How governance changes affected the supply of ecosystem services in Berg en Dal

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MSc Thesis in Environmental Sciences

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Content

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For now, I wish you a good read, Enjoy your day and enjoy ecosystem services!

With kind regards,

Nina

Summary

Temporal changes in the supply of ecosystem services (ESs) are important to address, but they are often neglected. These changes are difficult to assess and their drivers are poorly known. This study therefore demonstrates a method to assess temporal changes in potential supply so to evaluate the used method and this study identifies the effects of governance changes on ES supply in Berg en Dal in the Netherlands over the last two decades.

Literature review and stakeholder interviews identified the most important ESs. Land use and land cover (LULC) and their recent changes are assessed from detailed LULC maps from 1997, 2000, 2003, 2007 and 2012. These maps are converted by a matrix method to ES potential supply maps for seven ESs (i.e. water-flow regulation; pest and disease control; pollination; crops; livestock; recreation and tourism; and natural heritage and natural diversity). This allows to calculate potential supply and changes therein for each ES. Additionally, temporal changes in LULC and ESs potential supply are assessed through stakeholder interviews and literature review. The ES maps from 2012 are further validated using stakeholder interviews and reference maps for two ESs.

Governance changes, potential and actual drivers of change in ES supply, changes in demand for ESs and the role of (changes in) demand as a driver are identified through literature review and interviews. The identified changes in potential supply, drivers and developments in governance are combined to determine the effects of governance changes on ES supply.

The identified important ESs are: water-flow regulation; erosion regulation; crops; livestock; recreation and tourism; landscape aesthetics, amenity and inspiration; and natural heritage and natural diversity.

Ecosystem or land management directly drives changes in ES supply, including changes in LULC. The most influential past landscape changes are related to agricultural intensification, nature development and the implementation of several water-management projects. Demand indirectly drives ES supply changes, because it affects decision-making processes. Unsustainable uptake of ESs, unsatisfied demand and changes therein are likely stronger indirect drivers than the demand itself. The demand for ESs likely increased from 1995 to 2015 for most studied ESs.

The (potential) supply increased from 1995 to 2015 for: water-flow regulation; recreation and tourism; and natural heritage and natural diversity. Water-flow regulation increased through the water-management development projects. Recreation and tourism increased through facility development like pathways, nature development and increasing demands. Natural heritage and natural diversity increased through nature development in both natural and agricultural areas.

Intensification initially increased crops and livestock but they later decreased because the extent of cropland and pastures decreased. Intensification also decreased pest and disease control and pollination services but they later increased through increasing natural habitats.

Nature management is largely driven by (changes in) top-down regulations, available funding and involvement of local stakeholders. Changes in governance of nature and landscape are likely driven by an increase in (unsatisfied) demand for ESs, including natural heritage and natural diversity. Water management projects are largely driven by the (expected) effects of climate change and the (expected) rise in need to regulate water flows.

Changes in management of agricultural land that occurred from 1995 to 2005, are driven by the upscaling and intensification trends and by an increased availability of chemical pesticides and more efficient equipment. These management changes increase crop production and reduce the supply of most other ESs. From 2005 to 2015, engagement of farmers in nature management increased but in the form of developing semi-natural landscape elements. This was mainly driven by available subsidy schemes.

Top-down EU and Dutch regulations concerning nature and landscape increased. Decentralisation and regionalisation occurred, through which the Dutch government and the provincial governments delegate responsibilities to municipals and water boards. Area specific approaches are now used more frequently. A more integrated approach to nature and landscape is now used, in which multiple societal goals are combined into one vision. In Berg en Dal, participation of local stakeholders and cooperation among them increased substantially. Generally, collaborative governance, in which all governance levels cooperate to identify area-specific solutions, improved.

The shift towards collaborative governance positively affected ES supplies. This was facilitated by the increased inclusion of local stakeholders and their local knowledge. The increased collaboration among governance levels and decentralisation of tasks to the optimal governance level had positive effects on the quality of nature and the landscape. Establishing an integral vision on nature and landscape allows to find solutions that benefit multiple ESs.

The used matrix method of transforming multiple LULC maps into ES maps is found to be a good method to assess the temporal changes in potential supply. To combine the use of LULC maps with expert judgement and scientific literature is recommended to validate results.

1. Introduction

1.1. Background

1.1.1. Conceptualisation in the ecosystem service approach

Landscapes benefit humans through the supply of ecosystem services (ESs, singular: ES). ESs can be defined as the direct and indirect contributions of ecosystems to human wellbeing ("TEEB," 2010). ESs can be classified according to their properties and many different classification systems have been developed. An influential classification system is the one proposed by "TEEB" (2010), in which ESs are grouped into four categories: provisioning services, habitat services, regulating services and cultural services (see Box 1).

The broad aim of the ES approach is to contribute to better ecosystem and natural resource management (Power, 2010). In ES assessments the supply of ESs in a specific area over a specific time period is determined. The term (ES) supply indicates the actual use of an ES over a given time period. The core aim of performing ES assessments is to gain understanding of the effects of management choices on ES supply (Carpenter et al., 2009). Much research is done to make the concept of ESs operational and useful in decision-making (Ruckelshaus et al., 2015). One point of focus is the establishment of a clear conceptualisation and terminology.

Provisioning services: the material outputs from ecosystems, including food, water and other resources

Habitat services: services that underpin other services. They include: living spaces for plants or animals; they also maintain a diversity of different breeds of plants and animals.

Regulating services: the services that ecosystems provide by acting as regulators, such as regulating the quality of air and soil or by providing flood and disease control.

Cultural services: the non-material benefits people obtain from contact with ecosystems, including aesthetic, spiritual and psychological benefits.

Box 1: The categories of ESs as proposed by "TEEB" (2010)

In the scientific literature the terms 'capacity' and 'potential supply' are often used to indicate concepts concerning the ability of ecosystems to supply ESs, but these terms are not well defined (Hein et al., 2016a). In my study potential supply is defined as: the ability of an ecosystem to generate an ES under current condition and uses, at the highest sustainable yield or use level, taking into account other ESs and irrespective of demand for ESs, as proposed by Hein et al. (2016a). Distinguishing between the potential supply and the supply is important, to be able to determine whether ESs are used sustainably or not (Burkhard et al., 2014; Hein et al., 2016a). If the supply is higher than the potential supply, then the ecosystem likely degrades. Degradation leads to a lower ability to supply ESs in the future.

1.1.2. Temporal aspects of potential supply and demand for ESs

Concerning ES supply both the temporal and spatial dimensions can be distinguished. Spatially, ES supply varies locally, regionally, continentally and globally. Land use and land cover (LULC) influence ES supply and spatial variation therein (Burkhard et al.,

2012; Setiawan et al., 2013). The term ‘land use’ refers to the purpose for which humans use the land (e.g. food production or space for living), whereas ‘land cover’ reflects the vegetation, soil, water and human structures that cover the land surface and subsurface (Lambin et al., 2006). LULC maps are useful tools in localising ESs and much research is done to improve ES mapping methods (e.g. Petz & van Oudenhoven, 2012).

Besides spatial scales, studying the temporal dimension of ESs is important because the demand and the potential supply change over time (Rounsevell et al., 2010). The (potential) supply of a landscape can vary over different temporal scales, including short-term, seasonal, annual, medium-term and long-term periods (Burkhard et al., 2014). Concerning potential supply, variations over time can be caused by changes in biophysical conditions like long-term climatic changes (Burkhard et al., 2012; Holland et al., 2011). But potential supply can also vary over shorter time periods, for example within the year as a result of seasonal changes; an example is the variation in cultural ESs among tourist season and non-tourist season (Burkhard et al., 2014). Naturally occurring changes in ecosystem composition such as forest succession also influence potential supply over time.

Potential supply of ESs can also be influenced by human actions. This is the focus of this research. Human-induced changes in LULC result in a temporally varying potential supply: the potential supply is different before, during and after the LULC change. An example of a LULC change is the realisation of landscape elements like hedges in agricultural land. Semi-natural landscape elements like hedges differ in ES supply from pastures or arable land; these landscape elements generally have a higher supply of regulating and cultural ESs and a lower supply of crops and livestock (Melman & van der Heide, 2011; Petz & van Oudenhoven, 2012).

Within a certain land-use type, sequential variations in land cover can occur, resulting in temporal variations in potential supply (Burkhard et al., 2012). For example, Indonesian paddy-rice fields undergo a sequence of vegetation covers through the year (Setiawan et al., 2013). Plantations, such as timber forests, undergo longer rotation periods with varying (potential) supply of ESs (Burkhard et al., 2014). Such rotation periods occur also under Dutch conditions: in agriculture annual crops are usually sown in the beginning of the growing season and harvested at its end..

Next to the potential supply, the ES demand from society varies over time as well, influenced by many factors, among which are policies, population dynamics, economic factors, cultural norms and governance (Curran & de Sherbinin, 2004). As with other goods and services, an interplay of (potential) supply and demand of ESs exists (Hein et al., 2016b). Changes in demand can trigger land management changes, such as land-use changes, that will lead to a change in (potential) supply. Changes in land management and (potential) supply can in turn affect the demand.. Thus, temporal changes in demand likely drive changes in ES supply.

The integration of temporal varieties of ES supply and demand in ES assessments is important (Burkhard et al., 2014). The temporal aspect of ES supply is, however, often neglected. Data availability is limited and data collection is costly, as a result of which researchers have combined available data from different time periods to assess the spatial distribution of ESs (Holland et al., 2011). Holland et al. (2011) found that studies mapping the distribution of multiple ESs over large spatial scales have used datasets composed of data from an average time period of 17.25 years. In these and other studies the temporal variation in the biophysical conditions of ecosystems are often not assumed to be of influence, which can lead to wrong conclusions concerning the effects of LULC on ES supply (Holland et al., 2011). Therefore, considering the temporal aspect of ES supply in ES assessments is essential. Researchers are working on this, but no final ES assessment method which includes the temporal aspect has been found so far (Burkhard et al., 2014).

1.2.3. The role of governance in ES supply

The term land management covers the human activities that together determine land use and directly affect land cover (van Oudenhoven, 2015). A land management regime consists of multiple activities, which contribute to the purpose of the land and thereby support the land-use type (Lambin et al., 2006; van Oudenhoven, 2015). These land management activities drive changes in ES supply. Thus, drivers influencing decision-making about land management indirectly influence ES supply. Concerning decision-making processes, the scale of decision-making and the stakeholders involved determine which drivers are of influence (Leemans et al., 2003).

Decision-making processes are part of governance and the form of decision-making processes can be determined by the governance approach that is used. The term governance is used for all processes of governing; it is about creating institutional structures (Vatn, 2010). As Vatn (2010) writes, governance is about '*how we establish goals, how we define rules for reaching the defined goals, and finally how we control outcomes following from the use of these rules*.' Thus, the governance approach that is used determines which drivers are of influence and how important these are, for example concerning land management or ES supply. There are three main types of governance approaches: top-down, market-based and collaborative approach (Vatn, 2010). Top-down approaches are hierarchical systems in which decisions are made at a top level and commands are given from top level to subordinate levels. Market-based approaches rely on voluntary exchanges. All participating agents can make their own decisions and the final allocation of resources follows from actors' willingness to pay and willingness to accept. Collaborative government approaches, multi-level governance and (adaptive) co-management are often used as synonyms (Borrini-Feyerabend, 1996; as cited in Enengel et al., 2014); hereafter the term collaborative government approaches will be used in this report. Collaborative government approaches include '*governance systems that combine state control with local, decentralized decision-making and accountability and which, ideally, combine the*

strengths and mitigate the weaknesses of each' (Singleton, 1998; as cited in Enengel et al., 2014). In collaborative government approaches stakeholders on different levels collaborate.

Collaborative government approaches are considered as the most appropriate governance approach for the achievement of more effective management solutions (Wallington & Lawrence, 2008). Regional or local communities are assumed to be able to respond more effectively to local environmental problems because they are more responsive to context and local priorities, they have access to local, experiential knowledge and they have the capacity to recruit local communities (Lane & Corbett, 2005).

Although collaborative government approaches are considered a good governance approach to achieve effective land management, the actual effects of shifts from top-down or market-based governance to collaborative government approaches on ES supply are largely unknown. More knowledge about the drivers of changes in ES supply and the role of collaborative governance approaches therein is needed to sustain ES supply.

1.2. Study area

The study area is the municipality Berg en Dal, the Netherlands. Berg en Dal is located east from Nijmegen, adjacent to the German border and south from the Waal river. The area is part of the National Landscape Gelderse Poort, which is an area of agricultural, natural and historic value for the Netherlands. Berg en Dal covers a land area of 93km^2 and it encompasses 12 villages, of which Groesbeek is the largest. The total population size is about 34,000 inhabitants[1].

Figure 1 shows the Landgebruik Nederland (LGN) land-use map of the area of Berg en Dal in 2012. The area contains a variety of different landscapes, including floodplains (Ooijpolder and Duffelt), forested ridges surrounding Nijmegen and mixed agricultural lands. Berg en Dal contains the Natura 2000 areas Gelderse Poort, Bruuk and Sint Jansberg[2]. These areas consist of among others river landscapes, swamp areas and alluvial forests.

[1] Gelderland Databank: https://gelderland.databank.nl/jive/?report=bevolking. Accessed on: 06-07-2017

[2] Gemeente Berg en Dal: https://www.bergendal.nl/zien-en-beleven/bijzondere-natuurgebieden_45626/. Accessed on 21-07-17

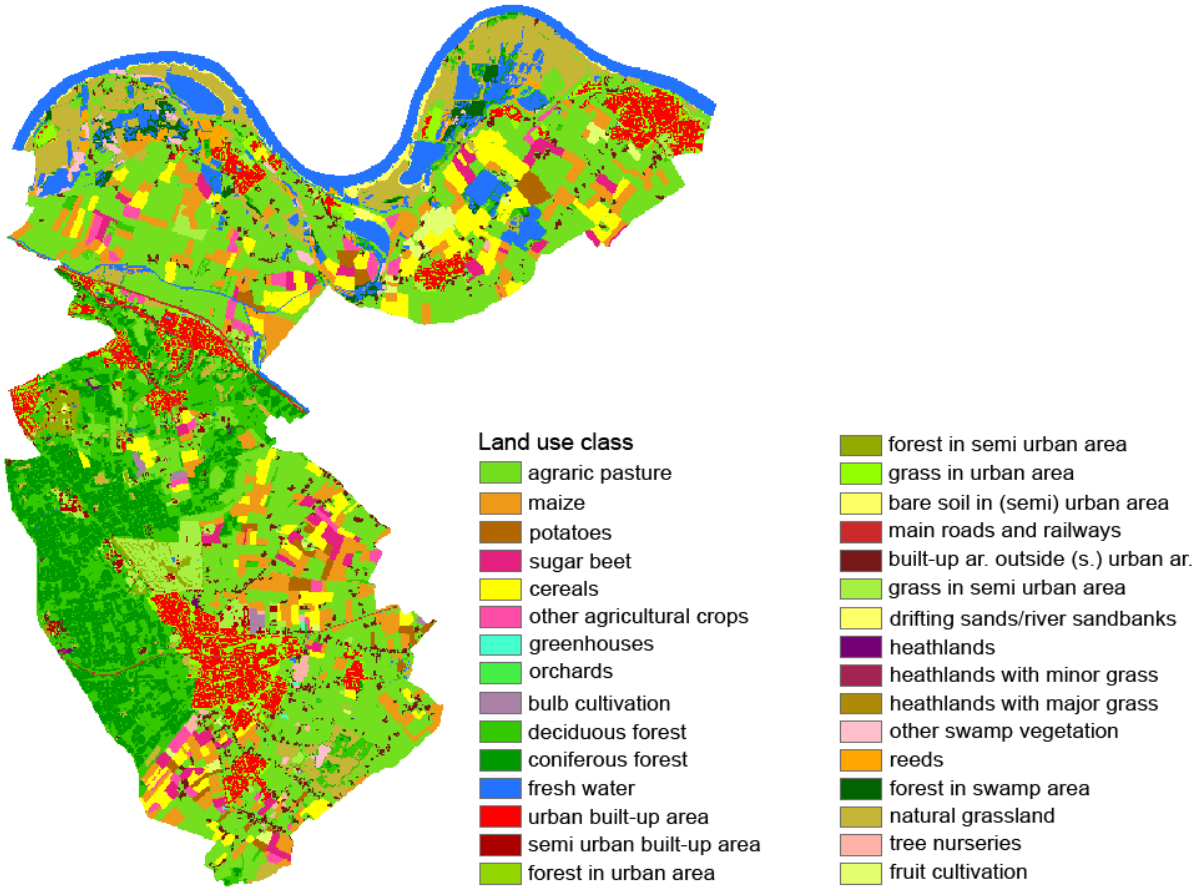

Figure 1: LGN land use map of Berg en Dal, 2012. Source: Hazeu (2013)

The landscape of Berg en Dal supplies among others the ESs water-flow regulation, recreation and food. Water-flow regulation is supplied by the present water courses, including the Waal and smaller streams, and the floodplain area. Agricultural activities in Berg en Dal include the production of dairy products, as well as the production of wine and other crops. The high landscape quality contributes to recreation and thereby the local economy; the recreation sector accounts for about 15% of its income in the municipality ("LOP Berg en Dal 2015 - 2025," 2015). Additionally, because of the high value of the landscape, several knowledge institutions and medical and healthcare institutions and offices are settled in the area ("LOP Berg en Dal 2015 - 2025," 2015).

To ensure the landscape will remain of high value, the municipality of Berg en Dal (previously the municipality of Groesbeek) established a landscape development plan (LOP, in Dutch: Landschapsontwikkelingsplan) for the time period of 2005 to 2014 (called LOP 2004). One of the aims of LOP 2004 was to increase involvement of local inhabitants and organisations in landscape development. Through LOP 2004, land owners and inhabitants have become more actively involved with the landscape through organisations such as Ploegdriever, IVN and Stichting Landschap Ooijpolder – Groesbeek. Other successful gains of the LOP 2004 are a strengthened identity of the area by increased visibility of historic elements and an improved network of

pathways and natural landscape elements. ("Achtergronddocument LOP 2015-2024," 2015)

Following LOP 2004, LOP 2015-2025 was established for the time period of 2015 to 2025. In this time period, important challenges concerning nature and landscape are a general cut back in public funding, from the State and the province, and the impacts of climate change, especially concerning the occurrence of floods ("Achtergronddocument LOP 2015-2024," 2015). The aims of LOP 2015-2025 are in line with the aims of LOP 2004. The municipality aims for an integral approach, wherein goals concerning e.g. agriculture, nature and recreation can be combined in projects that benefit the landscape and the inhabitants ("LOP Berg en Dal 2015 - 2025," 2015).

The LOP documents include a section with project proposals, which is meant as an invitation for civil society to take up these or other suitable projects in collaboration with the municipality. Through both LOPs, the municipality stimulates collaborative government approaches in landscape development with an increased participation of local stakeholders and organisations.

1.3. Problem statement

ES (potential) supply and demand vary over spatial and temporal scales. Despite acknowledgement of its importance, the temporal variability in ES (potential) supply and demand is often neglected in ES assessments, which can lead to wrong conclusions. Currently no final method is available to include the temporal variability of ES supply in ES assessments. Land-use maps are often used in ES assessments, but the potential application of using land-use maps to assess temporal changes in ES supply still needs to be tested.

In order to sustain ES supply, the drivers of change in ES supply need to be known. Potential drivers, like governance and land-use changes, need to be correlated to occurring changes in ES supply. Therefore, studies are needed that assess changes in ES supply and the influence of potential drivers of change in a study area over a certain time period, so to identify the actual effects of drivers of change on ES supply over time. Governance can potentially be used as a tool to sustain ES supply, but the actual effects of governance changes on ES supply are poorly known. Therefore, more knowledge is required about the effects of governance changes on ES supply.

1.4. Purpose

1.4.1. Objective

The study's purpose is to improve current ES assessment methods by developing and testing a method to assess temporal trends and variability of ES (potential) supply and to give recommendations about use of this method to assess the temporal variability of ES supply. Next to assessing changes in ES supply, this study aims to identify the

drivers of change in ES supply. This study addresses the role of governance changes as a driver of in ES supply.

An assessment of ES potential supply in Berg en Dal for the period between 1995 and 2015 is performed. Using the matrix method of Burkhard et al. (2014), a series of subsequent land-use maps are transformed into ES maps, from which developments in potential supply over time are identified. The results are validated through literature review and stakeholder interviews. In addition, the created maps are validated through interviews and with help of existing ES maps of the same area. Based on the performed validations, recommendations about use of this method are formulated.

Changes in governance of nature and landscape are identified through literature review and interviews. Drivers of change in the (potential) supply of ESs are identified. Specifically, the role of (changes in) demand as a driver of change in ES supply is assessed. The results are combined to identify the effects of governance changes on ES supply.

1.4.2. Research questions

In order to fulfil the purpose, the following research questions are formulated.

Research aim 1:

- RQ1.1 Which ESs are important in the landscape of Berg en Dal?
- RQ1.2 How did the potential supply of ESs in Berg en Dal develop between 1995 and 2015 as a result of land-use changes?
- RQ1.3 Can the matrix method with generic parameterization of potential supply be used to assess spatial and temporal dimensions of potential supply in a local study area?

Research aim 2:

- RQ2.1 How did governance in Berg en Dal change between 1995 and 2015?
- RQ2.2 What are potential drivers of change in the supply of ESs?
- RQ2.3 How did the demand for ESs in Berg en Dal develop between 1995 and 2015?
- RQ2.4 What are important drivers of change in the supply of ESs in Berg en Dal?
- RQ2.5 How did governance changes in Berg en Dal affect the supply of ESs between 1995 and 2015?

1.5. Outline

The framework of this study is made visible with help of the DPSIR framework (Figure 2). The study focusses on changes in ES supply resulting from human actions. Therefore, ES supply is the *state* of the system to be studied. The state of ES supply refers to the supply of all different ESs on a given point in time or over a given time period. Consequently, the (indirect) *drivers* are developments that lead to *pressures* that directly influence the state of ES supply. A change in ES supply leads to negative or positive *impacts* on *'individuals, society and/or environmental resources'* (Rounsevell et al., 2010). These impacts lead to *responses* from society, which are aimed at minimising negative impacts or maximising positive impacts.

