg VOormalige Stortplaatsen (NAVOS)
- 'Aftercare Fund' : *Nazorgfonds*
- VOS project : *Verkennend Onderzoek Stortplaatsen*
- ICM-measure (isolate, control, monitor): IBC-maatregel (isoleren, beheersen controleren)

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APPENDIX I

Information of (former) landfill sites

NAVOS reports

<http://www.nazorgstortplaatsen.nl/VM/Achtergronddocumenten.aspx>

[http://www.nazorgstortplaatsen.nl/VM/docs/Achtergronden%20bij%20het%20advies%20Nazorg%20voormalige%20stortplaatsen%20\(NAVOS\),%20april%202005.pdf](http://www.nazorgstortplaatsen.nl/VM/docs/Achtergronden%20bij%20het%20advies%20Nazorg%20voormalige%20stortplaatsen%20(NAVOS),%20april%202005.pdf)

National overview operational landfill sites:

<http://www.rwsleefomgeving.nl/onderwerpen/bodem-ondergrond/verwerking-grond/stortplaatsen/>

Werkprogramma Bodem en ondergrond 2015-2020:

[https://staten.zuid-](https://staten.zuid-holland.nl/DMS_Import/Statencommissie_Verkeer_en_Milieu_VenM/2016/Verkeer_en_Milieu_13_januari_2016/Opening_procedurevergadering/Ingekomen_stukken/Stuknr_539535765)

[holland.nl/DMS_Import/Statencommissie Verkeer en Milieu VenM/2016/Verkeer en Milieu 13 januari 2016/Opening_procedurevergadering/Ingekomen stukken/Stuknr 539535765](https://staten.zuid-holland.nl/DMS_Import/Statencommissie_Verkeer_en_Milieu_VenM/2016/Verkeer_en_Milieu_13_januari_2016/Opening_procedurevergadering/Ingekomen_stukken/Stuknr_539535765)

Information per Province

Noord-Brabant

<https://www.brabant.nl/dossiers/dossiers-op-thema/milieu/bodem-en-stortplaatsen/stortplaatsen.aspx>

Limburg:

http://limburg.nl/Beleid/Milieu/Bodem/Bodemgebruik/Nazorg_stortplaatsen?highlight=stortplaatsen

Gelderland:

http://kaarten.gelderland.nl/viewer/app/thema_stortbagger

<https://opendata.gelderland.nl/dataset/milieu-bodem-voormalige-stortplaatsen-navos-provincie-gelderland>

Zeeland:

<http://zldgwb.zeeland.nl/geoloket/?Viewer=Stortplaatsen>

Zuid Holland:

<https://www.zuid-holland.nl/onderwerpen/ruimte/bodem-ondergrond/nazorg-stortplaatsen/>

Noord-Holland:

<https://noordholland.archiefweb.eu/#search.1487865372953>

Utrecht:

https://www.provincie-utrecht.nl/algemene-onderdelen/zoeken/?mode=zoek&zoeken_term=voormalige+stortplaatsen&Zoeken_button

Groningen:

https://www.provinciegroningen.nl/nc/zoeken/?tx_bwoisearch_pi1%5Bq%5D=stortplaatsen

Overijssel:

http://www.overijssel.nl/algemene-onderdelen/zoeken/?zoeken_term=voormalige+stortplaatsen

This report was developed in the framework of the interreg Europe project COCOON. This report only reflects the author's view, the programme authorities are not liable for any use that may be made of the information contained herein.

COCOON: Consortium for a Coherent European Landfill Management Strategy

COCOON is the first European project on policy of Landfill Management (LfM). The COCOON partners will improve regional policy on LfM in 6 regions, starting from existing regional legislation, and learn from the best practices and lessons learned in the other regions. Working with a regional stakeholder group on the development of the policy will enhance the implementation of the policy.

Europe has been disposing vast levels of waste in landfills. Estimates have revealed that 90% of Europe's 500,000+ landfills are "non-sanitary" landfills, which predate the EU Landfill Directive and have limited environmental protection technologies. The EC has acknowledged that a vision for managing Europe's landfills is urgently required. LfM supports reclaiming land and avoids astronomic remediation and aftercare costs. Although many EU regions are already implementing LfM, no targeted, specific European LfM legislation currently exists. Nor are existing Waste Management and Soil Protection policies integrated in an overarching circular economy framework. Therefore, the COCOON objective is to develop, integrate and improve relevant policy instruments, while increasing subsidies through operational programmes (OPs) for LfM projects. COCOON brings together distinct EU regions to share and capitalise on regional good practices. The six targeted policy instruments include (a) the Soil Remediation Decree in Flanders (BE), the Environmental Protection Act in the Netherlands and (b) funding of LfM projects through the OPs in Andalucia (ES), Brandenburg (DE), Cyprus and Malta. As a result of LfM projects, the recovery of resources (landfill gas and water first, other resources later), as well as land recovery is increased while future environmental hazards can be avoided. LfM projects generate economic development opportunities; create new (local) jobs, all within the context of an EU-wide transition to a resilient, low-carbon, circular economy.

Goals

- Development of 6 regional action plans for LfM policy.
- Installation of 6 regional LfM stakeholder groups.
- Implementation of LfM policy in 6 regions.

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