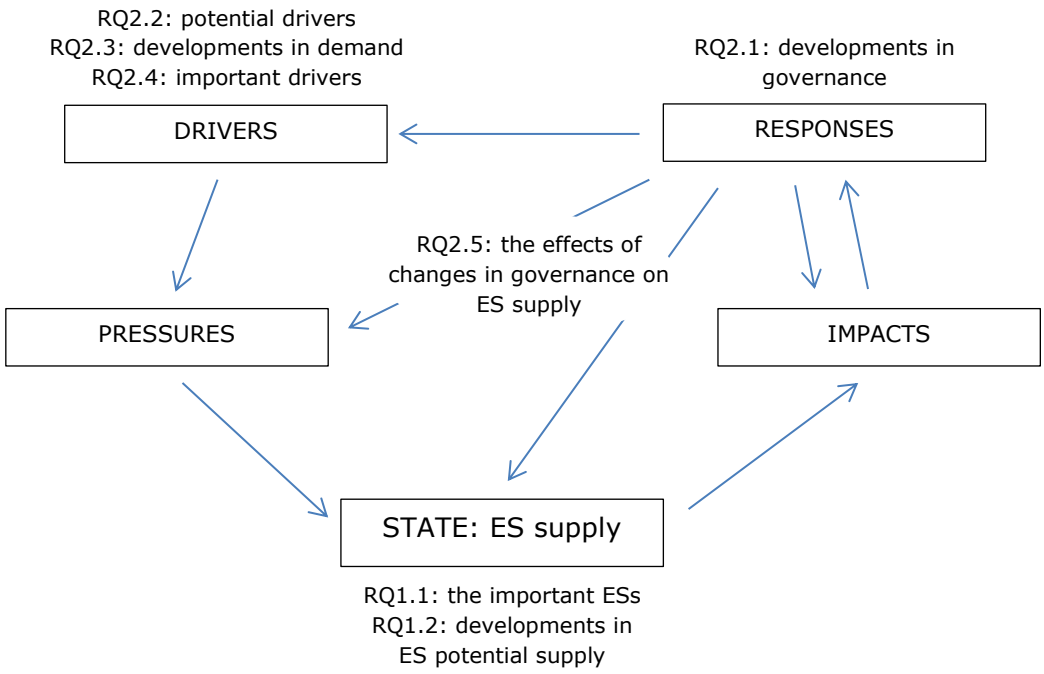

Figure 2: DPSIR diagram depicting the relationships between the state of a system, how it is influenced by drivers and pressures, how a change in the state causes impacts which lead to responses, which can influence the drivers, pressures, the state and the impacts.

Firstly, the state of ES supply in the landscape of Berg en Dal is assessed, with a focus on identifying the most important ESs (RQ1.1). Next, changes in the potential supply of a selection of ESs in a selected time period are assessed (RQ1.2). The assessment method that is used to identify changes in potential supply is evaluated (RQ1.3, not in DPSIR).

Changes in governance of nature and landscape are identified (RQ2.1). Potential drivers of changes in ES supply in Berg en Dal are identified (RQ2.2). Actual drivers of change in ES supply are identified (RQ2.3), including the role of demand (changes) as a driver (RQ2.1). Finally, the effects of governance changes on ES supply are identified (RQ2.5).

In Figure 2, developments in governance (RQ2.1) are placed at the response box, because responses often take the form of acts of governing. However, governance may be placed as a driver in the DPSIR diagram, depending on the focus of the research. In this study, governance is regarded as both a response and a driver. The effects of governance changes on ES supply are assessed, in which governance is mostly a driver. The drivers of governance changes are also lightly addressed. These drivers include (un)satisfied demand and (un)sustainable uptake, which can be regarded as impacts.

2. Methodology

2.1. Literature review

The literature review focusses on identifying:

- Important ESs (RQ1.1);
- Developments in governance of nature and landscape (RQ2.1);
- Potential drivers of changes in ES supply (RQ2.2);
- Developments in demand for ESs (RQ2.3);
- Actual drivers of changes in ES supply in Berg en Dal (RQ2.3).

Different types of literature sources are used. Scientific literature is predominantly used to identify potential drivers of changes in ES supply. Scientific literature is also used to identify general trends concerning demand for ESs and developments in governance. Scientific literature is found through the WUR Library.

Other search engines are used to find information about the landscape of and governance in Berg en Dal. Sources include websites of government bodies, such as those of the EU, the Dutch ministries, the province of Gelderland, the municipality and the water board, and websites of local organisations that are involved with the landscape, for example the NGO 'Ploegdriever'. Next to websites, online documents (e.g. government documents), legal regulations, reports, presentations and pamphlets are used. Similar sources are used to identify developments in demand and important drivers of change in ES supply.

A selection of ESs to be studied in more detail is made based on occurring land-use types (and their purposes in terms of ES supply) and reports about Berg en Dal (e.g. "Achtergronddocument LOP 2015-2024," 2015), including information about the intentions of the municipality in terms of development of the region. The selected ESs have to be defined in the same way as in Burkhard et al. (2014). This way the exemplary matrices can be used to make ES maps for the selected ESs (see Section 2.4.).

2.2. Interviews

2.2.1. Interview format and interviewee selection

The aims of the interviews were:

- Identifying important ESs in Berg en Dal;
- Evaluating the created ES maps;
- Identifying drivers that lead to changes in land use; and
- Identifying the effects of governance changes on land use.

An interview guideline with the different interview topics and suggested questions was created and used in the interviews (in Dutch, see Annex 2 for altered guidelines). The main format of the interviews was semi-structured, which allowed for additional, explanatory input from the interviewees. The exact questions and topics addressed in the interviews differed among stakeholders, because of their different expertise. In Sections 2.2.2. and 2.2.3. the main themes and questions of the interviews are explained.

Five stakeholders are interviewed. The interviewees are selected based on their knowledge and their different backgrounds. The interviewees include an employee of the municipality of Berg en Dal, an employee of water board Rivierenland that is responsible for water control in the area (including water management and looking after dikes and drainage quays), a farmer who's farm is located in Berg en Dal who is involved in landscape management, a member of the nature management organisation 'Ploegdriever' and a member of the landscape development organisation 'Via Natura'. An overview of the interviewees is given in Annex 1.

2.2.2. Interviewees' opinion about important ESs and ES maps

Interviewees are asked about their understanding of ESs, after which the definition of ("TEEB" 2010) is given. Interviewees are provided with a list of the ESs that are used in Burkhard et al. (2014). Thereafter the interviewees are asked to select the ESs that they perceive as most important in Berg en Dal. They are asked to select 4-5 ESs or more if preferred. They are asked to reason aloud so that their reasoning is known. If their reasoning or interpretations of ESs are incorrect, these are corrected. Additional explanation is asked for when they select ESs that are not pre-selected in this study.

The ES maps of 2012 (see Section 2.4.) are validated through asking the interviewees whether according to them the spatial distribution of potential supply is depicted correctly. They are asked to indicate potential improvements of the maps according to them, including which areas should have a lower or higher potential supply.

Interviews are used to validate the temporal assessment of potential supply through ES maps. Interviewees are asked to complete statements about temporal changes in potential supply of the pre-selected ESs. These statements address the time periods 1995 to 2005 and 2006 to 2015. To complete the statements, interviewees have to indicate an increase (++ or +), a constant potential supply (0) or a decrease (- or --). Additionally, if interviewees indicated a change, they were asked which drivers were of major influence on the change.

2.2.3. Land use and governance

The themes of the part of the interview that addresses land use and governance are:

- Land use and changes therein over time;
- Drivers of land-use changes and of changes in ES supply;
- Stakeholders that are involved with land use and with changes therein;
- Changes in the demand for ESs ;
- Changes in governance of nature and landscape in Berg en Dal; and
- The effects of changes in governance on land use and ES supply in Berg en Dal.

2.3. Construction of ES maps

This section explains the conversion of land-use maps to ES potential supply maps and the analyses of all maps.

2.3.1. Matrix method

The “matrix method”, which is developed by Burkhard et al. (2012) and improved by Burkhard et al. (2014), can relate ES supply to land-cover type. To do this, the following matrix is completed: on the columns specify the different ESs and on the rows specify the geo-biophysical spatial units (i.e. the land-cover types). The matrix can be used for assessing ES potential supply, supply and/or demand. The matrix is completed through indicating the relevant (potential) supply or demand for each ES in each land-cover type for each. To do this, ES (potential) supply or demand is assessed using different indicators for the different ESs. The found indicator values are normalised to values on a scale from 0 (no relevant supply or demand) to 5 (maximum relevant supply or demand), to make them easier to interpret.

One of the advantages of this method is that all kinds of data can be integrated and that the method can be used for both data-poor and data-rich environments. The resulting matrix can be used to create ES maps out of land-cover maps. ES maps give a visual representation of the spatial variation of ES supply on a specific point in time. The matrix method is a method to assess ESs (potential, supply or demand) on a specific point in time and it does not directly include a temporal scale. However, once the matrix is established, it can be used to perform multiple assessments of different time points. This approach allows for assessment of the temporal aspect of ESs.

Burkhard et al. (2014) assessed ES potential (potential supply), ES flow (supply) and ES demand for each different CORINE land-cover type ‘*for a hypothetical “normal” European landscape at one time point in summer before harvest*’. From the results, exemplary matrices were made for ES potential, ES flow and ES demand as well as for ES potential-flow comparison and ES flow-demand budget. The exemplary matrices illustrate the application potential of the matrix method.

The exemplary matrices contain the 0-5 values and not the used indicators or found indicator values. However, indicator selection is discussed and tables with suggested

indicators for each ES for potential supply, supply and demand are included. Most of the presented values are based on expert opinions and Burkhard et al. (2014) emphasized that '*the proper quantification and testing of the values should be done within the distinct case studies*' (p. 23).

The matrix method in other studies

Since the introduction of the matrix method by Burkhard et al. (2012), variations of the matrix method have been used in many ES assessment studies. Seppelt et al. (2011) compared 153 regional ES assessments from before 2010 and found that two-thirds of all studies used look-up tables that assign ES indicators to land use or land cover. The matrix method has been used in several studies to assess the temporal scale of ES supply, including the recent studies of Dick et al. (2016) and Li et al. (2016).

Dick et al. (2016) used the matrix method in assessing the changes in ES supply in nine UK Environmental Change Network sites over 20 years. Dick et al. (2016) combined a qualitative approach with a semi-quantitative approach, to be able to compare the methods. For the qualitative approach, site managers wrote an unstructured report about the change in ES supply at their sites during the time period of 1993 to 2012. Site managers also reported what they perceived as the most likely drivers. In the semi-quantitative approach, the same site managers were provided with the exemplary matrix of Burkhard et al. (2014) in which ES supply scores are suggested per CORINE land-cover class. The site managers assessed ES supply in the land-cover classes that were present in their sites at two points in time: 1993 and 2012. For each change in score between 1993 and 2012, site managers gave possible reasons or drivers. The two methods used by Dick et al. (2016) generally had similar results concerning trends of provisioning, regulating and cultural ESs. The qualitative approach allowed for more explanatory or contextual information, whereas the matrix method was more reductionist. Dick et al. (2016) conclude that *'applying both qualitative and quantitative methods to the same assessment sites provided insight which could not be provided by one method alone.'* (p.124)

Li et al. (2016) used LULC maps to make ES maps for potential supply, supply and demand for two time points. They assessed the potential supply, supply and demand of 21 ESs in nine regions of Taihu River Basin, China, in 2000 and 2010. Eight experts were asked to rate potential supply, supply and demand for each ES in each present LULC class, using the 0-5 scale as suggested by Burkhard et al. (2014). ES maps were made based on the found values. Additionally, they introduced new indicators that were calculated and mapped per region: (1) the supply rate; and (2) the supply-demand ratio (see original article for details). Then, comparisons were made among regions and among the two time points. Focus of the study was on testing the newly introduced indicators.

The matrix method in this study

My study used the exemplary matrix for ES potential of Burkhard et al. (2014) to convert land-use maps to ES maps. The definition of 'potential' as given by Burkhard et al. (2012) and used in Burkhard et al. (2014) is: '*the hypothetical maximum yield of selected optimized ecosystem services*'. I assume that potential as used by Burkhard et al. (2014) is similar to 'potential supply' as defined by Hein et al. (2016a) and I continue to use the term potential supply. Potential supply represents maximal sustainable supply levels and does not take into account the demand for the ES.

In my study ES potential supply maps are made for five subsequent years. The subsequent maps are used to assess spatial-temporal changes in potential supply. The most recent ES maps are visually evaluated through interviews and temporal changes in potential supply are assessed through interviews (see Section 2.2.2.). In addition to assessment of potential supply, changes in demand and supply are also addressed in interviews.

2.3.2. LGN maps

This study uses land-use maps of LGN (Hazeu, 2013), which is a Dutch database that shows the spatial distribution of land-use classes in grid cells of 25×25 meters. There are seven versions, LGN1-LGN7, with reference years from 1986 (LGN1) until 2012 (LGN7). The maps are made using data that includes satellite imagery, topographical maps, aerial photographs and other information sources. The process of creating LGN databases improved over time and *'a comparison of the different LGN databases shows an increase in thematic detail, in thematic accuracy and in the number of satellite images used for classification (in later versions mainly for the classification of agricultural crops)'* (p.285 in Hazeu, 2014).

Table 1: Used LGN maps and corresponding years of data the maps are based on for Berg en Dal

Version	Year
LGN3plus	1997
LGN4	2000
LGN5	2003
LGN6	2007
LGN7	2012

In this study LGN3plus to LGN7 were used, spanning from 1997 to 2012 (see Table 1). LGN3plus is an improved version of LGN3 and it has the same land-use classification system as LGN4 and LGN5. In LGN6 and LGN7 a land-use classification system is used that differs from the one of LGN3plus to LGN5. An overview was made of the classes used in LGN3plus/4/5 and LGN6/7 that occurred in Berg en Dal, using an existing overview of the land-use classes of LGN1-5 (lgn1-5-legend-overview.xls), which is an addition to the LGN database (Hazeu, 2013), and Hazeu (2014). Annex 3

shows the overview of how the different LGN classification systems relate to another and how they relate to CORINE land cover (CLC) classes (see Section 2.3.3.).

The original LGN class names are in Dutch. I used the English LGN6 class names of Hazeu (2014) for LGN6 and LGN7, because I also use his study to convert LGN classes to CLC classes (see Section 2.3.3.). However, Hazeu (2014) classified the urban area in an inconsequent way, which is why I use slightly different class names for these urban classes (see Annex 4). For LGN3plus/4/5 I used English class names as presented in the existing overview of LGN1-5 (lgn1-5-legend-overview.xls).

2.3.3. Conversion from LGN classes to CLC classes

The potential supply matrix of Burkhard et al. (2014) used CLC classes. Therefore, to be able to use this matrix, the LGN land-use maps are converted to "CLC maps". Annex 3 shows how the LGN classification systems correspond to each other and to CLC classes (only including land-use classes occurring in Berg en Dal). LGN classes were linked to corresponding CLC classes following Table 18.6 of Hazeu (2014) in which LGN6/7 classes and CLC classes were correlated based on semantics.

In most cases, LGN classes correspond each to one CLC class in Hazeu (2014). In some cases the CLC classification system is more specific than the LGN classification, as a result of which multiple CLC classes correspond to the same LGN class. In those cases, one CLC class is chosen based on Hazeu (2014) and Kosztra and Arnold (2014) (see Annex 4 for details about this process). I chose to select only one corresponding CLC class per LGN class, because for most classes this is truthful and because it is time consuming to classify land area more accurately while it may not contribute much to the results of the study.

Concerning the LGN class fresh water, the CLC class water courses is used, because the Waal river has slightly more surface area than the remaining fresh water in Berg en Dal. In further analysis a correction is made to distinguish the surface area of water courses and water bodies and the potential supply thereof (see Section 2.3.5.).

2.3.4. Creating the ES potential supply maps

ArcMap10.2.1 is used to convert the LGN maps into CLC maps and to convert the latter into ES maps. ES maps are created for the following ESs that are selected based on literature research (see Section 3.1.): water-flow regulation, pollination, pest and disease control, crops, livestock (domestic), recreation and tourism and natural heritage and natural diversity.

First, the original LGN maps (LGN3plus to LGN7) are clipped to the area of the municipality of Berg en Dal. The 'LGN to CLC conversion table' (see Annex 3) is used to create CLC maps from the LGN land-use maps. Next, the 'potential supply' exemplary matrix is used to create ES maps from the CLC land-cover maps. The creation of new maps is done through adding columns in the attribute tables of the LGN maps and changing which values are shown in the map.

2.3.5. Temporal analysis of land-cover maps and ES maps

Temporal changes in land cover are detected through comparing land cover distribution throughout the years. Similarly, temporal changes in potential supply are detected through comparing potential supply values of different years (as is explained in this section). Additionally, changes in potential supply are attributed to certain changes in land cover that have occurred.

Determining surface areas of land-cover classes

The attribute tables of the LGN maps contain data of the surface areas per LGN class in units of 25×25 m^2. These surface area values per LGN class are used to determine the surface areas per CLC class. The attribute tables of the LGN maps of Berg en Dal are used as data: these tables include per LGN class the surface area in units of 25×25 m^2; the CLC class code corresponding to the LGN class; and the potential supply values for the selected ESs, which correspond to the CLC class.

Following, the dataset is made more accurate through distinguishing between the CLC classes water courses and water bodies (see Annex 4). The surface area of the Waal river in Berg en Dal, which is determined using a water type layer file based on 2008 (*Watertypekaart*, 2008), is used for the class water courses and the remaining water surface in Berg en Dal is used for water bodies.

Calculating potential supply values

The potential supply in the total study area is determined in the following way. First, the potential supply of ESs is calculated separately for each ES and land-cover class. The sum of these potential supply values represents the potential supply of the total study area.

The potential supply values as given by Burkhard et al. (2014) have no unit of measure, only a scale from 0 to 5. In the ES maps these 0-5 values are assigned to the units of which the raster layer is composed, which are units of 25×25 m^2. These 0-5 values represent a scale from 'no relevant potential supply' up to 'very high (maximum) relevant potential supply'. In the analyses, I chose to always normalise the potential supply values to this 0-5 scale. This means that the 0-5 scale is used in slightly different ways in the original matrix, the ES maps and in the different analyses and that it needs to be interpreted as such.

In the first analysis, the 0-5 scale is used over the whole surface area of Berg en Dal. This can be explained in an example: The potential supply value for crops of non-irrigated arable land is 5: very high (maximum) relevant potential supply. If the whole surface area of Berg en Dal is assigned the CLC class non-irrigated arable land, the whole surface area would have a potential supply of 5 for crops. Following, the potential supply of Berg en Dal for crops will be 5 as well: very high (maximum) relevant potential supply.

In another example, in Berg en Dal 50% of the surface area is non-irrigated arable land and 50% is pastures. Non-irrigated arable land has a potential supply of 5 for crops and a 0 for livestock, whereas pastures has a potential supply of 0 for crops and 5 for livestock. So, 50% of the land surface has a supply of 5 for crops and 50% of the surface area has a supply of 0 for crops. This leads to a total potential supply of crops of 2.5 in Berg en Dal. In the same way, the potential supply of livestock (domestic) will be 2.5 in Berg en Dal. In other words, the contribution of non-irrigated arable land to the potential supply of crops is 2.5 and the contribution of pastures to the potential supply of livestock is 2.5.

Each CLC classes' contribution to the potential supply of the total study area is calculated. This is done from the CLC classes' potential supply value and its surface area in relation to the total surface of the study area. The potential supply is calculated per ES per CLC land-cover class following Equation 1.

$$potential\ supply_{CLC_i} = \frac{potential\ supply\ value_{CLC_i} \bullet area_{CLC_i}}{total\ study\ area} \qquad \textit{Equation 1}$$

The outcome represents the contribution of the CLC class to the potential supply of Berg en Dal on a scale from 0-5.

The potential supply of the study area is calculated through summing the potential supply of the present CLC classes in Berg en Dal, using Equation 2.

$$total\ potential\ supply = \sum_{i=1}^{n}(potential\ supply_{CLC_i}) \qquad \textit{Equation 2}$$

2.3.6. Assessment of the effects of small-scale landscape elements on potential supply

The effects of the semi-natural elements and recreational pathways of the Groenblauwe Diensten program on ES potential supply are assessed through the matrix method. Maps of the landscape elements of the Groenblauwe Diensten program (in October, 2016) are used to determine the area size of the elements. The landscape elements are appointed land-cover types that occur in the exemplary matrix of Burkhard et al. (2014). Thereafter, the effect of the development of these elements on potential supply is calculated.

Semi-natural landscape elements

The semi-natural landscape elements occur predominantly in and alongside pastures and non-irrigated arable land. For these landscape elements, the CLC class 'land principally occupied by agriculture, with significant areas of natural vegetation' (short: agriculture & natural vegetation) and its appointed potential values in Burkhard et al. (2014) are used. The class agriculture & natural vegetation is defined as '*areas principally occupied by agriculture, interspersed with significant natural or semi-natural areas (including wetlands, water bodies, mineral outcrops)*' (Kosztra & Arnold, 2014). This class includes mosaics of agricultural parcels and patches of natural/semi-natural

areas, with the latter occupying in between 25% and 75% of the area (Kosztra & Arnold, 2014).

The potential supply values of agriculture & natural vegetation in Burkhard et al. (2014) are compared with values of agricultural land-cover classes (pastures and non-irrigated arable land) and natural land-cover classes (grasslands, broad-leaved forest and coniferous forest). This comparison leads to the conclusion that the potential supply values of agriculture & natural vegetation are in between the values of agricultural land-use types and forests. These values seem to be good estimates for the potential supply in the agricultural areas with present semi-natural small-scale landscape elements.

The different types of semi-natural landscape elements are depicted in the used maps as polygons, points or lines. The surface areas of the polygon shaped elements as registered in the Groenblauwe Diensten program are given in the attribute table. Some assumptions are used to determine the surface areas of the point and line shaped elements.

The point shaped elements are solitary trees of different sizes (<20cm, 20-60cm and >60cm in diameter). The roots and canopy of trees are larger than the stem and the ground close to the stem may harbour vegetation that differs from the surrounding area. Therefore, a larger surface area than the surface area of the stem can be used: the surface area of $2m^2$ is used for solitary trees.

For all line shaped elements the length is known and for most line shaped elements the width and/or area surface is given. For 32 hedges only the length is known. The hedges of which the width is known have an average width of 4.39m, which is used to calculate the surface area of the other hedges too. For three grass herb strips no width is given; based on the widths of the other grass herb strips, a width of 3m is chosen to use to calculate the surface area.

For rows of (knot) trees the length or the row and the number of trees are known, but not the width. The assumption is used that the surface area is $4m^2$ per tree. This surface area is larger than the surface area used for solitary trees ($2m^2$), which is based on the assumption that in a row of trees more space between and around the stems is covered with natural vegetation than in individual trees.

Using the above written assumptions and values, the surface areas of landscape elements as presented in Table 2 are obtained. The total surface area of semi-natural landscape elements is 29.3ha. Though, a different surface area should be used for class 243, because the definition of CLC class 243 dictates that in between 25% and 75% of the area is natural vegetation and the rest is agricultural land. Here I used the average of 50% nature with 50% agriculture. As a result, the surface area of class 243 is twice the surface area of the landscape elements, leading to a total of 58.7ha.

Table 2: Surface areas of semi-natural landscape elements of the Groenblauwe Diensten program, categorised by shape in the ArcGIS layer files: point shaped, line shaped and polygon shaped. Recreational pathways are not included.

Landscape elements	**Total surface area (ha)**
Solitary trees (point shaped)	4.2×10^{-3}
Line-shaped elements	25.5
Polygon-shaped elements	3.8
Total	29.3

Comparison of the layer files of the landscape elements with LGN7 (converted to CLC classes) shows that the semi-natural landscape elements are likely slightly more often situated (in terms of surface area) in pastures than in non-irrigated arable land. However, the latest LGN map (LGN7) is based on data of 2012, whereas the landscape elements layer files are based on 2016. Between 2012 and 2016, agricultural fields may have changed land-use types. Thus, I assume that landscape elements are placed for 50% in non-irrigated arable land and for 50% in pastures.

Recreational pathways

The pathways are likely bare soil or grass and other types of low vegetation, so they likely have a low potential supply of regulating and provisioning services and a high potential supply of recreation and tourism. I chose to use the land-use type sport and leisure facilities, which are relatively high for recreation and tourism and relatively low for most other ESs.

The total length of the recreational pathways on and alongside agricultural fields is 75.8km, as was found in the Groenblauwe Diensten maps. The pathways generally have a width of a few meters (Niemeijer et al., 2016), so I used an average width of 2m to calculate the surface area. Following, the surface area of the recreational pathways is approximately 15.2ha.

Concerning the location of recreational pathways, the same assumption is used as for semi-natural landscape elements: pathways are placed for 50% on former non-irrigated arable land and for 50% on former pastures.

Analysis of the impact of landscape elements

The effect of the landscape elements on the potential supply of the agricultural area only is considered, because focusing on the agricultural area makes the effect more visible. To do this, only the present agricultural land-cover classes are considered: non-irrigated arable land, pastures and fruit trees and berry plantations.

The potential supply of ESs in the agricultural area is determined for four scenarios:

- Landscape elements are absent (control scenario):
- Semi-natural elements are present and pathways are absent;
- Semi-natural elements are absent and pathways are present; and
- Both semi-natural elements and pathways are present.

Surface values of the agricultural classes of the land cover map of 2012 are used to calculate the potential supply of the area without landscape elements. The determined surface areas of the landscape elements and corresponding land-cover classes are used to calculate the surface areas of the land-cover classes in the presence of these landscape elements. Following from these surface areas, the potential supply is calculated for the four scenarios using Equation 3:

$$potential\ supply_{agr} = \sum \frac{potential\ supply\ value_{CLC_i} \times area_{CLC_i}}{total\ area_{agr}} \qquad \textit{Equation 3}$$

in which 'agr' stands for 'agricultural area'.

The effects of the presence of the landscape elements is then determined by subtracting the potential supply of the control scenario from the scenarios with present landscape elements. Additionally, the potential supply values of the different scenarios are compared to determine the effects of the landscape elements.

2.4. Validation of ES maps and assessment method

The created ES potential supply maps based on LGN7 (2012) are validated in two ways: through comparing the maps to other ES maps of Berg en Dal and through stakeholder interviews. The outcomes of these validations are used to evaluate the used ES assessment method.

ES maps for pest control and pollination produced by Remme et al. (2017) (hereafter called 'reference maps') are used to validate the ES maps for the corresponding ESs that are made in the current study. The reference maps are made using land use data of 2013. The values of the reference map are subdivided into 6 groups, representing the used 0-5 scale, and visualised as such in the maps. The maps are evaluated through visual evaluation of the general spatial pattern. The ES maps that are validated are the pest and disease control and pollination maps of 2012.

The validation of the ES maps through stakeholder interviews is described in Section 2.2.2.

2.5. Analysis of drivers of change in ES supply

The results are integrated into narratives and overviews of land use developments, potential supply developments, governance changes, demand changes and important drivers therein. Based on these narratives and overviews the effects of governance changes on ES supply are determined.

3. Results

3.1. Developments in land use in Berg en Dal from 1995 to 2015

Land-use changes that are identified from LULC maps, literature and interviews are presented. For changes in land use that are associated to a specific implemented project, the project is shortly described. See Section 3.5.3. and Annex 5 for more information about the executed projects.

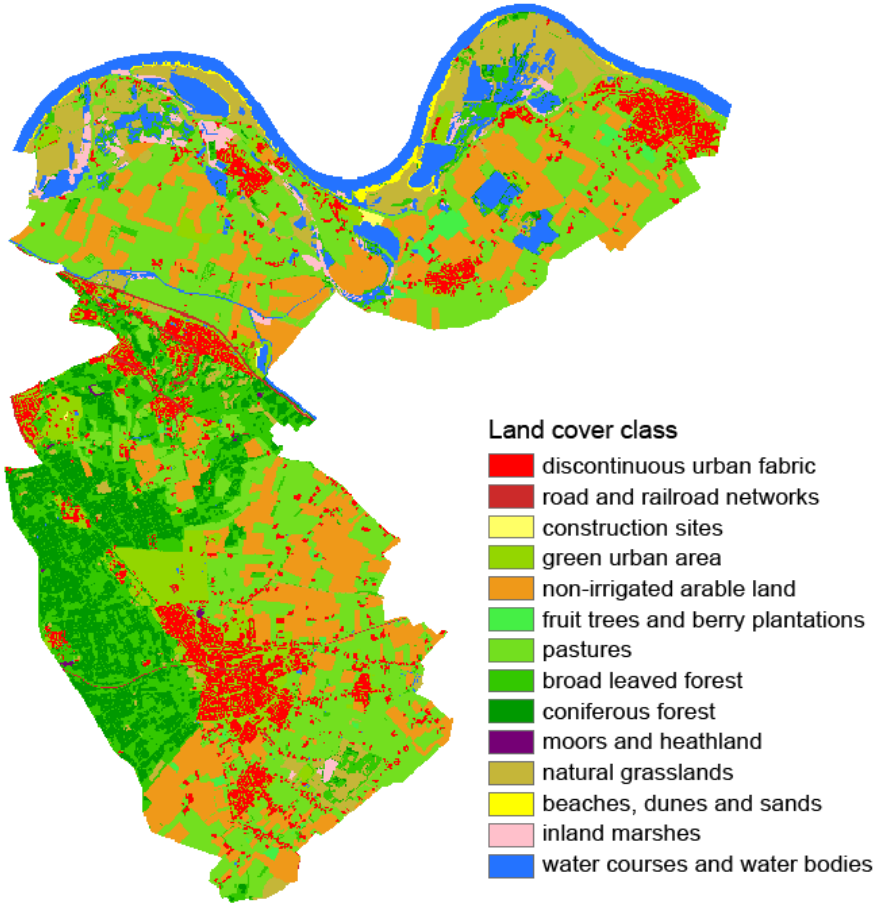

Figure 3: Land cover map of Berg en Dal, 2012. Based on LGN7 map.

Figure 3 shows the LGN land cover map of Berg en Dal in 2012. Figure 4 shows the surface areas of land-cover types in Berg en Dal for the years 1997, 2000, 2003, 2007 and 2012. Concerning the surface areas, the most clear developments are a decrease in surface area of pastures and an increase in natural grasslands. The graph shows a decrease in road and rail networks and associated lands and in discontinuous urban fabric from 2003 to 2007, which is largely a result of an improve in mapping methods (see Section 2.3.2.). In the maps, where the road and rail networks and associated lands decrease in surface due to different mapping methods, these areas are generally newly classified as pastures and non-irrigated arable land.

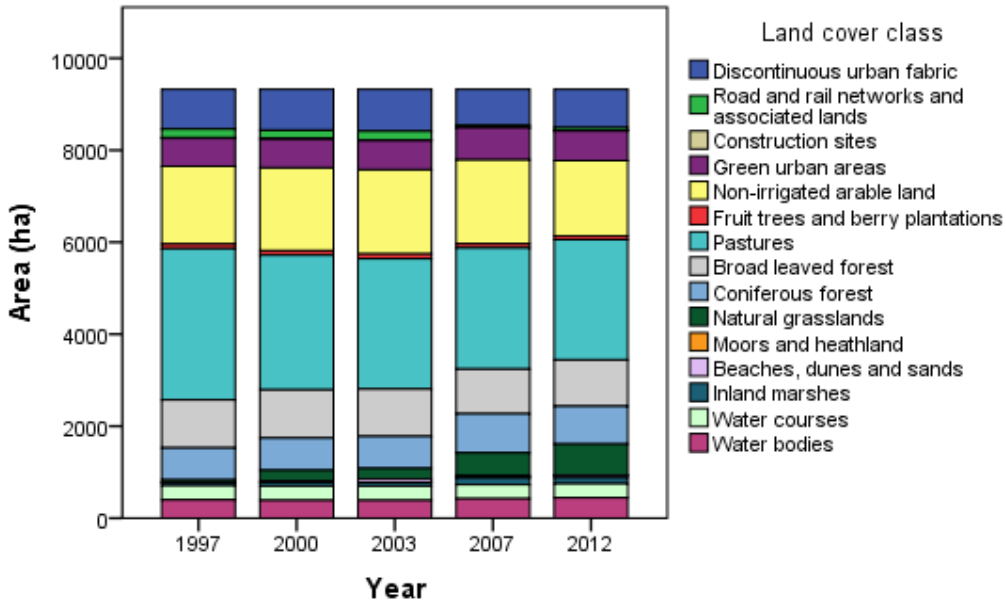

Figure 4: Bar plot of present land-cover classes and their surface area in Berg en Dal, based on LGN3plus to LGN7

The floodplain area changes drastically over the years. From 1997 to 2003, a large surface area of floodplain area Ooijpolder is used as pastures, whereas from 2007 to 2012 most of the area is used as natural grassland with relatively small patches of pastures. The presence of inland marshes in Ooijpolder increased from 1997 to 2003. Land-cover changes in Ooijpolder are largely a result of the Landinrichting through which agricultural parcels in the floodplain were replaced by natural grassland and other natural vegetation types.

Through Landinrichting, the area on the land-side of the dikes became destined for agriculture. As a result of this, in this area agricultural parcels increased in size and landscape elements were removed. Concerning other land-cover types in the area of the former municipality Ubbergen, there are some forest patches newly visible from 2007 onwards. One of them is fairly large and is probably newly developed. The others are very patchy, consisting of broad leaved forest mixed with pastures, and may have been wrongly classified in earlier land-use maps while they were already forested.

Southern from the stream Het Meertje, near the village Ubbergen, an area of pastures and arable land is converted to natural grasslands, including an expansion of water-covered area and inland marshes. In the area of Ubbergen and Beek the Water Werkt project was executed from 1999 to 2003. Some developments are belated (Van Dijck, 2003), so the mentioned developments that are visible on the maps are probably belated constructions of the Water Werkt project.

In the village Erlecom, a large water body is developed in between 2003 and 2012, in an area that was predominantly classified as non-irrigated arable land from 1997 to 2003. This area used to be a sand extraction site ("Dorpsvisie Erlecom," 2014; *Inspraakverslag Streefpeilbesluiten Groesbeek & Ooijpolder*, 2011).

A general increase in inland marshes occurred, judged from Figure 4. The inland marshes are predominantly situated in the floodplain areas and in Bruuk. In Bruuk and Millingerwaard, inland marshes are visible from 2007 onwards. The increase in inland marshes area is most clearly visible from 2003 to 2007.

In 1997 a large area of the floodplains of Millingerwaard was used as pasture, alongside a large water-covered area. Throughout the years, this area is converted from an agricultural area to a natural area with natural grasslands and, from 2007, inland marshes. From 2011 to 2020, the Millingerwaard is reconstructed as part of the Ruimte voor de Rivier program (translated: Space for the River)[3]. Additional water channels are created next to the main water course, in order to increase water storage capacity and prevent floods[3]. Near the area with natural vegetation, open sands along part of the Waal are also newly visible from 2000 onward.

Developments in other areas of Berg en Dal are less apparent from visual evaluation. For example, the surface area of the golf course may have expanded, judged from an increase in green urban area surface from 2007 to 2012. In the former municipality of Groesbeek, multiple water streams are reconstructed from 2006 to 2015 to increase the water-storage capacity("Waterplan Groesbeek," 2015)[4]. This is not visible on the LULC maps.

Several developments occurred in the agricultural area and not all of them are visible on the maps. Average parcel size increased and naturally vegetated corners or strips of parcels largely disappeared, as was found through stakeholder interviews. These developments predominantly occurred in the first half of the time period, from 1995 to 2005. From 2005 to 2014 the agricultural land area decreased as a result of construction works, including realisation of permanent nature ("Achtergronddocument LOP 2015-2024," 2015). Mostly in the same period, an increase in semi-natural landscape elements and recreational pathways in agricultural area occurred (e.g. through Groenblauwe Diensten program of Via Natura, see Section 3.5.3.).

The maps also do not show changes in nature quality as long as the land-use class is constant. The quality of nature in natural areas has improved through improved management, according to stakeholders. Nature management changes can also have led to changing land-use classes both before and after 2012. For example, the new occurrence of inland marshes on the map of 2007 may be a result of better management of the natural areas where inland marshes occur.

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[3] Ruimte voor de Rivier: https://www.ruimtevoorderivier.nl/project/uiterwaardvergraving-millingerwaard/. Accessed on: 29-06-2017

[4] Waterschap Rivierenland: https://www.waterschaprivierenland.nl/common/beleid/waterplannen/waterplan-per-gemeente/waterplan-groesbeek.html. Accessed on: 29-06-2017

3.2. Important ESs in Berg en Dal

3.2.1. Literature search results

The ESs that are selected to be assessed in more detail are: water-flow regulation, pollination, pest and disease control, crops, livestock (domestic), recreation and tourism, and natural heritage and natural diversity. Box 2 gives definitions of the selected ESs, as given in Tables 1-3 in Burkhard et al. (2014).

Water-flow regulation: water cycle feature maintenance (e.g. water storage and buffer, natural drainage, irrigation and drought prevention)

Pollination: bees, birds, bats, moths, flies, wind, non-flying animals contributing to pollen transfer and reproduction of plants

Pest and disease control: ecosystem ability to control pests and diseases due to genetic variations of plants and animals making them less prone to diseases and actions of predators and parasites

Crops: plants used for human nutrition

Livestock (domestic): domestic animals usable for nutrition and related products (dairy, wool)

Recreation and tourism: outdoor activities and tourism relating to the local environment or landscape, including forms of sports, leisure and outdoor pursuit

Natural heritage and natural diversity: the existence value of nature and species themselves, beyond economic or direct human benefits

Box 2: ESs that are selected as important in Berg en Dal and that are studied in the current research. Definitions according to Tables 1-3 in Burkhard et al. (2014)

The river Waal and its floodplains are partly situated in the north of Berg en Dal. Consequently, water-flow regulation is important to prevent floods in this area. Also, there are moraines in the south of the area and heavy rainfall can cause large amounts of water to flow down towards the lower areas, for example the village Groesbeek. There, water-flow regulation is important to prevent floods in and around Groesbeek.

In Berg en Dal, a large part of the land area is used for agricultural purposes, for producing crops and domestic livestock. Therefore, the ESs crops and livestock are probably regarded as important by the inhabitants, including the farmers.

Berg en Dal has a varied landscape with largely different natural areas, including lowland floodplains and forested moraines. Three Natura 2000 areas are partly situated in Berg en Dal: Gelderse Poort, Bruuk and Sint Jansberg. Next to the present natural areas, a network of semi-natural landscape elements is recently established through agricultural fields (as part of the Groenblauwe Diensten program). The municipality and inhabitants seem to greatly value natural heritage and natural diversity.

In literature the ESs pollination and pest and disease control do not stand out as important in Berg en Dal. However, pollination and pest and disease control do play an important role in agriculture, which is regarded as important in the area. Recent interest and developments regarding the creation of semi-natural landscape elements

on or next to agricultural parcels (as part of the Groenblauwe Diensten program) are likely not only driven by a demand for natural heritage and natural diversity, but also by a demand for other ESs, including pollination and pest and disease control. Semi-natural landscape elements are expected to have a positive effect on the potential supply of pollination and pest and disease control (see Section 3.4.1.). Therefore, assessing whether the recent developments had positive results in terms of pollination and pest and disease control is useful. Additionally, these ESs can play a role in decreasing the negative environmental impacts of the agricultural sector.

The sector of recreation and tourism accounts for about 9% of employment opportunities in Berg en Dal[5]. The municipality aims to strengthen possibilities of recreation in Berg en Dal, which is also one of the aims of the Landschapsontwikkelingsplan (translated: Landscape development plan, LOP) for 2005-2014 (see Section 3.5.3.) ("Achtergronddocument LOP 2015-2024," 2015). The Groenblauwe Diensten program, which is part of LOP, includes a network of recreational pathways which have the purpose of increasing the potential supply of recreation and tourism in the agricultural area.

3.2.2. Interview results

Table 3 shows which ESs were selected by stakeholders as the most important ESs in Berg en Dal and the reasons given by interviewees for selecting the ESs that were not pre-selected in this study. Stakeholders were asked to select 4-5 ESs or more if preferred and all stakeholders selected more than five ESs. All stakeholders commented that the question is difficult to answer. Most stakeholders had a good understanding of the concept of ESs. Though, the concept of potential supply of ESs led to some confusion.

Most stakeholders seemed to be very certain about selecting the cultural ESs: recreation and tourism; landscape aesthetics, amenity and inspiration; and natural heritage and natural diversity. These three ESs are selected by all stakeholders. Several stakeholders mentioned that recreation and tourism and landscape aesthetics, amenity and inspiration are linked to each other.

The selection made by stakeholder compares well to the pre-selection made in this study. From the seven most selected ESs (3-5× selected), five are also in the pre-selection. The two others that are often selected by stakeholders are: landscape aesthetics, amenity and inspiration (5×) and erosion regulation (3×). As mentioned, the first is much related to recreation and tourism. Erosion regulation is related to water-flow regulation, because sufficient water-flow regulation can contribute to erosion prevention. Therefore, the often-selected ESs that are not studied in this study, are

[5] Statistisch Zakboek Gelderland: https://gelderland.databank.nl/jive. Accessed on: 03-10-2017

studied indirectly through the study of the ESs recreation and tourism and water-flow regulation.

Table 3: Overview of ESs that are selected as important by interviewees and the given reasons for the selection of the ESs that were not pre-selected in this study.

Times selected	**ES**	**Given arguments**
5×	Recreation and tourism	
5×	Landscape aesthetics, amenity and inspiration	• People like to see beautiful things • The landscape is (regarded as) beautiful • This ES is important to tourists and local inhabitants
5×	Natural heritage and natural diversity	
4×	Crops	
4×	Livestock (domestic)	
3×	Water-flow regulation	
3×	Erosion regulation	• Erosion occurs in Groesbeek and leads to problems • Better land management can help prevent erosion • Erosion is expected to become worse due to heavier rainfalls as a result of climate change
2×	Pollination	
2×	Wild foods, semi-domestic livestock and ornamental resources	• Abundance of natural areas in Berg en Dal • Wild/semi-domestic animals present, which lead to food products • Presence of permaculture farm in the area • More permaculture and/or small-scale farming like urban agriculture should occur, this would be more beautiful than current practices and it would help prevent erosion
1×	Local climate regulation	• The landscape plays a role in regulating the regional climate
1×	Pest and disease control	
1×	Regulation of waste	
1×	Aquaculture	• Presence of watercress cultivation company
1×	Freshwater	• Presence of drinking water extraction site

3.3. Spatial distribution of ESs in Berg en Dal

3.3.1. ES maps

Figure 5 shows the ES maps of the selected ESs of Berg en Dal, 2012. The maps show that different ESs have different spatial distributions in the landscape. The map for water-flow regulation only shows 4 classes: from 0 (no relevant potential supply) to 3 (medium relevant potential supply). Following the exemplary matrix of Burkhard et al. (2014), the water course of the Waal should have a class 5, but this is not visible on the map (see Section 2.3.3.).

The mapped provisioning services, crops and livestock, have clear patterns of a high potential supply in the low rural area which is predominantly used for agricultural production, and very limited supply in the rest of the area. The agricultural area shows a patchwork of parcels that have a high potential supply of crops and parcels that have a high potential supply of livestock. In the rest of the area of Berg en Dal, only discontinuous urban fabric has a low relevant potential supply of crops and only natural grassland areas have a medium relevant potential supply. These natural grasslands are predominantly situated in the floodplains and in the natural area Bruuk.

The regulating services and the cultural services have more complex spatial distributions, because more land-cover types have a relevant potential supply score above 0. The maps show that the forested areas have a relatively high potential supply for all pictured regulating services and cultural services. Furthermore, there are many differences in spatial distribution among the ESs.

The five regulating services and cultural services all have a relatively low potential supply on arable land and pastures (values of 0 – 2). Pollination and natural heritage and natural diversity show large surface areas with no relevant potential supply. All five ESs show patches of higher potential supply in the agricultural area, which are patches of fruit trees and berry plantations, water surface, forested areas or other natural areas, urban green area or urban fabric.

The floodplain area has a great variety of land-cover types, which have different potentials to supply ESs. The cultural services recreation and tourism and natural heritage and natural diversity show similar spatial distributions, with relatively high values in natural grasslands and other natural vegetation covers in the flood plain areas. The regulating ESs have lower potential supply values in natural grasslands.

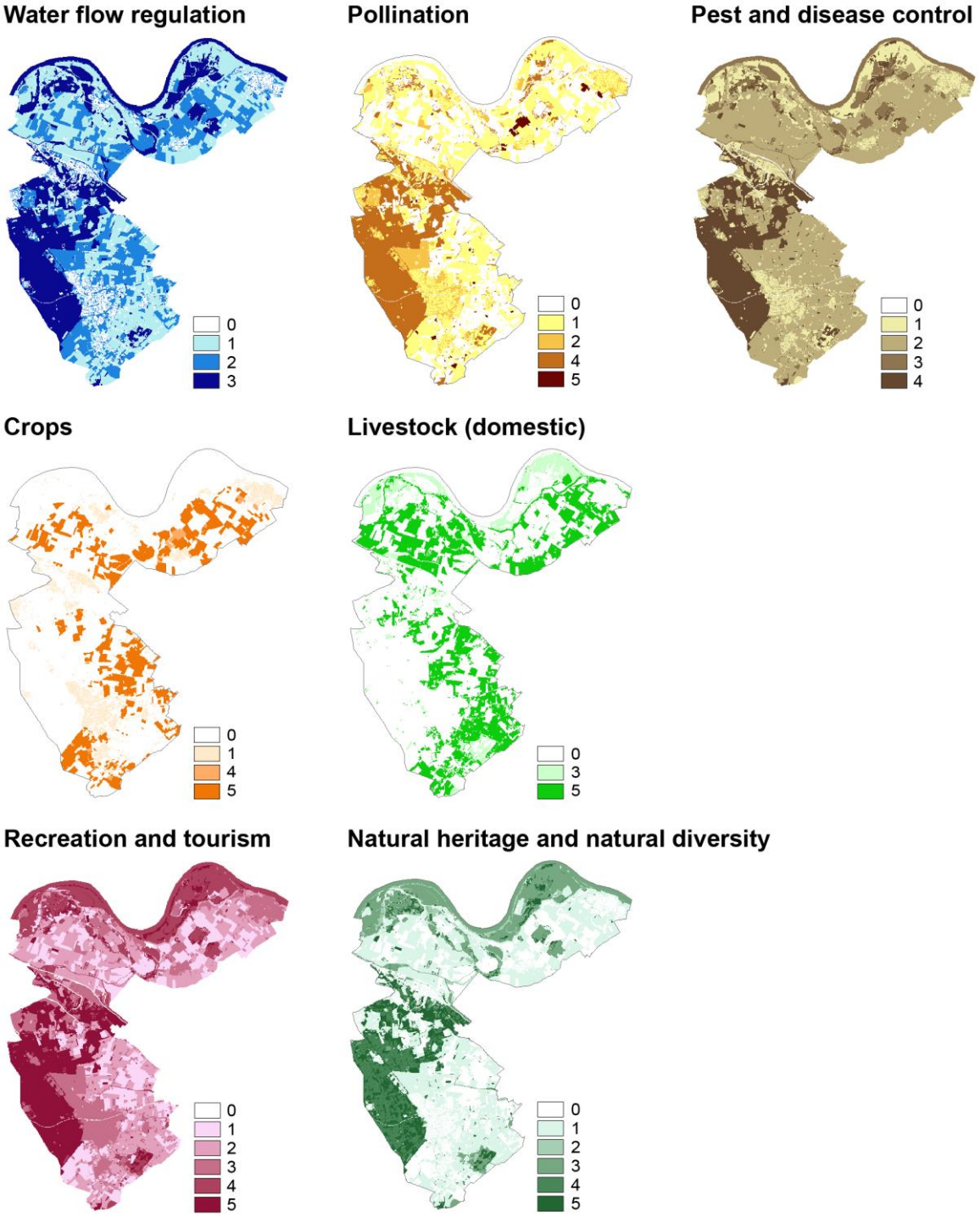

Figure 5: ES maps of Berg en Dal in 2012 for the ESs water-flow regulation, pollination, pest and disease control, crops, livestock (domestic), recreation and tourism, and natural heritage and natural diversity. Scale from 0 = no relevant potential supply; 1 = low relevant potential supply; 2 = relevant potential supply; 3 = medium relevant potential supply, 4 = high relevant potential supply; and 5 = very high (maximum) relevant potential supply.

3.3.2. Validation of ES maps through interviews

General comments and findings

Stakeholders were positive about the creation of ES maps and they thought that ES maps can be useful tools in taking management decisions. They liked the process of evaluating the ES maps so to contribute to improving them.

Generally, stakeholders found the ES maps 'too rough', with the resolution of 25×25m. Small-scale landscape elements are important in terms of ES supply but are invisible on the maps. Examples of small-scale elements in Berg en Dal are small river streams and dikes planted with flowers. The ES maps also do not show surface properties like land altitude. These properties are important for several ESs, for example recreation and tourism and erosion regulation. Another factor is (ecosystem) quality: quality can differ within a certain land-cover type and this is not visible on the maps.

To improve the ES assessment stakeholders recommend to examine (potential) supply on a smaller scale. This way more information about the actual quality of the area is taken into account and the results are more accurate. Specifically, the use of maps or other data of the present semi-natural landscape elements, in addition to using land-use maps, will improve accuracy of results.

Generally, the maps of crops and livestock were easiest to interpret for stakeholders. The ES recreation and tourism is also relatively easy to interpret, which resulted in the stakeholders having many comments about this map. The ESs pollination and pest and disease control were more difficult to relate to a spatial distribution pattern and therefore stakeholders were more hesitant in commenting.

Water-flow regulation

The stakeholders generally agreed that water streams and bodies and forests have a high potential supply of water-flow regulation. Also of high importance are the human-made constructions, which are not specifically visible on the map. Stakeholders found the ES water-flow regulation hard to visualise on a map, because of its broad definition. Several stakeholders explain the course of groundwater flows in Berg en Dal.

Multiple stakeholders mention that the map is not specific enough: some elements that are important are not visible on the map, like small water courses that should have a high relevant potential supply. Previously performed reconstructions are not visible either, with the example of the river Groesbeek which has recently been reconstructed in order to improve the water storage capacity and to decrease disturbance. Retention basins should also have a higher potential supply. One stakeholder mentions that in reality there is more differentiation in classes than only the four classes that are visible on the map. He thinks that if the map was made more specifically for smaller areas, this differentiation would be visible.

One stakeholder commented that the area of the moraine that is prone to erosion should have a higher potential supply for water-flow regulation. One stakeholder doubts the medium relevant score of the forests on high, sandy grounds. One stakeholder also doubts whether there is a difference in potential supply between pastures and arable land and suggests to assign the score relevant potential supply to these land-cover classes.

Pest and disease control

Multiple stakeholders mentioned that they found the term 'natural pest and disease control' difficult to completely understand and to relate to a spatial distribution pattern. Several stakeholders agreed that pastures and arable land have a minimally relevant potential supply, because of the intensive use and the use of chemical pesticides. The natural grasslands in floodplain areas have a higher relevant potential supply than arable land, which is not visible as such in the map. Stakeholders doubted whether the floodplain area has a lower potential supply than forests. The floodplain area is thought to harbour many insects and to be more diverse than the forest. The forest is thought to be too far from arable land to be of importance for pest and disease control on croplands. Water is thought to not contribute to pest and disease control and should therefore be white in the map. Flower strips along agricultural parcels are thought to be important for pest and disease control, but these are not visible on the map.

Pollination

The stakeholders agreed that fruit trees and berry plantations had the highest relevant supply of pollination, because natural pollination is important for their businesses. They also mentioned that pastures have no potential supply, because these grasslands are mown and grazed often. Natural grasslands are thought to have a higher potential supply than pastures because they harbour more flowering grasses and herbs, which is in line with the maps. Some stakeholders stated that natural grasslands have a higher potential supply than the low relevant potential supply as is depicted in the map. Additionally, stakeholders argued that natural grasslands are more important than arable land, even though these land-cover classes have the same potential supply values in the map. Natural grasslands are thought to be more varied than arable land, which is often a monoculture with just one crop.

One stakeholder mentioned that the urban area is important for pollination, because the vegetation in gardens and such is quite varied. He thought that urban area is more important than arable land, because arable land is often monotonous. There are varied semi-natural landscape elements along agricultural parcels and these landscape elements have a high potential supply of pollination, but these may not be regarded as integral part of the agricultural parcels themselves. The same stakeholder commented that these landscape elements are only present if farmers can make money from it and that managing landscape elements is not common agricultural practice, suggesting that farmers do not value the ESs supplied by landscape elements.

The three larger green urban areas are thought to have a lower potential supply value than what is shown on the map. One stakeholder doubts the importance of forests for pollination of crops, due to the distance between the forests and croplands.

One stakeholder states that the relevant potential supply as indicated on the map is too low for the nature development area, which is the area of the floodplains. The area is extensively managed to allow natural processes to occur; it is not mown and is only slightly grazed. The area includes the dike, which is covered in flowering plants and is an enormous source of seeds. Ooijsche Graaf should also have a higher potential supply according to some stakeholders. Several stakeholders commented that the water streams near Groesbeek that are recently reconstructed have vegetated riverbanks that should be visible in the maps, because they supply pollination.

Agricultural products (crops and domestic livestock)

The ES maps for crops and domestic livestock were easiest to interpret. Stakeholders commented that these maps represented facts, because the areas that are marked as relevant are areas which are actually used for the purpose of cultivating crops or producing animal products. It was mentioned that the parcels used as pastures and as arable land change over the years, because dairy farmers are obliged to do so.

One stakeholder mentioned that the difference in meaning between high and very high relevant potential supply is unclear for the ES maps of crops. The stakeholder mentioned that in Berg en Dal different soil types are present (loess and polder), which results in a difference in the variety of crops that can be cultivated. This variety can be seen as a difference in potential supply, but it is not visible as such on the ES map. The specific product watercress was mentioned in two interviews, because of its uniqueness and high value. Stakeholders confirmed that in the urban built-up areas there is a (low) relevant potential supply of crops, because people in Berg en Dal have vegetable gardens.

The natural area Bruuk is not used for livestock and the production of maize and other grains of the area is all composted. Therefore, this area should be white (no relevant potential supply) on the map. There is no livestock in the Natura 2000 area Ooische Graaf either. Other natural grasslands in the north (the nature development area) should be lighter than they are on the map too, because there are only large, wild animals.

Recreation and tourism

Generally, the stakeholders did not agree with this map. The stakeholders stressed that perception of the landscape is an important factor in recreation and tourism and that this cannot be seen in the maps. The variation in the landscape of Berg en Dal, concerning nature and land altitude, is very important for recreation and tourism. The stakeholders stressed that there are many options for recreation and tourism in Berg en Dal and that different areas allow for different ways of recreating and attract different

people. For example: the forested areas have height differences and attract people who like that, and the floodplain areas and the agricultural polder area are thought to attract people who like flat areas and far views. The stakeholders are very positive about the possibilities for recreation and tourism in Berg en Dal.

The ES map shows relatively low values for the agricultural land area and most stakeholders gave arguments for why the potential supply is actually higher in this area. The area is thought to be pretty varied because of present line shaped landscape elements like hedges and wind breaks; it is more varied than may be expected from the land-use types or from the ES map. The Groenblauwe Diensten program and its recreational pathways are important in terms of potential supply of recreation and tourism. One stakeholder mentioned that this area is the habitat of the Eurasian skylark, which adds to the potential supply of recreation and tourism. The view from this relatively flat area on the slopes of the moraines plays an important role as well. The area near Millingen and Leuth where the water streams lie is also considered suitable for recreation and tourism and some stakeholders wish to make it more suitable.

The stakeholders thought that the floodplain area is as important as the forests in Groesbeek. Another stakeholder also mentioned that not all forests have the same potential supply: Bruuk has a higher potential supply than other forests.

Natural heritage and natural diversity

Stakeholders found this map recognizable, with high values for the forests and the floodplain area and lower values for pastures and arable land. However, most stakeholders thought that floodplain areas have a higher biodiversity than forests. They stressed that the biodiversity is very different in each of these land-cover types, but to quantify it is difficult. One stakeholder mentioned that the dikes next to the Waal have a higher potential supply value than what is visible in the map.

Concerning water surface, there is a large variety in quality between for example in water bodies in concrete reservoirs and the water streams near Groesbeek, which leads to a difference in biodiversity and other ESs. These differences in quality and potential supply of ESs within one land-use type are not visible on the ES maps.

One stakeholders suggests to use less categories or to make the map less specific for different land-use types: coniferous and broad leaved forests could have the same colour and the whole floodplain area could have just one colour.

One stakeholder mentioned that the biodiversity on arable land is probably lower than in pastures. However, the occurrence of semi-natural landscape elements is increasing which leads to an increase in natural heritage and natural diversity in or close to arable land.

3.3.3. Validation of ES maps through other ES maps

General findings

The reference maps showed more specific indicators than my potential supply maps. It is unknown which indicators and indicator values form the basis of my maps, which makes comparison between the maps difficult. In addition, most control maps showed the actual supply whereas my maps show the potential supply.

The comparison between de reference maps and my maps shows that for many ESs the spatial distribution of ESs is based on more factors than only land-cover type. Moreover, concerning ESs that are mostly supplied by living organisms (e.g. pest and disease control and pollination) the potential supply is closely related to the present habitat for these species, thus to whether the species' habitat is present in the land cover. However, actual supply of the service depends on land-cover types that occur nearby and to which extend these demand the ESs.

Pest and disease control

The reference map that is used for validating the pest and disease control map shows the visitation of crops by ladybugs. Ladybugs are known to feed on aphids, which often cause pests in croplands. An underlying assumption that is used is that ladybugs spend winter in forests. Based on this assumption, the potential supply of pest control by ladybugs is attributed to forests. The reference map shows the use of the ES by nearby croplands. Following, only forests that are nearby croplands supply pest control.

In my map, forests have the highest potential supply value (4), which is in agreement with the reference map. However, in my map most other land cover values have a potential supply value higher than 0 too. The reference map shows only the pest control of ladybugs, whereas the definition for pest and disease control as used by Burkhard et al. (2014), on which my map is based, is much broader.

Pollination

Figure 6 shows the pollination map of the current study and the pollination reference map. The reference map of potential supply by natural habitat and my potential supply map have differing spatial distributions. My map shows relatively high values (4-5) in forested areas and fruit trees and berry plantations and relatively low values (0-2) in all other categories, which leads to a spatial pattern of high potential supply on the moraines in the west of Berg en Dal and in smaller patches spread throughout the area. The reference map shows a spatial distribution in which next to forested areas other natural areas, including pastures, have relatively high potential supply values too. The reference map seems more nuanced or homogenous than the map of the current study.

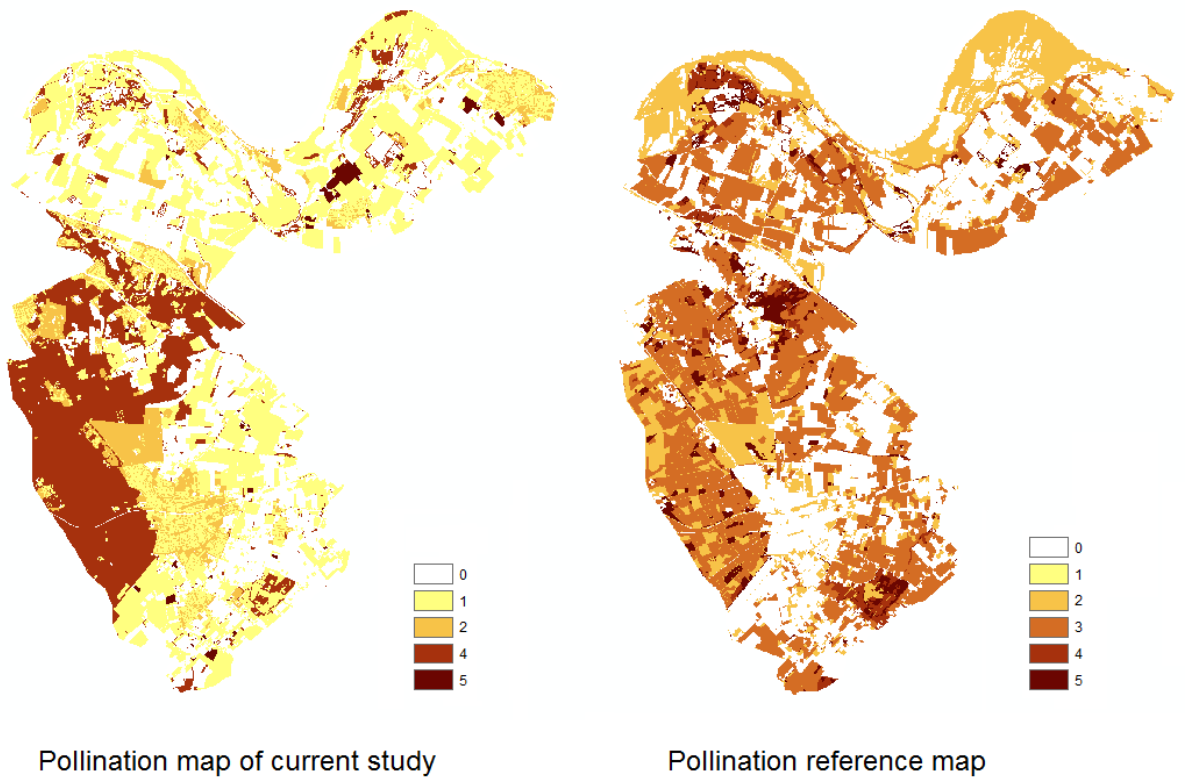

Figure 6: Pollination map of the current study and pollination reference map: showing the potential supply of pollination in Berg en Dal in 2012 (left) and 2016 (right). Scale from 0 = no relevant potential supply; 1 = low relevant potential supply; 2 = relevant potential supply; 3 = medium relevant potential supply, 4 = high relevant potential supply; and 5 = very high (maximum) relevant potential supply. Score 3 is not present in the map of my study.

A striking difference between the maps is in the potential supply values for croplands and fruit trees and berry plantations. In the reference maps croplands and fruit trees and berry plantations have no potential supply (0), because these land-cover types are regarded as the areas where the demand is located and where the ES is used instead of supplied. In my map, croplands have a low potential supply (1) and fruit trees and berry plantations have a maximum potential supply (5).

Additionally, pastures and natural grasslands have higher potential supply values in the reference map than in my map. In the reference map pastures have a medium relevant potential supply (3), whereas in the map of the current study pastures have no potential supply (0). Natural grasslands have a high relevant potential supply (3) in the reference map and a low relevant potential supply (1) in my map. An important difference between the maps is the classification of the floodplain area: in the reference map this area is classified as floodplains with a relevant potential supply (2), whereas in my map the floodplains are classified as natural grasslands with a low potential supply (1). This difference in classification leads to a striking difference in spatial pattern among the maps.

The reference map of the supply of pollination by natural habitat shows that the natural habitats of pollinators located in the north of Berg en Dal generally supply more

pollination than the natural habitats in the south, because demand for pollination by crops is larger in the than in the south.

The differences between the maps are likely caused by the use of different assumptions about the qualities of the different land-cover types in terms of habitats for pollinators. The distinction between service providing area and service benefiting area is important too in localising the potential supply, supply and demand.

3.4. Developments in ES supply in Berg en Dal between 1995 and 2015

3.4.2. Interview results

Table 4 shows the developments in potential supply as indicated by stakeholders. Several stakeholders chose to not fill in certain time periods or ESs, because of a perceived lack of knowledge. Potential supply of most ESs are thought to have increased in the two time periods.

Water-flow regulation

The water storage capacity has increased in the first time period as a result of the reconstruction of the Groesbeek water stream. In 1995 there was a huge flood, after which people had to be evacuated. This lead to enlargement of the dike, which was finished around 2000. In the second period (2006 – 2015), the Millingerwaard next to the Waal has been reconstructed to increase water storage capacity, as part of a Ruimte voor de Rivier project. This was mentioned by the stakeholders that wrote ++ in this period.

Pollination

Pollination has decreased in agricultural areas as a result of agricultural intensification and the decrease of semi-natural landscape elements, whereas it has increased as a result of the increase in surface area destined for nature and of improved management which is more aimed at flowering herbs and green and blue infrastructure. One stakeholder who recognized this, thought that over all pollination has increased in both time periods.

Table 4: Changes in ES potential supply in the time periods 1995 to 2005 and 2006 to 2015 as indicated by interviewees, in which -- means strongly declined, - means declined, 0 means constant, + means inclined, ++ means strongly inclined and -+ means both declined and inclined. In some cases +++ is used to indicate changes in the rate of incline between the two time periods. Blank intersections were not filled in.

	Time period	Coordinator of De Ploeg-driever	Coordinator of Via Natura	Employee Municipa-lity	Employee Water board	Farmer engaged in landscape	Average
Water-flow regulation	1995 - 2005	+	+	++		+	+
	2006 - 2015	+	++	0	++	+	+
Pollination	1995 - 2005	+	+	-			+
	2006 - 2015	+	++	+	++	+	+
Pest and disease control	1995 - 2005	+	0	-			0
	2006 - 2015	+	+	+	+		+
Crops	1995 - 2005	++	+	+		+	+
	2006 - 2015	++	++	0	0	+	+
Livestock (domestic)	1995 - 2005	++	+	+		+	+
	2006 - 2015	++	++	0	0	0	+
Recreation and tourism	1995 - 2005	+	++	+		+	+
	2006 - 2015	+	+++	++	++	+	++
Natural heritage and natural diversity	1995 - 2005	-+	+	0		+	0/+
	2006 - 2015	-+	+++	+	++	+	+

Acknowledgement of pollination increased. Another example is the increase in initiatives that aim to facilitate bees by sowing flowers. The acknowledgement for natural processes and knowledge about facilitation and use of these processes increased. However, among farmers the acknowledgement is not yet widespread.

Pest and disease control

Multiple stakeholders mention that even though pest and disease control has decreased in agricultural areas as a result of intensification, generally in the study area

pest and disease control increased. This resulted from the increase in natural areas and improved nature management. Acknowledgement of the importance of natural pest and disease control among policymakers increased. Newly introduced regulations regarding the use of chemical pesticides contributed to an increase of acknowledgement of natural pest and disease control among farmers. Farmers are inclined to consider alternatives, however they likely still focus on chemical pesticides. At the same time, farmers may try to use less pesticides because of economic reasons. Additionally, people search for crops that are resistant against pests and diseases, which can also contribute to an increase in the supply of natural pest and disease control and of crops.

Crops

The potential supply of crops has increased due to intensification of agriculture: agricultural practices have become more efficient and effective, leading to higher yields. The productivity of agricultural parcels changed due to Landinrichting: the newly assigned parcels had better soil, were more accessible and closer to farmers' homes. Also, interest in local products increased (in Groesbeek), which led to an increase in variation of products, for example newly cultivated wine grapes.

Livestock (domestic)

The potential supply of livestock has increased because of intensification. Stakeholders did not mention other developments.

Recreation and tourism

All stakeholders indicate an increase in recreation and tourism. Several stakeholders state that recreation will continue to increase. The economic value of the tourist sector in Berg en Dal increases as well: the amount of overnight stays has increased and so has the amount of jobs in the sector. However, tourists may not spend much money in the area when they visit.

The increase in recreation and tourism was driven by development of recreational facilities: The amount of walking paths increased, their connectivity improved and in the variation among them increased. The connection of natural areas through walking paths also improved. Through de Landinrichting program a larger part of the floodplain area became accessible for recreation. One interviewee mentions that even though recreation and tourism has increased in some places, in other places recreational 'elements' have disappeared.

Natural heritage and natural diversity

Natural heritage and natural diversity decreased on agricultural land due to scale enlargement and intensification. The (potential) supply increased in natural areas due to nature development and improved management. In addition, the (potential) supply increased in the rural area through development of semi-natural landscape elements. This occurred mainly in the second time period (from 2005 to 2015). In the first time

period (from 1995 to 2005) the potential supply decreased in the inland agricultural area, whereas it increased in the floodplain area as a result of the Landinrichting program in Ooijpolder.

3.4.1. Literature search results

In this section developments in ES supply that occurred in Berg en Dal from 1995 to 2015 that were identified from literature search are discussed. In this section only literature that addresses the (potential) supply of ESs is discussed.

Recreation and tourism

From 2005 to 2014 the area of Berg en Dal has become more well-known as being suitable for recreation and tourism. New recreational pathways are constructed so to increase the potential supply of recreation and tourism. The facilitation of cycling in the area has slightly improved. An actual increase in interest in recreation and tourism in the area is observed. ("Achtergronddocument LOP 2015-2024," 2015)

Natural heritage and natural diversity

Even though there are no detailed monitoring data, concerning the track 'strengthening of nature values' spectacular results are observed. For example, the network of semi-natural landscape elements in Ooijpolder is used as habitat by badgers, and the northern crested newt lives in newly developed water bodies. Several other increases in habitat types and species are observed. ("Achtergronddocument LOP 2015-2024," 2015) These results indicate an increase in natural heritage and natural diversity from 2005 to 2014.

The effects of landscape elements on ES supply

Through the Groenblauwe Diensten program semi-natural landscape elements and recreational pathways were developed in selected agricultural areas in Berg en Dal from 2015 to 2016. Niemeijer et al. (2016) monitored species diversity in selected areas in which the Groenblauwe Diensten program was executed. They compared data from before and during/after development of the landscape elements (data from time periods 2010 – 2012 and 2014 – 2016); and data from the area with landscape elements and the surrounding rural landscape without landscape elements. The results showed that species diversity was higher in the area with landscape elements than in the surrounding rural areas, suggesting that there was an increase in species due to the development of landscape elements. An increase of rare and indicative species in the area with landscape elements was found, which is mostly a result of the natural areas nearby, from which species disperse to the landscape elements. Further improvement of management, e.g. mowing in phases, is expected to lead to a higher increase in biodiversity. In some types of elements, e.g. hedgerows and trees, the species diversity generally increases over time. Thus, an further increase in species is expected in several elements that are newly developed. (Niemeijer et al., 2016)

An increase in biodiversity, as was reported by Niemeijer et al. (2016), leads to an increase in the potential supply of the ES natural heritage and natural diversity, which is defined by Burkhard et al. (2014) as '*The existence value of nature and species themselves, beyond economic or direct human benefits.'* (Table 3) Additionally, the presence of natural areas and natural landscape elements is found to have a positive effect on the potential supply of cultural services and regulating services, including pollination and natural pest control (Melman & van der Heide, 2011; Petz & van Oudenhoven, 2012). In the agricultural area Hoeksche Waard in the Netherlands the presence of flower strips along croplands clearly contributed to an increase in the ES pest and disease control; an increase in natural predation of aphids resulted in a lower pesticide use on the farm (Geertsema et al., 2015).

Holland et al. (2017) reviewed 270 publications about the effects of semi-natural habitat on biological control, pollination and soil conservation, all using data collected in Europe. Most studies about pest control and pollination found a positive effect of semi-natural habitats on (potential) supply, however, these studies had weaknesses. For example, most studies do not measure the effects of pest control and pollination on crops, but instead measure the presence of service providers (Holland et al., 2017). Thus, semi-natural habitats likely have a positive effect on the potential supply of pest control and pollination, but not enough evidence about the effects on supply is generated.

3.4.3. Results of temporal assessment of ES maps

The calculated potential supply valuesfor five years from 1997 to 2012 are shown in Figure 7. Next to the total potential supply, the bars also show which segment thereof comes forth of which land-cover type.

The most striking developments concerning land-cover types and potential supply are a decrease in pastures and an increase in natural grasslands and the effects thereof. The increase in natural grasslands is notable in all potential supply values of all ESs except for crops. The decrease in pastures is most notable in livestock, of which the potential supply decreases as a result. Most ESs show an apparent change in potential supply from 2003 to 2007. These changes are partly a result of improved mapping methods that are used for the maps of 2007 and 2012 as opposed to 1997, 2000 and 2003 (see Section 2.3.2.).

The regulating services (water-flow regulation, pollination and pest and disease control) show varying developments from 1997 to 2003. From 2000 to 2007, they show an increase in potential supply, followed by a slight decrease from 2007 to 2012. From these graphs, is it not immediately clear to which extent the shown developments are a result of the different mapping methods or of actual land-use changes. However, the bars show the effects of a decrease in pastures and an increase in natural grasslands. Other land-use changes, including a decrease in croplands, had smaller or no effects.

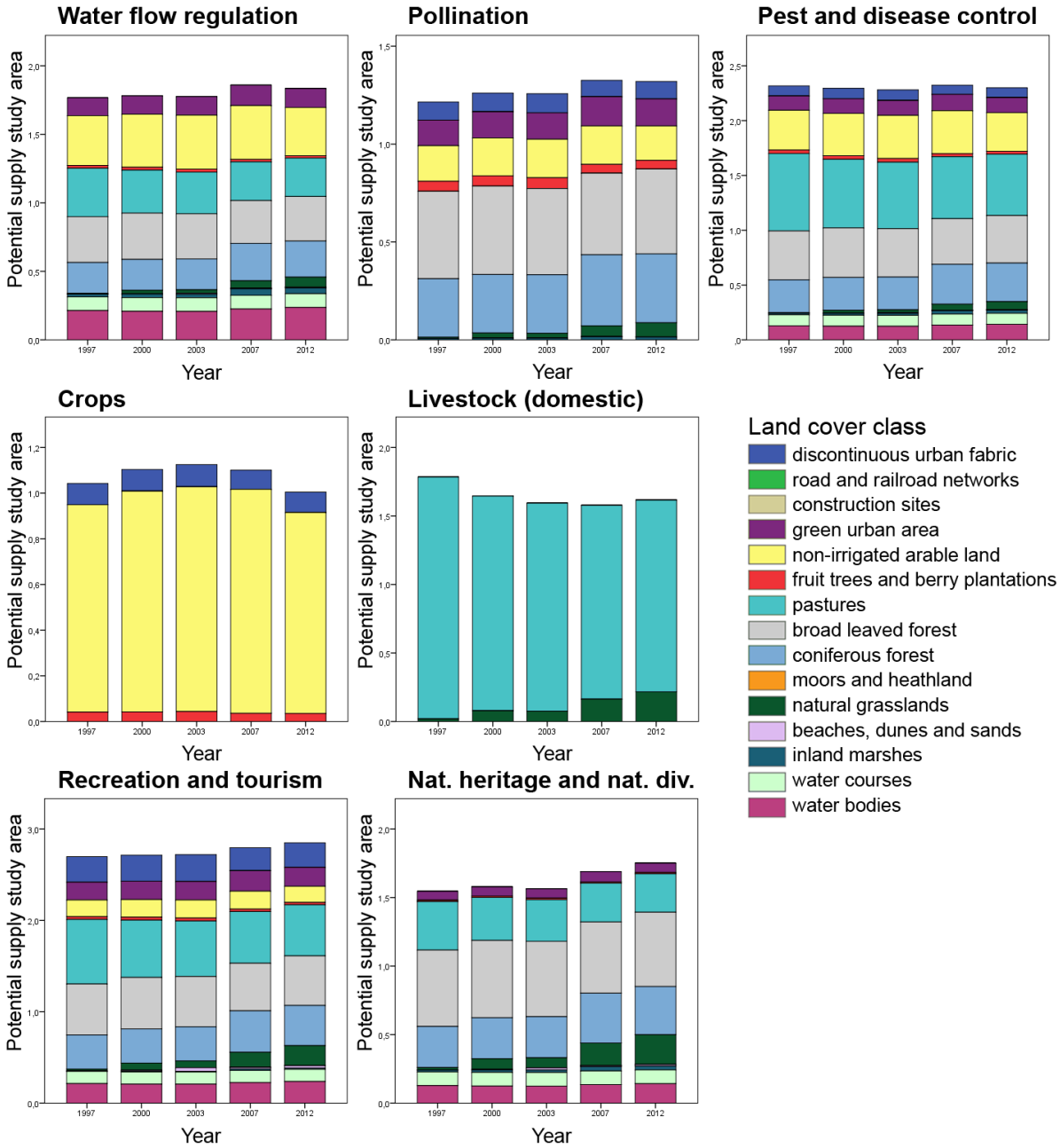

Figure 7: Potential supply in Berg en Dal as supplied by the present land-cover types. Graphs show the ESs water-flow regulation, pollination, pest and disease control, crops, livestock (domestic), recreation and tourism, and natural heritage and natural diversity. Scale from 0 = no relevant potential supply; 1 = low relevant potential supply; 2 = relevant potential supply; 3 = medium relevant potential supply, 4 = high relevant potential supply; and 5 = very high (maximum) relevant potential supply.

The potential supply of crops increased from 1997 to 2003 but decreases from 2003 to 2012. These changes predominantly result from a changing surface area of non-irrigated arable land. The potential supply of livestock decreases from 1997 to 2007 as a result of a decrease in pastures. Livestock increases from 2007 to 2012, resulting from an increase in natural grassland surface.

The cultural services recreation and tourism and natural heritage and natural diversity show an increase over time. Over the first three assessment years the potential supply values are rather constant, whereas from 2003 to 2007 and from 2007 and 2012 there are clear increases in both ESs. The increase in potential supply of both ESs largely results from an increase in natural grassland area.

Recreation and tourism and pest and disease control have potential supply values in between 2 and 3, which represents relevant potential supply to medium relevant potential supply. Water-flow regulation, natural heritage and natural diversity and livestock have values in between 1.5 and 2. Pollination and crops have values in between 1 and 1.5.

3.4.4. The effects of small-scale landscape elements in rural areas

The agricultural land area of Berg en Dal in 2012 and the development of semi-natural landscape elements and recreational pathways therein are shown in Figure 8. The left bar shows the agricultural land covers as depicted on the land cover map of 2012, whereas the right bar shows the same land covers corrected for the semi-natural landscape elements and recreational pathways that are present in 2016.

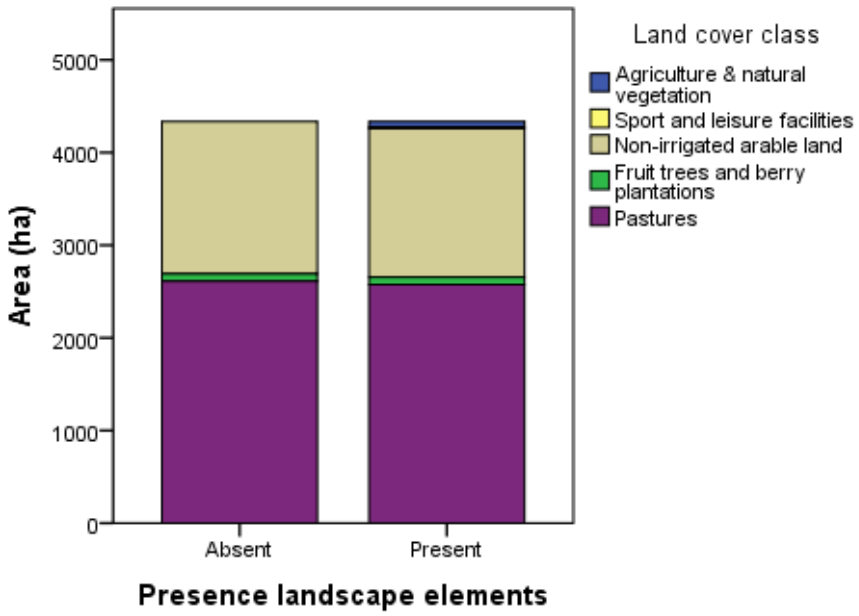

Figure 8: Land cover in the agricultural land area in Berg en Dal. Left: agricultural classes of LGN7 in Berg en Dal, converted to CLC classes. Right: agricultural classes of LGN7 in berg en Dal, corrected with the land cover area of small-scale semi-natural landscape elements and recreational routes as present in 2016.

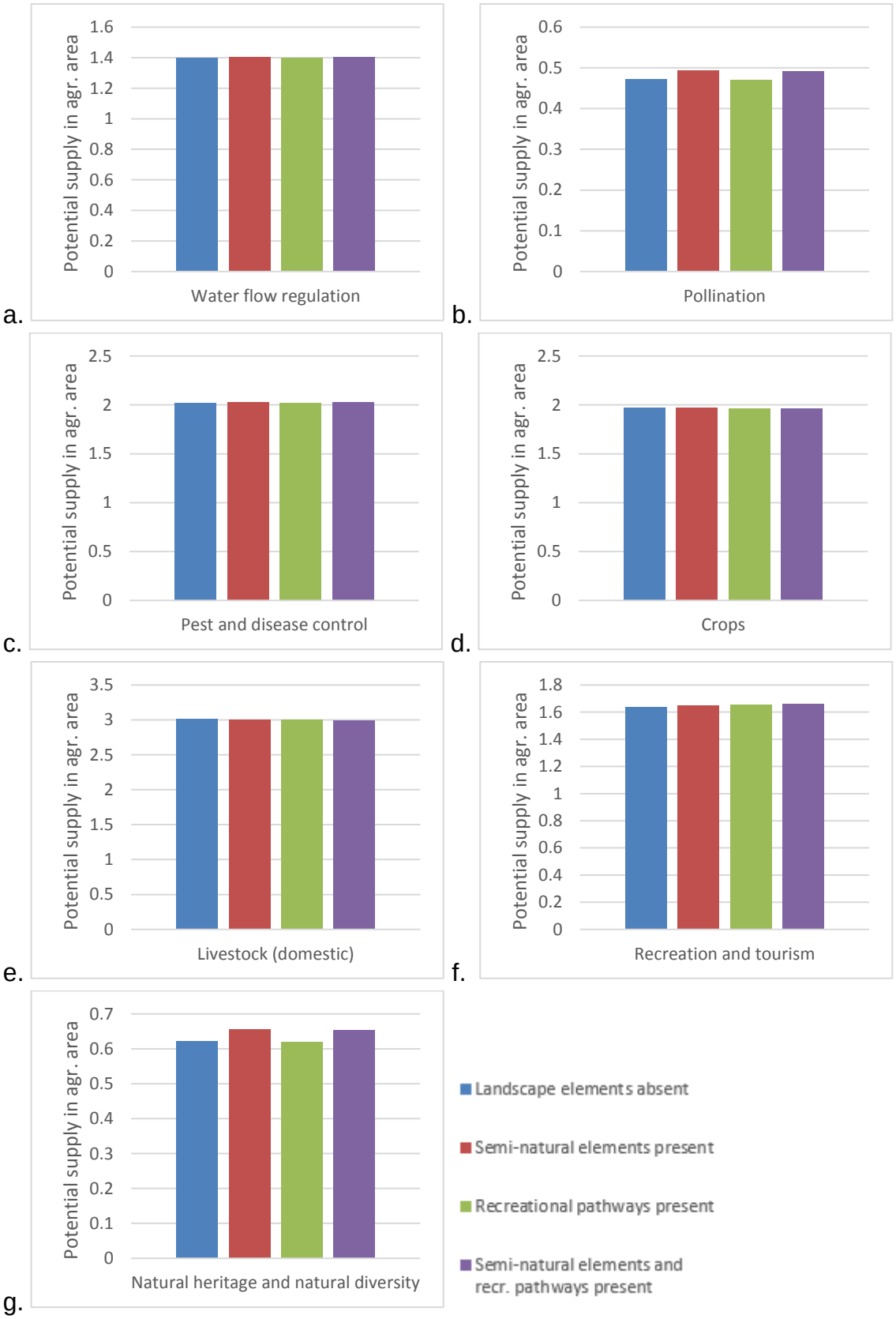

Figure 9: The effects of semi-natural landscape elements and recreational pathways in the agricultural area of Berg en Dal on potential supply of ESs. Note the different scales of the vertical axes. Scale from 0 = no relevant potential supply; 1 = low relevant potential supply; 2 = relevant potential supply; 3 = medium relevant potential supply, 4 = high relevant potential supply; and 5 = very high (maximum) relevant potential supply.

The effects of the semi-natural landscape elements and recreational pathways of the Groenblauwe Diensten program on potential supply of ESs in the agricultural area of Berg en Dal are shown in Figure 9. The presence of semi-natural landscape elements has a positive effect on the potential supply of all studied ESs except for crops. The presence of recreational pathways has a negative effect on the potential supply of all studied ESs except recreation and tourism. The presence of both semi-natural landscape elements and recreational pathways has a positive effect on the potential supply of all ESs except crops and livestock. The presence of semi-natural landscape elements has the largest effect on the potential supply of natural heritage and natural diversity (an effect of +0.034) and pest and disease control (+0.014). The presence of recreational pathways has the largest effect on the potential supply of recreation and tourism (+0.012).

3.5. Developments in governance in Berg en Dal from 1995 to 2015

This section describes important developments in governance from 1995 to 2015 that were relevant for the landscape in Berg en Dal. First, in 3.5.1. the governance background up to 1995 is illustrated. Section 3.5.2. describes developments in governance on high levels that occurred between 1995 and 2015. These developments include regulations and programs initiated by the governance levels EU, the Dutch government and the province. Section 3.5.3. gives an overview of developments in governance and the effects thereof on the landscape that occurred in Berg en Dal from 1995 to 2015. Section 3.5.4. presents a narrative of developments in governance of nature and landscape that integrates developments on high governance levels and local developments.

3.5.1. Governance background: before 1995

Around 1990, the government begins '*to become explicitly engaged'* in nature policy (Arnouts, 2010), which results in the Natuurbeleidsplan (Nature Policy Plan, NBP), which is launched by the Ministry of Agriculture, Nature and Fisheries (LNV)[6]. In NBP, the Ecologische Hoofdstructuur (Ecological Main Structure, EHS) was newly introduced: EHS would be a coherent network of important natural areas, which would form the base of the nature policy in the Netherlands[6]. Whereas the traditional focus of nature policy had been the purchasing of existing natural areas, the EHS also focused on developing new nature and on improving the interconnectedness of natural areas (Ministerie van LNV, 1990; cited in Arnouts, 2010). From 1994 onwards, the Dutch provinces are responsible for maintaining and enlarging the EHS (De Jong, 1999; cited in Arnouts, 2010).

[6] Groene Ruimte: https://www.groeneruimte.nl/dossiers/ehs/home.html. Accessed on: 22-06-2017

In 1992 the first Dutch national policy paper about landscape policy was published: Nota Landschap was the first policy paper with an explicit vision on the Dutch landscape[7]. In the 90s, Dutch authorities begin to use integrated area specific policies, in which several environmental and planning targets can be combined in specific areas. These targets can describe: '*the physical environment and the relation with other regions, regional (economic) activities and developments, impacts on the environment, use of space, groundwater and surface watersystems and sustainability on a regional level'* (Laak, 1989).

Since the World War II, the focus of the EU had been on securing food supply and ensuring income for the agricultural sector (Buizer et al., 2015). In 1958 the Common Agricultural Policy (CAP) was implemented by the EU with the purpose of optimising food production ("Achtergronddocument LOP 2015-2024," 2015). When the initial goals of CAP had been achieved and degradation of the landscape was noticed, a shift occurred in rural policy: from payments aimed at short term profit-maximisation towards *'a governance approach in which the management of rural landscapes relies less on central government direction'* (Schouten et al., 2013). As part of this shift, agri-environmental schemes (AESs) were integrated in CAP, through which farmers could voluntarily commit themselves to maintain nature on their land in return for payments (Schouten et al., 2013). The payments were independent of location and spatial configuration of the landscape (Peerlings and Polman, 2008; as cited in Schouten et al., 2013).

3.5.2. Developments in high level governance that occurred in between 1995 and 2015

Annex 5 gives an overview of changes in governance of nature, landscape, water management and agriculture that occurred on international and national governance levels between 1995 and 2015. In this section, the most important developments for governance in Berg en Dal are described.

General developments in governance

General trends in developments are: an increase in top-down demand and control governance from the EU in combination with decentralisation and regionalisation, with an increased participation of public and private stakeholders. Also, a shift occurred towards a more integral approach in which different themes, problems or legislations are combined into one integral vision or plan. These trends started before 1995 (see Section 3.5.1.).

[7] Landsobservatorium: http://www.landschapsobservatorium.nl/vrijepagina/landschapsbeleid-van-de-rijksoverheid/. Accessed on: 29-09-17

Conservation and management of nature and landscape

The EU got more involved in nature policy in national legislations through incorporation of the Bird Directive and Habitat Directive into the Nature Protection Act and the revised Flora and Fauna Act (in respectively 2005 and 2002). This is an example of an influential top-down demand and control governance style.

In 2000 a successor to the NBP is presented, in which is called for more involvement of non-governmental actors, including the public, and a more integral approach to nature conservation in which the broad societal functions of nature are taken into account (Arnouts, 2010). Around that time, a transition takes place in the form of governance: it changes from focusing on purchasing existing natural areas to engaging non-governmental actors in nature management (Arnouts, 2010). Through the new subsidy scheme Programma Beheer (Management Program: PB) farmers and private owners can be formally recognized as nature managers and obtain subsidies for the maintenance of nature, agricultural nature and landscape (Arnouts, 2010; Wiertz et al., 2007).

The Nota Ruimte of 2004 aims at landscape development and decentralisation of landscape management. The concept of National Landscapes is introduced with the aim of conserving attractive landscapes that are of high value for the recreational industry[8]. 20 National Landscapes are established in which further development is regulated. The National Landscape concept is implemented in the form of top-down governance, in which the Dutch government bears responsibility for the quality of the National Landscapes.

In 2010 the Programma Beheer is replaced by SNL, in which the provinces pre-determine nature development goals and subsequently grant subsidies for activities that contribute to meeting these goals. In Programma Beheer the Dutch government contracted nature managers, whereas in SNL the contract are between the province and the farmers or nature managers. Thereby the development of SNL is an example of decentralisation and regionalisation.[9]

In 2011 the EU introduces Natura 2000, a European network of natural areas in which important flora and fauna occur, from a European perspective. Natura 2000 is incorporated in the revised Natuurbeschermingswet of 1998.[10]

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[8] Provincie Gelderland: https://gldanders.planoview.nl/planoview/admin/viewer/default. Accessed on: 26-06-2017

[9] Portaal Natuur en Landschap: http://www.portaalnatuurenlandschap.nl/themas/subsidiestelsel-natuur-en-landschapsbeheer/over-het-subsidiestelsel-natuur-en-landschapsbeheer/, Accessed on: 27-06-2017

[10] Natura 2000: http://www.natura2000.nl/pages/wat-is-natura-2000.aspx. Accessed on: 22-06-2017

From 2010 to 2014 decentralisation of nature policy took place; many involved parties called for a more integral approach that did not focus only on internationally protected species but which included the human experience of nature. Decentralisation and regionalisation were regarded as positive developments. The State and provinces signed an act to decentralise nature policy in 2011[11]. From 2014 onwards the provinces are the first responsible authority of EHS or Natuurnetwerk Nederland, whereas before the State was responsible[12].

In the SVIR, which is published by the State in 2012, plans for infrastructure and space are set out. In SVIR different goals concerning infrastructure, nature, environment and space are integrated. Also, SVIR aims for decentralisation and regionalisation: responsibilities concerning spatial planning and infrastructure are handed over to provinces and municipalities, including the responsibility of the National Landscapes and Nature Network. International obligations that come forth out of the Natura 2000, WFD and protected species should be prioritized nu the provinces and municipalities. Additionally, the State now legally protects UNESCO world heritage sites. ("Structuurvisie Infrastructuur en Ruimte," 2012)

The additional policy paper 'Kiezen voor Karakter, Visie erfgoed en ruimte' aims: to conserve and strengthening the cultural, historical character of the Netherlands on a regional scale; and to connect the care for cultural heritage to other spatial issues that have to do with the economy, safety and sustainability. This policy paper strengthens the aims of regionalisation and integration of different goals as were already present in the SVIR. ("Achtergronddocument LOP 2015-2024," 2015)

The province of Gelderland established the Omgevingsvisie (translated: Environmental vision), in which is written which aims and qualities of the landscape are important in Gelderland and should be taken into account in development of the landscape. The addressed themes are: transportation, water, nature, environment and spatial planning and the most important goals are working towards a sustainable economy and a safe living environment of high quality[13]. The Omgevingsvisie contains the general aims and the associated document the Omgevingsverordening (translated: Environmental regulations) sets rules for the implementation.

The Omgevingsvisie and Omgevingsverordening came into effect on January 14, 2014 and they integrate and replace five separate plan documents that were in effect until then (Bijlage I, "Achtergronddocument LOP 2015-2024," 2015). One of the purposes is to encourage participation of stakeholders, private and public, to contribute to a sustainable economy and to the quality and safety of the living environment (Bijlage I,

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[11] IPO: http://www.ipo.nl/beleidsvelden/natuur. Accessed on 22-06-2017

[12] Groene Ruimte: https://www.groeneruimte.nl/dossiers/ehs/home.html. Accessed on: 22-06-2017

[13] Provincie Gelderland: https://www.gelderland.nl/omgevingsvisie. Accessed on: 22-06-2017

"Achtergronddocument LOP 2015-2024," 2015). The Omgevingsvisie and Omgevingsverordening provide a binding framework within which the municipalities in the province can operate. The documents include a destination plan of the area including the administered conservation areas and legislation about the development thereof (e.g. Natura 2000).

From 2014 the European Common Agricultural Policy includes a green direct payment, which farmers obtain if they meet certain requirements concerning diversifying crops, maintaining permanent grassland and using farm area as Ecological Focus Area.

From 2016 onwards, the subsidy scheme SNL-A (rural nature management) is replaced by Agrarisch Natuur- en Landschapsbeheer (rural nature and landscape management, ANLb), in which only certified management collectives with a local coordinator can participate. The local coordinator should have knowledge about the local network of nature and about which developments in nature would contribute to the goals of the province and which would not. The aim of the inclusion of a local coordinator is to obtain better results. The renewal of the AES occurred in 2016, however the renewal shows that the previous form of the program did not lead to optimal results.

Water management

Water management in the Netherlands is carried out by Rijkswaterstaat and the water boards. Rijkswaterstaat is responsible for the management of the large water bodies, including seas and rivers, and for controlling the water flow in rivers through enlarging the buffer area. The water boards are responsible for regional waters, including canals and smaller streams. They are responsible for water quality and for preventing floods. Recently, water boards gained responsibility for the dikes, according to the member of water board Rivierenland.

The Water Framework Directive (WFD), as implemented in 2000, is an international framework that aims for good quality of all surface waters and groundwater in the EU by 2015. The WFD came forth of a need for a more global and integrative approach to water policy. Within the WFD, water will be managed per river basin, the geographical and hydrological unit, and a combined approach of emission limit values and quality standards will be used. The WFD also aims to extent public participation.[14]

In 2003 the Dutch Nationaal Bestuursakkoord Water (translated: National Management Agreement Water, NBW) is implemented, with the aim of organising the Dutch water system until 2015 and improving cooperation between involved parties. NBW uses an approach in which separate visions are created per sub stream area. An

[14] European Commission: http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm. Accessed on: 23-06-2017

integral approach is used in which is considered whether the new vision and plans are in line with other provincial policy plans or regional plans. Thus, the NBW is in line with the WFD and shows regionalisation, increased cooperation and an integral approach. ("Het Nationaal Bestuursakkoord Water," 2003)

The Nationaal Waterplan was established for the time period of 2009 to 2015. It replaced previous policy documents and it aims to integrate the spatial aspects that concern water management. The program Ruimte voor de Rivier, as implemented from 2009 to 2015, aimed to increase safety in river areas and to make river areas more attractive as living environment[15]. This program was also implemented in Berg en Dal.

General trends in regulations concerning agriculture

A general trend in regulations about agriculture is an increase in administrative tasks for farmers, according to the interviewed farmer. Administration and planning has become required for: the amount of livestock animals present on the farm, the amount and handling of fertilizers and manure, the use of pesticides and the amount of medicines used. Especially manure regulations have become more strict because of environmental reasons. The overall feel among farmers is that the requirements become more strict and that this is not always useful. The required digital administrative tasks regularly change (e.g. the exact methods or programs that are used), as a result of which farmers have to invest time in learning how to comply. An additional comment is that many regulations are implemented from the top. This results in the fact that farmers are checked and corrected by employees of instances that are physically and psychologically far from the farm. This leads to a one-sided, impersonal form of communication that can be perceived as unpleasant.

Most farmers will dislike the mentioned developments of increased administrative tasks and the one-sided communication. Consequently, the development can contribute to farmers being hesitant to get involved in nature and landscape management, because farmers do not want more time-consuming administrative tasks and unpleasant communication.

3.5.3. Developments in governance and landscape that occurred in Berg en Dal from 1995 to 2015

Protected landscapes and natural areas in Berg en Dal

In Berg en Dal are many protected areas through different legislations. The protected landscapes in Berg en Dal as incorporated in the Omgevingsvisie (translated: Environmental vision) of the province of Gelderland for 2015[16] are shown in Figure 10.

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[15] Ruimte voor de Rivier: https://www.ruimtevoorderivier.nl/over-ons/. Accessed on: 13-11-2017.

[16] Provincie Gelderland: https://gldanders.planoview.nl/planoview/admin/viewer/default. Accessed on: 26-06-2017.

The province of Gelderland became responsible for landscape policy in 2012, including the National Landscape and the Nature Network.

The Natura 2000 network is a European network of natural areas and it is established in 2011 (see Section 3.5.2.). Three Natura 2000 areas are (partly) situated in Berg en Dal: Gelderse Poort, Bruuk and Sint Jansberg. Consequently, constructions in these areas are only approved if they do not have negative effects on the natural characteristics of the area or if an urgent problem of common interest for which there is no alternative solution occurs. ("Achtergronddocument LOP 2015-2024," 2015) The Natura 2000 areas in Berg en Dal are situated inside the EHS area and inside the National Landscape Gelderse Poort.

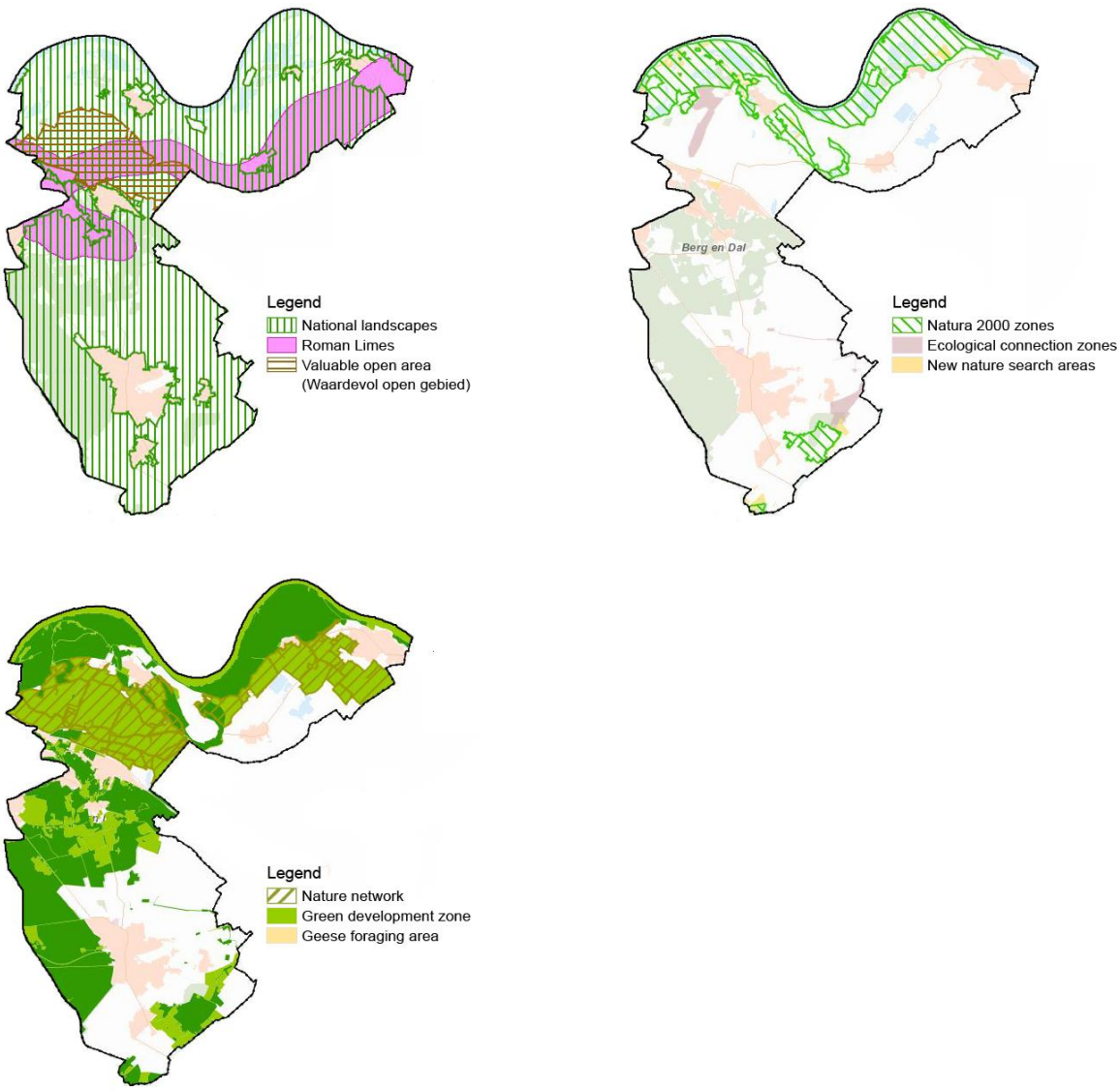

Figure 10: Protected nature and landscape areas in Berg en Dal as registered in Omgevingsvisie (translated: Environmental vision) of 2014 of the province Gelderland. a) National landscape Gelderse Poort, Roman Limes, Valuable open area. b) Natura 2000 zones (EU), Ecological connection zones, New nature search areas. c) Nature network, Green development zone, Geese foraging area. Source: https://gldanders.planoview.nl/planoview/admin/viewer/default

Water Werkt in Beek and Ubbergen (1999 – 2003)

The project Water Werkt (Translated: Water Works) was executed in the villages Ubbergen and Beek from 1999 to 2003 (Van Dijck, 2003). Many government bodies and organisations were involved, including the municipality of Ubbergen, Water board Rivierenland, the province and the Ministry of LNV. This project combined several aims concerning water-flow regulation and water quality into one integral plan. The project plan was developed in collaboration with interested parties, including inhabitants. Van Dijck (2003) evaluated the project and listed among the success factors: the interactive approach, which increased support for the project; the integral character, through which projects could enhance each other. Concerning integral water management projects in the future, Van Dijck (2003) recommends to manage the project on a small scale, to recognize the abundance of local knowledge and to recognize that an interactive approach is often necessary. (Van Dijck, 2003)

Landinrichting Ooijpolder (1996 – 2006)

Landinrichting was planned for the area of the Ooijpolder and an area southern from Groesbeek. Through Landinrichting the land was arranged into the most optimal land use arrangement. In Berg en Dal, the floodplain areas were converted to natural areas and the inland areas to agricultural areas. In this process, farmers generally got more productive parcels: larger in size, more accessible and with a more fertile soil. Many natural corners and ditches disappeared. The constructions were finished in 2006. (According to employee of municipality Berg en Dal.)

Ploegdriever was established (1999)

Ploegdriever is a local landscape management organisation and is founded by nature conservationists and farmers in 1999 with the aim of conserving the beauty of the rural cultural landscape[17]. Ploegdriever focuses on the organisation and implementation of landscape management in the area of Berg en Dal and a part of Nijmegen[17]. Ploegdriever manages many natural areas and landscape elements throughout Berg en Dal on behalf of several public authorities, organisations and private clients, for example municipalities, the water board, Staatsbosbeheer, Natuurmonumenten, Via Natura and private land-owners[18]. From 2016 onwards, Ploegdriever also facilitates the ANLb (rural nature and landscape management) subsidy program. The establishment and work of Ploegdriever contributed to an increase in local cooperation among stakeholders, according to multiple interviewees.

Via Natura (2005) and Landscape Development Plan: LOP (2005 – 2014)

The local NGO Via Natura was established in 2005 through a bottom-up process. Via Natura and the three municipalities initiated the first Landschapsontwikkelingsplan (translated: Landscape Development Plan, LOP), of which Via Natura took up the

[17] Ploegdriever: http://www.ploegdriever.nl/startpagina/vereniging. Accessed on: 27-06-2017

[18] Ploegdriever: http://www.ploegdriever.nl/startpagina/werkorganisatie. Accessed on: 27-06-2017

coordinating role. Landschapsontwikkelingsplan 2005-2014 (LOP 2004) was compiled through a cooperative process with the aim to set a direction or vision for the development of the landscape and to invite stakeholders to participate through taking initiatives. LOP 2004 included an Uitvoeringsprogramma (Implementation program) in which 77 projects were presented and stakeholders were invited to take up these projects. Stakeholders were also encouraged to start different projects than were already enlisted, as long as these would be in line with the vision as presented in LOP. ("Achtergronddocument LOP 2015-2024," 2015)

LOP focused on several distinct themes: to strengthen the identity of the region; to conserve sustainable extensive agriculture; to strengthen of the value of nature; to strengthen recreation possibilities; to strengthen water management; to realise sustainable forms of rural living. The main results of LOP were the results of the Groenblauwe Diensten program in terms of nature and recreation (which is explained next) and an increase in cooperation between stakeholders. ("Achtergronddocument LOP 2015-2024," 2015)

Groenblauwe Diensten program (implementation: 2009 – 2015)

Groenblauwe Diensten program aims to obtain a coherent network of line shaped semi-natural landscape elements through the rural landscape to preserve the cultural landscape and increase its quality. Additionally, the second aim is to establish a network of recreational pathways through the agricultural lands to make it accessible for recreationalists[19]. The current network of landscape elements of the program is shown in Figure 11.

Through the program the creation and management of semi-natural landscape elements along agricultural parcels can be subsidised for a management period of 30 years. The program is shaped through a process in which all involved parties could participate. The funding for the execution in the example area got available in 2009, after which Via Natura contacted farmers and land-owners in the area. The organisations Ploegdriever and Vereniging Nederlands Cultuurlandschap helped the farmers or land-owners to create suitable management plans. The plans were executed until 2015.

The program is funded by VROM, Ministry INM, Ministry Landbouw (currently: Ministry Economische Staten), the province, municipalities, Nijmegen, the water board and the Postcodeloterij. However, funds were only available for on specific area.

[19] Via Natura: http://www.vianatura.nl/over-via-natura. Accessed on: 27-06-2017

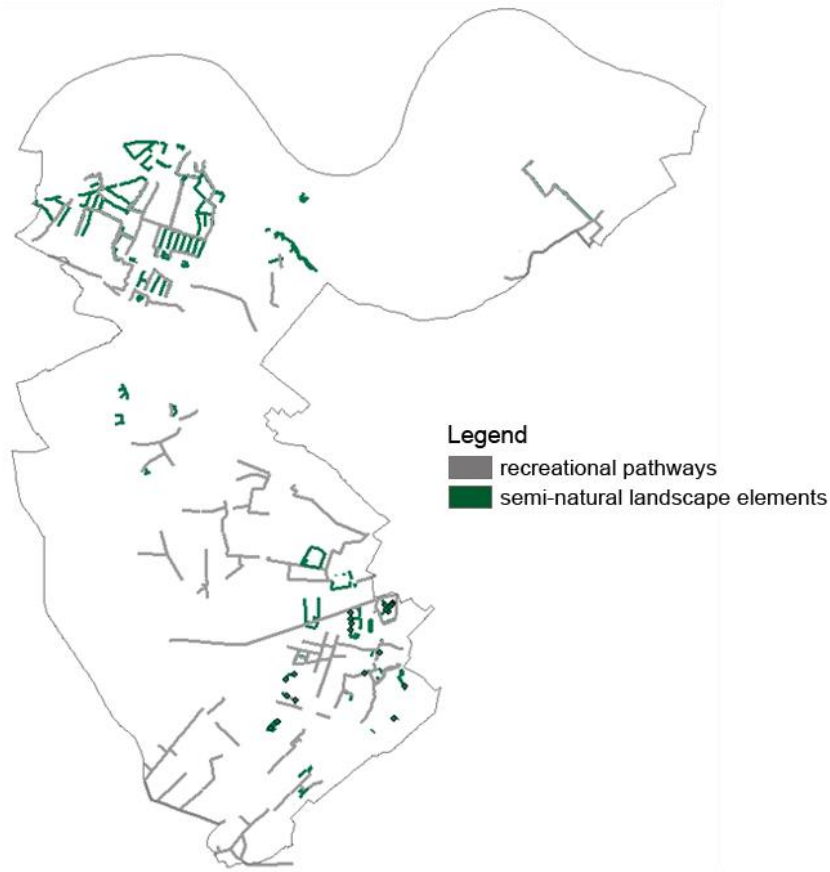

Figure 11: Landscape elements of the Groenblauwe Diensten program, in 2016. (Source: Via Natura)

Developments in AESs in Berg en Dal

Multiple AESs were in place in Berg en Dal from 1995 to 2015, including: Groenblauwe Diensten through Via Natura; SNL-A (which is replaced by ANLb in 2017); Stimuleringsregeling Akkeranden Rivierengebied 2011; and Stimuleringsregeling Natuurvriendelijke Oevers 2014. These subsidy programs are managed by different government bodies; respectively the municipality, the province and the water board (the last two mentioned). The subsidy programs had particular aims and areas in which they were applicable. In 2017, only ANLb is still open for applications; for the other three the available funding is already used and the current aims of the schemes are fulfilled. The subsidy programs of the water board Rivierenland have the aim of increasing water quality and water storage capacity, which contributes to the goals of the WFD and NWB.

Next to the mentioned subsidy programs, bottom-up initiatives also occur, like landscape funds that aim to raise money to (collectively) finance natural landscape elements or nature in the rural area.

Landscape community was established in 2011

In 2011 the landscape community Groesbeek-Ooijpolder-Duffelt is established, which is a cooperation of organisations that are active in agriculture, landscape, nature,

education, recreation and cultural history in the area[20]. This landscape community organises meetings and offers an online and offline platform for information exchange[20] Regularly, a 'breedsparoverleg' (broad consultation meeting) is organised, in which the municipality and interested organisations meet to discuss developments and plans concerning nature and landscape.

Ecological Focus Area in CAP (2014)

From 2014 the CAP includes a green direct payment which farmers can receive if they meet certain criteria regarding nature and landscape, including establishing Ecological Focus Areas (EFAs) (see Section 2.5.2.). However, in the Netherlands most farmers do not have to establish EFAs to obtain the green direct payment, because many exceptions are made. Therefore, in Berg en Dal the change in CAP is not expected to lead to changes in landscape. ("Achtergronddocument LOP 2015-2024," 2015)

Water stream expansion in Groesbeek (2006-2015)

In the former municipality of Groesbeek multiple water streams are reconstructed to increase the water-storage capacity. These reconstructions have increased biodiversity and recreation opportunities along the water streams.[21]

Reconstruction of floodplains of Millingerwaard (2011-2020)

In 1995 the Waal flooded, because of which 250,000 people and 1 million livestock animals were evacuated. As a result of climate change such high water levels are expected to occur more often. Therefore, the floodplain area of the Millingerwaard is reconstructed from 2011 to 2020 as part of the Ruimte voor de Rivier program which is initiated by Rijkswaterstaat. The general purpose is to increase the water storage capacity through the creation of additional water channels next to the main water course[22].

Merge of three municipalities into one: Berg en Dal

The municipality of Berg en Dal is established in 2015 through a fusion of the municipalities Millingen aan de Rijn, Groesbeek and Ubbergen. Through National changes in governance structure the municipalities have gotten more tasks, which lead

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[20] Gemeente Berg en Dal: https://www.bergendal.nl/zien-en-beleven/landschap-van-iedereen-landschapscommunity-groesbeek-ooijpolder-duffelt_45641/. Accessed on: 27-06-2017

[21] Waterschap Rivierenland: https://www.waterschaprivierenland.nl/common/beleid/waterplannen/waterplan-per-gemeente/waterplan-groesbeek.html. Accessed on: 29-06-2017

[22] Ruimte voor de Rivier: https://www.ruimtevoorderivier.nl/project/uiterwaardvergraving-millingerwaard/. Accessed on: 29-06-2017

to small municipalities, including Millingen aan de Rijn, having difficulties in maintaining their facilities[23]. The municipalities are merged to resolve some difficulties.

Landscape development plan: LOP 2015-2024

LOP 2015-2024 is the successor of the first LOP. The goals of the new LOP address the themes: employment in the rural area; climate change; the landscape as living and working environment; the presence of characteristic biodiversity; recreation; participation of inhabitants in landscape related activities; and learning from the landscape. For each theme specific targets are formulated. Additionally, LOP 2015-2014 presents an overview of subsidy programs and regulations that are relevant concerning the funding of landscape development projects. It also stimulates the integration of different functions in the landscape, for example development of the landscape surrounding healthcare institutions or companies. ("Achtergronddocument LOP 2015-2024," 2015)

Ploegdriever as local coordinator in ANLb

In the new ANLb (rural nature and landscape management) scheme that replaces SNL-A (rural nature management), Collectief Rivierenland is responsible for the management contracts in the province of Gelderland. Ploegdriever functions as the local coordinator of Berg en Dal that connects Collectief Rivierenland to the right farmers and inhabitants of Berg en Dal. Decisions on management schemes and contracts are made locally, taking into account the present ecological system. The coordinator of the program in Berg en Dal is positive about the new approach and suspects better results than with the previous, uncoordinated approach. (According to member Ploegdriever.)

3.5.4. Narrative of developments in governance of nature and landscape in Berg en Dal from 1995 to 2015

From the changes in regulations and legislations of nature and landscape that occurred from 1995 to 2015 several trends can be observed. In this section the general trends in governing that occur on EU, the State and province level are discussed, as well as the influences thereof on regional governance and the landscape in Berg en Dal.

An increase in top-down governance

There has been an increase in top-down regulations from international and national governance levels with the aim of protecting nature and landscape (e.g. the establishment of Natura 2000 areas and National Landscapes). Nature quality and quantity seem to have improved partly as a result of the increase in regulations.

[23] Provincie Gelderland: https://www.gelderland.nl/Nieuwe-gemeente-Berg-en-Dal-klaar-voor-de-toekomst!. Accessed on: 28-06-2017

Decentralisation and regionalisation

Decentralisation and regionalisation occurred in which provinces and municipalities obtain responsibilities concerning nature and landscape, which were previously handled by the State. Area specific approaches and policies are used more frequently, with the aim of determining area specific solutions which are supported by all involved (local) stakeholders (Roza & Boonstra, 2009). The over-all governance structure changed, in which high governance levels focus on what is important on those levels and decentralise the rest. This happened on both national scale and provincial scale.

A more integrated approach to nature and landscape

An integrated approach to nature and environment is adopted. Through this approach different societal goals are combined in one vision and solutions are sought that have positive effects on the different goals or aspects. On higher governance levels, examples of this shift are NBP (2000), which acknowledges the broad societal function of nature, and the concept of National Landscapes, which acknowledge the value of landscapes for recreation and tourism. On provincial level, the Omgevingsvisie of Gelderland covers the themes: transportation, water, nature, environment and spatial planning and the most important goals are working towards a sustainable economy and a safe living environment of high quality[24].

On the local level the integral approach is visible in LOP 2004 and LOP 2015-2025 in which a broad vision on the landscape is given and which include and combine themes like cultural heritage, natural quality, recreation and tourism and working possibilities in the area.

Water management

Many governing bodies are involved with water management. An integral approach to water management is introduced through WFD. Water management is generally discussed at international level (e.g. through WFD), after which measurements are taken on regional scale, per sub stream area (as was determined in NBW). Recently, water boards gained responsibility of the dikes, whereas previously Rijkswaterstaat was responsible, according to the water board employee that was interviewed.

Multiple development projects are carried out in Berg en Dal to improve water management (e.g. Water Werkt project, Ruimte voor de Rivier, expansion water streams near Groesbeek). Planning and executing the local measurements seems to increasingly occur in open consultation processes (e.g. the establishment of WFD, that also stimulates public participation). Involvement of local stakeholders in water management projects is found to have positive effects on the process and the results, for example through evaluation of the Water Werkt project of Van Dijck (2003).

[24] Provincie Gelderland: https://www.gelderland.nl/omgevingsvisie. Accessed on: 22-06-2017

Increased participation and cooperation in Berg en Dal

The participation and cooperation of stakeholders in Berg en Dal has increased ("Achtergronddocument LOP 2015-2024," 2015). Stakeholders mentioned that Ploegdriever played a role in increasing involvement of inhabitants with the landscape and increasing the cooperation among citizens and organisations. Many organisations that aim to improve nature or the living environment are present in the area of Berg en Dal and the number of such organisations increased from 1995 to 2015. The establishment and actions of the landscape community Groesbeek-Ooijpolder-Duffelt also illustrates the interest and cooperation in landscape management.

The interviewed stakeholders were positive about the cooperation between stakeholders in Berg en Dal. Cooperation among local stakeholders is more positively judged than cooperation with stakeholders on higher governance levels with larger administrative areas. Local stakeholders sense that they have common goals and work together towards achieving those goals, whereas communication and cooperation with more distant parties is more difficult and more often takes the form of formal top-down regulations. One stakeholder expressed to be positive about the fact that he could approach Ploegdriever and related organisations if he had issues with other organisations on higher governance levels. Ploegdriever could often mediate to make the process easier.

The water board employee that was interviewed was also positive about the cooperation in the area, even though the water board itself is more distant because of its larger working area. The water board is limited in its contributions, because it only has funds available when it has an assignment in the area (assigned by the EU, the Dutch government or Rijkswaterstaat). This is in line with the perceived sense that cooperation between local stakeholders is different from cooperation with more distant stakeholders.

Decentralisation and regionalisation in landscape governance contributed to the increase in participation of local stakeholders in Berg en Dal and more cooperation between them. Via Natura, The Landscape Development Plan (LOP 2004) and Ploegdriever also played a role in increasing participation and in mobilizing inhabitants to contribute to improvement of the landscape.

Increase in collaborative governance

Generally, collaborative governance approaches increasingly occurred. Cooperation among different governance levels improved. Decentralisation and regionalisation have occurred, through which more local stakeholders have become involved. An increase in participation of public and private actors is stimulated (e.g. through WFD, LOP). Area-specific solutions are increasingly used and local initiatives are stimulated.

Effects on the landscape

International and national legislations concerning the conservation of natural areas and landscape qualities (e.g. Natura 2000 areas and National Landscape De Gelderse Poort) positively contributed to the conservation and improvement of the quality of nature. Generally, management of natural areas improved in Berg en Dal, which results from a combination of top-down regulations and collaborative governance approaches. Local stakeholders like Via Natura and Ploegdriever played an important role in stimulating better nature management.

In the rural area, legislations concerning agriculture and livestock production are important factors in landscape management, because farmers determine the management practices on their land. From 1995 to 2015 agricultural parcels increased in size and landscape elements disappeared as a result of intensification (e.g. through Landinrichting). Legislations concerning the use of pesticides and manure management affect land management by farmers. AESs contributed positively to farmers being willing to manage nature on their land.

The involvement of non-governmental actors in nature management increased the opportunities for development of nature. The AES SNL (subsidy scheme nature and landscape management) that was implemented through the EU and the Dutch government generally did not have optimal results. The AESs that were implemented locally (e.g. Groenblauwe Diensten program, the subsidy programs of the water board and the ANLb) likely had better results in terms of added natural value. The involvement of local coordinators with local knowledge leads to better results. Additionally, intensive cooperation with (local) stakeholders increases the chances for success.

Concerning water management and developments therein, the combination of top-down regulations and collaborative governance seems successful. International collaboration is useful, because water management is a cross-boundary issue. Projects are generally carried out locally per sub stream area (as is determined through WFD and NBW). Inclusion of local stakeholders during the process seems to positively influence the results (Van Dijck, 2003).

3.6. Drivers of change in ES supply

3.6.1. Potential drivers of change in ES supply

Generally, a distinction is made between direct and indirect drivers, that directly or indirectly cause changes in the state of the system that is assessed (Leemans et al., 2003). Ecosystem properties determine the potential supply of ESs of that ecosystem, therefore I consider direct drivers of change in ecosystems as direct drivers of ES supply.

Three types of direct drivers of ecosystem change can be distinguished: ecosystem processes, ecosystem management and external pressures (Hein et al., 2016b). Ecosystem processes are the natural processes that occur in an ecosystem, for example succession. External pressures, as used by Hein et al. (2016b), are effects of the overall environment of the ecosystem, for example climate change and the deposition of eutrophying or acidifying substances. In this study, the focus is on changes in ecosystem management and the drivers thereof.

van Oudenhoven (2015) used the term land management and defined it as a set of direct drivers which have a direct influence on ecosystems. Examples of these human-induced, direct drivers include changes in LULC, species introduction and removals and external inputs like the use of pesticides (Leemans et al., 2003). LULC change is an important driver of change of ES supply (Lawler et al., 2014; 2003). Croplands are often intensively managed ecosystems (Bommarco et al., 2013), whereas natural areas are generally more extensively managed than croplands.

Indirect drivers of ecosystem change are factors that affect the decision-making processes of land management. These indirect drivers are primarily: demographic; economic; socio-political; scientific and technological; and cultural and religious (Leemans et al., 2003). Decision-making processes about land management occur on different governance levels. Leemans et al. (2003) distinguish three levels of decision-making: individuals and small groups at the local level; public and private decision-makers at municipal, provincial and national level; and public and private decision-makers at the international level. The influence of drivers on a decision-maker process depends largely on the level of decision-making.

The role of demand as a driver of change in supply of ESs is twofold. The demand is an integral aspect of ES supply. At the same time, the demand for ESs can influence governance on all scales, because the involved stakeholders can be influenced. Additionally, the combination of potential supply and demand results in (un)sustainable uptake and (un)satisfied demand (Baró et al., 2016). For example, if the demand is higher than the potential supply, the demand is likely unsatisfied. Unsustainable uptake and unsatisfied demand and changes therein may be more influential drivers than the actual demand itself.

3.6.2. Developments in demand for ESs in Berg en Dal from 1995 to 2015

General developments in demand for ESs

The drivers of the occurred developments in potential supply are not fully known. However, these developments are likely driven by an increase in demand for ESs or by a decrease in potential supply and an increase in unsatisfied demand. For example, the increase in involvement in nature conservation of the EU likely resulted from an increase in demand for nature from certain stakeholders. However, the increase in involvement can also be driven by trends of decreasing quality and/or quantity of nature and of decreasing potential supply of ESs. In the latter scenario, the demand can have been stable.

Knowledge about ESs drives changes in demand. An increase in knowledge can lead to an increase in demand and vice versa, for example concerning recreation and tourism. An increase in knowledge about ESs occurred between 1995 and 2015 and this drove an increase in demand for most of the studied ESs (at least water-flow regulation, pest and disease control, pollination, recreation and tourism). The increase in knowledge partly resulted from scientific research on ESs.

The demand is also affected by the developments globalisation and population growth. Globalisation results in an increase in accessibility of ESs from far away, thereby 'diffusing' their demand. This is illustrated by large transportation distances of products and by travel distances to holidays destinations. Population growth results in more people demanding ESs. This leads to an overall increase in demand. The population size of the area of Berg en Dal has been stable from 1995 to 2015[25]. with an average annual population growth of 0.05% from 2007 to 2015. The population of neighbouring city Nijmegen has grown from 147,600 inhabitants in 1996 to 170,680 inhabitants in 2015, which represents a growth of 15.64% over 19 years[26]. National or global population growth can also influence the demand for certain ESs in Berg en Dal.

Water-flow regulation

The demand for water-flow regulation clearly increased, judging from the legislations that were initiated by the EU and the State (e.g. WFD) and from the actual implementations in Berg en Dal: the reconstructions of the water streams in the former municipality of Groesbeek and the floodplains of Millingerwaard (see Section 3.1.). Heavy rainfall and high water levels are expected to occur increasingly as a result of climate change. This leads to an increase in demand for water-flow regulation in Berg

25 Gelderland Databank: https://gelderland.databank.nl/jive/?report=bevolking. Accessed on: 06-07-2017

26 Centraal Bureau voor de Statistiek: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=70634ned&D1=0-2&D2=0&D3=0-2,8,21-22&D4=31,476&D5=a&VW=T. Accessed on: 06-07-2017

en Dal because of the present water streams, which can potentially flood and can regulate water flows.

Water-flow regulation is defined by Burkhard et al. (2014) as *'water cycle feature maintenance (e.g. water storage and buffer, natural drainage, irrigation and drought prevention)*' (see Box 2). Water-flow regulation does not include erosion prevention, however these two ESs are related. Interviewees mentioned that the occurrence of erosion increased on the moraines near Groesbeek because of removal of landscape elements. The negative effects of erosion can be limited by water-flow regulation, therefore the increase in demand for water-flow regulation is likely driven by the increase in erosion.

Pollination

Acknowledgement of the value of pollination and related natural processes increased, according to the members of Via Natura and Ploegdriever. This likely led to an increase in demand among farmers and other stakeholders. Several local initiatives were set up to increase public awareness of the presence and importance of bees and to facilitate bees, for example by sewing flowers in public places. The recent development of landscape elements in agricultural areas is partly driven by an increased recognition of and demand for natural processes like pollination.

The variety of crops that are cultivated in Berg en Dal has increased. This may lead to an increase in demand for pollination. Also, intensification in agriculture lead to a higher density of crops. This could indicate an increased demand, depending on the used crops.

Pest and disease control

The demand for pest and disease control likely increased due to intensification. Agricultural parcels have become larger and more monotonous and crop density increased. As a result of this, crops likely became more prone to pests and diseases. The availability of chemical pesticides increased. This likely lead to a decrease in demand for natural pest and disease control. More recently, regulations about using chemical pesticides became more strict. This lead to a decrease in pesticide usage and an increase in demand for natural pest and disease control. Additionally, recognition of and knowledge about natural pest and disease control increased However, among farmers the acknowledgement of natural processes is still small.. (According to interviewees.)

Crops and livestock (domestic)

The demand for crops and animal products results from human consumption, thus from the number of demanding people and amount of products demanded per person. The population of Berg en Dal has been stable, but the populations of Nijmegen, the Netherlands and the world have increased in numbers over the last two decades[25] [26]

However, due to globalized trade systems determining the effects of growing populations on the demand for food products from Berg en Dal is difficult.

The variety of crops cultivated in Berg en Dal increase. The increase is likely driven by a change in demand. Developments in demand for animal products are unclear, because animal products from Dutch farmers are distributed over a large area.

Recreation and tourism

The demand for recreation and tourism has increased. Interviewees were very certain about this development. Developments of influence on the increase are: the increase in Dutch people spending holidays in the Netherlands; an increase in publicity of the area; and an increase in population numbers of Nijmegen (see Section 3.4.2). At the time of establishing LOP 2004, the area was already popular among recreants and tourists ("Achtergronddocument LOP 2015-2024," 2015). The area and its cultural-historical elements have become more well-known from 2004 to 2015, predominantly among inhabitants of Ooijpolder ("Achtergronddocument LOP 2015-2024," 2015).

Natural heritage and natural diversity

The demand indicator for natural heritage and natural diversity as suggested by Burkhard et al. (2014) is: '*Relevant guidelines for nature protection (n/ha)*' (Table 3). In the Netherlands and in Berg en Dal specifically the amount of regulations and programs that concern nature protection has increased over time. Many regulations are implemented by the EU (e.g. Natura 2000). The increase in regulations concerning nature conservation indicates a demand for nature from higher governance levels. The occurrence of local initiatives that aim to benefit the quantity and/or quality of nature (e.g. the development of semi-natural landscape elements) indicates a demand for nature among local stakeholders.

The demand for nature likely not only results from the demand for the ES natural heritage and natural diversity; other factors or ESs likely play a role. Whether the demand for natural heritage and natural diversity changed over time is unclear as well; the newly introduced regulations and programs likely resulted from a constant demand in combination with a decrease in potential supply, as was mentioned before.

3.6.3. Drivers of change in ES supply in Berg en Dal from 1995 to 2015

The identified important drivers of change in ES supply are given in this section. The following potential drivers are considered: ecosystem management including LULC changes; indirect drivers that influence decision-making about ecosystem management, including high-level governance and the drivers thereof; demand as driver of decision-making processes and as condition for ES supply to exist.

This section focuses on ES supply in natural areas and agricultural areas. Generally, an increase in quantity and quality of nature leads to an increase in ES supply, except for the provisioning services that are mostly provided by the agricultural area (here: crops and livestock). In the agricultural area a trade-off exists between the provision of

crops and livestock and most other ESs. Management of naturel elements on agricultural land benefits the potential supply of ESs like pest and disease control and pollination but contributes to a decrease in the supply of crops and/or livestock.

Public nature management

Nature management depends largely on regulations, available funding and the use of local knowledge. Top-down regulations concerning nature and landscape conservation increased. This drove nature management changes that contributed to an increase in nature quality. Examples of natural areas in which the quality of nature increased are De Ooijpolder and Millingerwaard. The use of local knowledge also contributed positively to the quality of nature: Ploegdriever uses knowledge about the present ecosystems and the possibilities of cooperation with other stakeholders to come to management solutions that are optimal for nature.

Agricultural land management

Farmers determine the land use and management practices on their land. The trends of upscaling and increasing production efficiency largely influenced the food production system and agricultural practices. These trends have contributed to the initiation of the Landinrichting. The Landinrichting contributed to upscaling and to a decrease in number of semi-natural landscape elements in the agricultural area of Berg en Dal. Additionally, technological and chemical developments resulted in more efficient machinery and chemicals to use in agriculture. These trends influenced the ES supply of agricultural areas; they contributed to an increase in food production and a decrease in most other services.

The production and income of a farmer drive changes in land management. Many factors affect the production and income of farmers. Legislations concerning agricultural practices create a framework within farmers can operate (e.g. CAP). The production or yield of a farm is influenced by many factors, for example weather conditions and occurring pests and diseases. The production is increased through use of external inputs, thus availability of external inputs and legislation concerning use thereof are important as well. The profit of farmers is largely influenced by developments on the market, for example fluctuations in milk prices.

Private nature management

The willingness of farmers to invest in nature management is influenced by their income. When agricultural land gets converted to nature, the farmers cease to obtain agricultural subsidies for that land area. Thus, when farmers develop nature they experience a loss of income from a decrease in production and from a decrease in obtained subsidies. Therefore, many farmers are not willing to invest land, time or energy in developing and managing nature of natural landscape elements. In addition, farmers fear possible negative influences of semi-natural landscape elements on the production, for example through the spread of weeds from borders onto cropland (according to member Ploegdriever). Additionally, land used for landscape elements

cannot be used for spreading manure. This can cause additional costs for manure handling or a decrease in income from livestock for dairy farmers (according to farmer). Regulations concerning manure management have also become more strict from 1995 to 2015 (according to farmer).

The willingness of farmers to develop natural elements on agricultural lands is positively influenced by available subsidy schemes (according to member of Via Natura, member of Ploegdriever, farmer). Other positive drivers are societal appreciation of farmers that manage nature and pride of the nature or landscape (according to farmer). Additionally, nature can be developed in land corners or strokes that are relatively difficult to cultivate, for example due to shape or slope (according to member Ploegdriever). Furthermore, the regulations concerning the use of chemical pesticides have become more strict, which has led to an increase of interest of farmers in natural pest and disease control. However, acknowledgement of the importance of natural processes is still small among farmers (according to member Via Natura, member water board and farmer).

The recent increase in semi-natural landscape elements in Berg en Dal largely resulted from the actions of a relatively small group of people that are actively engaged with nature and natural processes, including Ploegdriever and Via Natura. The available subsidy schemes were major drivers for land-owners to develop semi-natural landscape elements.

Drivers of high level governance of nature and landscape

Governance changes concerning nature and landscape are likely driven by developments in demand for ESs. The demand for ESs likely increased throughout all governance levels, mostly as a result of an increase in knowledge and acknowledgement of nature and landscape and their functions. A decrease in potential supply of ESs, due to developments like deforestation, can also have led to an increase in unsatisfied demand. In that case, the demand may have been constant, but an increase in unsatisfied demand was the actual driver of change in governance.

Globalisation plays a role concerning the distribution of demand for ESs, mostly concerning provisioning services, including food (Burkhard et al., 2012). Globalisation and the increased cooperation of the EU are important concerning the involvement of different stakeholders and the style of governance that is used.

Water management

Many projects were carried out to improve water management in Berg en Dal. The (expected) effects of climate change and the (expected) rise in demand for water-flow regulation are very important drivers of developments concerning water management thus changes in the supply of water-flow regulation.

An increase in recreation and tourism

The demand for recreation and tourism is an important driver of change in supply. The growing population of Nijmegen leads to an increase in demand for recreation and tourism, according to a member of Via Natura. The demand also increased through promotion of Het Rijk van Nijmegen, which is an area that includes Berg en Dal (according to employee municipality). Stimulating recreation and tourism is also an aim of the municipality. A (potential) increase in income from the presence of recreants and tourists likely drives changes in the potential supply and in promotion of recreation and tourism.

The potential supply increased through development of recreational facilities, including recreational pathways through the agricultural areas as part of the Groenblauwe Diensten program. Potential supply also increased through the reconstruction of de Ooijpolder (Landinrichting). Also, several implemented projects that aimed to improve water management were combined with efforts to improve recreation and tourism, for example the reconstructions of the water streams near Groesbeek (according to member Via Natura).

Acknowledgement of nature and local cooperation

The increase in acknowledgement of nature and landscape and their functions likely lead to an increase in demand for ESs and an to nature development in Berg en Dal. The improved cooperation was largely driven by the establishment of and work of Via Natura, LOP 2004 and Ploegdriever.

3.7. The effects of governance changes on ES supply in Berg en Dal from 1995 to 2015

From EU and National governance levels new regulations regarding landscape and nature protection have been established. These regulations have contributed to conserving nature and thereby protecting ES supply. However, at the same time governance of nature and landscape shifted from a top-down approach towards a combination of top-down and collaborative governance approaches. Through decentralisation and regionalisation public and private stakeholders on lower governance scales became more involved. These stakeholders include the provinces, the municipalities, farmers and inhabitants. This shift in governance likely affected the landscape and nature quality positively.

Through decentralisation, provinces gained responsibility over the landscape and over nature conservation and realisation (through signing Natuurpact). Provinces conserve the aspects or things that are valuable on the provincial level and delegate responsibilities that are mostly important on regional or municipal level. Through this multi-level approach, aspects can be addressed on the governance level that is most suitable to address them.

Provinces conserve species through SNL (subsidy scheme nature and landscape management), in which the provinces set goals in terms of target species in certain areas. Based on these goals, potentially beneficial contract types are determined. Only these contract types are then used in the areas. This approach has better results than the previously used approach of Programma Beheer in which management activities under contract were not linked to nature targets.

Programs that include a local coordinator can be more successful than programs that do not, because through inclusion of a local coordinator local knowledge about the landscape, ecology and the wishes of local stakeholders can be used. The coordinator of the ANLb program is very positive about the added value of a local coordinator. LOP and the Groenblauwe Diensten program are regarded as very successful in terms of added value to nature and recreation and tourism. Involvement of local stakeholders throughout the whole process of establishing LOP and the program has been very important for obtaining the results. Also, the coordinating organisation, Via Natura, played an important role in connecting stakeholders and knowledge. From evaluation of the Water Werkt! Project was found that including local stakeholders is beneficial.

The two coordinators of the Groenblauwe Diensten program and ANLb that were interviewed agree that improvement in nature and landscape management is still possible. For example, creation and use of a map of all nature and landscape elements in Berg en Dal and of the managers thereof would be useful. One overview or registration system that includes all nature and landscape elements can contribute to an increase in efficiency in cooperation processes.

The formal acknowledgement of land-owners as nature managers (formalised through Programma Beheer) contributed to the presence of nature in Berg en Dal. Farmers are reluctant to sell their land for nature purposes, but are more willing to transform it for nature purposes if they can remain the owners (Arnouts, 2010). AESs are important drivers for farmers to engage in nature management. Local cooperation and support are found to have a positive effect on the willingness of farmers to engage in nature or landscape management. This emphasizes the importance of cooperation.

Generally, concerning nature and landscape governance, participation of stakeholders and cooperation among them increased in Berg en Dal. Important factors therein are the establishment of Ploegdriever, Via Natura and LOP. LOP was established through an extensive, inclusive process.

LOP presents an integral vision for the landscape of Berg en Dal and specific projects or actions that would contribute to the envisioned landscape and its use. This includes different sectors, for example economy, agriculture and recreation and tourism. In all governance levels a shift towards an integral approach on landscape is observed. An integral approach is likely to be beneficial for the landscape and ES supply, because it allows for solutions that benefit multiple ESs. In Berg en Dal, several projects initiated

by the water board to improve water-flow regulation have contributed to an increase in supply of recreation and tourism as well (according to member Via Natura). In these projects, local stakeholders got involved and saw opportunities to combine the water-flow-regulation goals with improvement of other aspects.

An integral vision on landscape can also enhance the idea that people work together on realizing similar or related goals. In Berg en Dal this feeling of having a shared goal contributes positively to the motivation of individuals to contribute.

The effect of governance changes on ES supply differs per ES. In the rural areas, a trade-off between agriculture and nature occurs. The ESs crops and livestock are predominantly produced by farmers on agricultural fields, whereas many other ESs have a higher potential supply in natural areas. Top-down regulations concerning agriculture can influence land management by farmers, including the use of pesticides, and thereby the potential supply of ESs. Land management practices influence the production of crops and livestock. The willingness of farmers to engage in landscape or nature management is influenced by governance too, through regulations that affect their income, the needed investment to develop and manage nature and the sense of cooperation that comes forth of the governance type.

Pest and disease control and pollination are mostly demanded on croplands and can be supplied by nearby nature. The potential supply has increased as a result of an increase in natural areas and landscape elements and improved nature management, which partly results from changes in governance. The demand is influenced by the amount and species of crops, but currently the knowledge about the ESs plays a more important role. Legislations concerning the use of pesticides have contributed to an increase in demand for pest and disease control.

Water-flow regulation is coordinated on the EU governance scale, after which regional projects are executed. Many projects that were executed had positive effects on water-flow regulation. The (expected) effects of climate changes are an important driver for the demand for water-flow regulation. The approach to water-flow regulation has become more integral, combining multiple aspects that concern water, including water quality and water flow. This change in governance likely has positive effects on the results in terms of ES supply.

Concerning recreation and tourism, the establishment of the National Landscape Gelderse Poort was effective in conserving the potential supply in Berg en Dal. Conservation of natural areas, including Ooijpolder and Millingerwaard, may also contributed to recreation and tourism. The inclusion of local stakeholders in these project likely affected the supply of recreation and tourism positively, because of their knowledge about local demand for recreational facilities. Additionally, the potential supply and demand increased as a result of more local efforts. These efforts include the promotion of Het Rijk van Nijmegen, the creation of recreational pathways of the

Groenblauwe Diensten program and the creation of facilities like bridges, which was integrated with projects of the water board. Since recreation and tourism is an ESs that is used locally, a local approach is likely to be most effective.

The demand for natural heritage and natural diversity is difficult to determine. However, governance affects the potential supply: conservation of natural areas including improved nature management result in an increase in quantity and quality of nature, which increases the potential supply. Additionally, the establishment of nature on agricultural fields contributes to the potential supply. Decentralisation and regionalisation likely have a positive effect on the quantity and quality of nature. The combination of international, national and provincial targets with a decentralised and regionalised approach, including the involvement of local coordinators, likely has positive results. The involvement of local stakeholders is useful not only because of their knowledge on the local natural systems, but also because of their knowledge about other local stakeholders and their wishes and demands in terms of natural heritage and natural diversity.

4. Discussion

4.1. LULC as proxy for potential supply

The relation between LULC and potential supply differs per ES. For most assessed ESs, potential supply is highly related to LULC. This is why the matrix method links (potential) supply to LULC type and why it has been used in many studies. In my study, the ES maps were made using generic parameterization. The maps were validated through stakeholder interviews. Generally, the stakeholders were positive about the spatial patterns of potential supply that were depicted in the ES maps. This indicates that using this method can have valuable results.

However, for some ESs the spatial pattern of potential supply does not clearly correlate to LULC type. For example, the potential supply of recreation and tourism is influenced by many factors, as was indicated by stakeholders. It is likely largely influenced by the LULC of the surrounding area and factors like variety in the landscape. Perceived aesthetics plays an important role in recreation and tourism. Therefore, mapping potential supply of recreation and tourism may require more integrated approaches. For example, Baró et al. (2016) map recreational potential index (capacity) using as main input data: naturalness of habitats; protected natural areas and features; and water features.

The potential supply of crops is likely mostly influenced by land management. However, the surrounding area can supply regulating services like pollination and natural pest and disease control. The supply of these regulating services likely influence the potential supply or the supply of crops. For the (potential) supply of crops other factors than LULC are important too, for example water table and soil type.

The maps for pest and disease control and pollination were validated using reference maps. The general spatial patterns were similar in maps of the same ES. Differences between maps of the same ES resulted from the use of different assumptions. This emphasizes the importance of being careful in using assumptions and of being aware of what these assumptions mean for the results.

4.2. Matrix method is too coarse

One of the drawbacks of the matrix method is that small-scale landscape elements are not visible on the land-use maps and are thus not taken into account, whereas these elements can be very important concerning ES supply. In evaluating the ES maps, stakeholders emphasize the importance of missing elements, like semi-natural landscape elements and water streams. Dick et al. (2016) recorded similar comments about the coarseness of the matrix method from their participating stakeholders.

My study illustrates an assessment of the effects of small-scale landscape elements on potential supply through the matrix method. The matrix method is generally used for relatively large land areas. Here, the areas of small-scale landscape elements were

assessed in the same way. The elements were assigned a land-cover class, after which the potential supply of the elements was calculated using the surface area and the potential supply value of the exemplary matrix. The effects of the landscape elements were determined through comparing different scenarios in which the elements were absent or present.

The results of this approach are similar to results from literature and interviews, however, they should be interpreted with care. Drawbacks of the matrix method in general also apply when considering small-scale elements or land areas. One important point is that in reality the (potential) supply of ESs is not only determined by the land cover itself, but potentially also by the land cover of the surrounding area. This is not a problem in my study, because all assessed landscape elements were situated in the agricultural area thus relatively similar surroundings. In that case, the same potential supply values can be used.

Secondly, the results are highly influenced by the chosen matrix values. The advantage of the matrix method is that it can easily be used for large land areas and, as shown in my study, over a large time span. My study underscores the drawbacks of not including small-scale landscape elements and quality differences among landscapes. However, to use a smaller resolution or using more LULC classes requires detailed information about the study area. If the used assumptions are uncertain, the results of using the more detailed approach may be less valuable than the potential results of a study performed using less-detailed land-use maps in combination with interviews and other data sources.

4.3. Stakeholder interviews

Generally, expert opinion is one of the main data sources used in ES assessments. In this study five stakeholders were interviewed, who are very familiar with the area and are experts in different relevant fields. The interviewees all had different backgrounds and were all involved with nature and landscape in the study area. The interview themes and questions were very specific, because of which the relevant knowledge of stakeholders was important. Therefore, interviewing only five stakeholders was enough.

The aims of the interviews were: to evaluate the ES maps; and to detect developments that took place in Berg en Dal that were of influence on the landscape and ES supply. The used semi-open structure of the interviews yielded much relevant information which would have been difficult to obtain through other methods.

Validation of ES maps through interviews

In validation of ES maps the understanding of the ES maps needs to be correct and clarity about the used concepts and definitions is needed (see Jacobs et al., 2015). In my study, interviewees had a good understanding of the concept of ESs. They were asked to reason aloud, so that I knew their reasoning and could correct when needed.

Exact definitions of the concepts and classes that were used in this study were available for clarification, including the original definitions (English) and translations in the language of the stakeholders (Dutch). Examples of concepts are the list of ESs and LULC classes.

Nevertheless, stakeholders commented that they found the ESs pollination and pest and disease control difficult to relate to the spatial distribution patterns as presented in the ES maps. Water-flow regulation has a very broad definition, which can also be difficult to understand and link to the area of Berg en Dal. This indicates that the results should be interpreted with care and that interviewing experts in the relevant fields (e.g. biologists and hydrologists) and using data from (scientific) literature is valuable.

4.4. Use of subsequent land-use maps

My study shows that the matrix method can be used to assess temporal changes in ES supply. The results of temporal changes in potential supply found through the matrix method and through interviews were largely similar. Analysis of the ES maps yielded useful information about the effects of land-use changes on potential supply of the different ESs.

One drawback is that the LGN maps used in this study are made through different mapping methods, resulting in differing classifications and accuracy among the maps of different years. Consequently, there are differences between the ES maps and potential supply values that are not a result of actual land-use changes. These differences in mapping methods should be taken into account while interpreting the results. In this study the effects of different mapping methods in terms of distorting the potential supply values is expected to be relatively small, because of the size of the study area. The different mapping methods contributed to small changes in area sizes of land-use types, however, this changes are very small relative to the study area. The most clear developments in land use and consequently in potential supply occur on larger scales and therefore independent of the changes in mapping methods. Additionally, in the future the mapping techniques that are used may be more stable, resulting in more consistent maps.

In my study, the conversion of LGN maps to maps with a CLC classification leads to uncertainties in the ES maps. However, the resolution of the maps is small (grids of $25 \times 25 m^2$) and the used land-cover classes are detailed enough to assess the effects of changes therein. Uncertainties occurred mostly in a small group of land-cover classes (e.g. green urban area and discontinuous urban fabric), whereas the most clear developments and effects occurred in other classes, which were more properly classified. Thus, the results likely are not largely influenced by this imperfect conversion of LGN classes to CLC classes.

4.5. Assessment of the temporal scale of ES supply

The aim of this study is to help including temporal changes in ES supply in ES assessment methods. Studies that use the matrix method to assess (potential) supply vary greatly in the exact method and focus that is used. Hereafter several methods that are used to assess the temporal changes in ES supply are discussed.

Multiple studies use LULC maps in combination with the matrix method, in which experts are asked to rate (potential) supply. In most studies that do this, only two LULC maps are used: one of the first and one of the last year of the assessment period. These studies emphasize the limitations of using only two maps and the value of additional qualitative research for explanatory or contextual information (Dick et al., 2016; Jiang et al., 2013). My study is, to my knowledge, the first study to use as many as five subsequent land-use maps.

Many studies that assess temporal changes in ES supply combine this with data about governance or management changes that occurred in the same time period. For example, Jiang et al. (2013) mapped three ecosystem services in a rural English county for 1930s and 2000, using land-use maps combined with other proxies. They chose to map 1930s, because large land-use changes occurred in this phase, which makes knowledge about land use and ES supply in the 1930s useful for planning landscape management (Jiang et al., 2013). My study is, to my knowledge, the first study to combine assessment of temporal changes in (potential) supply with a detailed assessment of governance changes and that includes the effects of governance changes on ES supply.

Identification of ES hotspots

Many studies aim to identify specific areas that are important in terms of (potential) supply of ESs and therefore important to conserve. Spatial assessment of not only potential supply but also demand and supply is valuable to identify areas with an unsatisfied demand or an unsustainable uptake of ESs (Baró et al., 2016).

Blumstein and Thompson (2015) aimed to identify ES hotspots and changes therein. They used LULC maps, models and land-use databases to map eight ecosystem service variables in Massachusetts for 2001, 2006 and 2011. They identified ES hotspots on three policy-relevant scales: state, watershed and municipality. They found *'that the scale at which hotspots are assessed strongly affects their abundance and spatial distribution.'* (p. 108, Blumstein & Thompson, 2015) They stress the importance of considering different spatial scales in determining the conservation value of different areas in a landscape. Their results suggest "*that achieving the sustained delivery of ecosystem services from nature requires a whole-landscape approach that considers the scales at which key services operate and combines conservation priorities identified through a large landscape lens with those delineated through a finer-scale approach."* (p. 108, Blumstein & Thompson, 2015)

The results of Blumstein and Thompson (2015) suggest that using a multi-scale approach in identifying hotspots of ES supply is useful in delineating hotspots for conservation prioritization. These findings are coherent with the findings of the current study that suggest that a multi-level governance approach in which each aspect or ES is dealt with on the proper spatial scale is successful in optimising ES supply. Inclusion of multiple governance scales allows for the inclusion of hotspots that are important on multiple spatial scales, including local, regional, provincial, national or international. In the current study was found that different aspects or ESs should be governed on different spatial scales and for multiple ESs it is useful to consider multiple spatial scales.

Blumstein and Thompson (2015) found that the most ES hotspots are identified on a small scale or using a small resolution. They argue that *"local-scale hotspots may identify small but important sites that would be overlooked by regional-scale analyses"* (p. 108, Blumstein & Thompson, 2015). This is in line with my findings about the value of involvement of local stakeholders in ES assessments. In evaluating the ES maps, stakeholders mentioned that they found the maps too rough to be very accurate and that small-scale elements were missing, even though these elements can be highly valuable for ES supply. These findings also imply that in governance of nature and landscape the involvement of local stakeholders who have local knowledge is useful, because this allows for identification and consideration of local-scale hotspots.

Mapping potential supply, supply and demand

If maps of potential supply and of demand are available, these can be used to make maps of ES supply and of unsatisfied demand, as has been done by Baró et al. (2016). The demand is often mapped through similar methods as the potential supply, using the matrix method (e.g. Li et al., 2016). However, demand may be less related to LULC type than potential supply. Therefore, mapping demand and supply may require a different approach. Demand is usually localised in populated areas like urban areas or rural settlements (Burkhard et al., 2014), but this is not always the location where the ES is supplied. It differs per ES how the potential supply and the demand relate spatially; some ESs have to be supplied in the same location, whereas other ESs can be traded over long distances (Burkhard et al., 2014). This has implications for mapping demand and using potential supply and demand maps for determining whether the demand is satisfied or not. Therefore, using the matrix method to map demand and supply may not be sufficient.

Weighted averages of ES supply

Li et al. (2016) introduce two new indicators to relate potential (supply), demand and supply to each other: the supply rate and the supply-demand ratio. They used the matrix method to create maps of the Taihu River Basin, China, in 2000 and 2010. The maps depict: potential (supply), demand, ES supply, supply rate and supply-demand ratio. For nine regions of the Taihu River Basin, the supply rate and supply-demand ratio were calculated for 2000 and 2010 (see next paragraph). The supply rate and

supply-demand ratio for 2000 and 2010 were compared among the regions. The results show that *'supply rate and supply-demand ratio are useful indicators for spatial and temporal comparisons of ecosystem service status in different regions.'* (p. 1015, Li et al., 2016)

The calculations of supply rate and supply-demand ratio were done as follows. The 'Zonal statistics' module in ArcGIS calculated weighted averages for potential (supply), demand and supply. The supply rate and supply-demand ratio were calculated per ES, after which the overall supply rate and supply-demand ratio were calculated as the arithmetic mean values of the individual supply rates and supply-demand ratios. The method of Li et al. (2016) is similar to the method of the current study in which weighted averages are calculated for the potential supply, supply and demand in a certain area, based on LULC types and their scores in the matrix. Jiang et al. (2013) calculate weighed averages in a similar way to indicate the total annual agricultural and timber production and the total carbon stock in tonnes of Dorset in 1930 and 2000.

4.6. Assessment of drivers

In this study drivers of change in ES supply were identified from literature and interview data. Several influential drivers are identified, including LULC changes and changes in demand. Because of the high complexity of the system the exact role of the drivers is not clear. However, even though not all factors and their influences are known, knowledge about potential and influential drivers can be used to improve governance and management so to conserve ES supply.

4.7. Governance research

The effects of governance changes on ES supply have to my knowledge not been studied before in a study area. Even though collaborative governance approaches are generally thought to be the best approach to achieve more effective management solutions, there is a lack of evidence to support this claim. The results of my study suggest that collaborative governance approaches aimed to conserve nature and landscape can potentially improve nature and landscape quality and ES supply.

Studies were done to assess the uptake of the knowledge about ESs in governance. Verburg et al. (2016) analysed the uptake of the ES approach in governance in the UK, Belgium and the Netherlands. They found that in the Netherlands top-down legislations concerning nature protection are seen as limiting economic development and that a new nature policy is wanted. Nature protection shifts from top-down governance towards collaborative governance in which green entrepreneurship is stimulated. The studied Dutch national policies are found to be focused on clearly dividing tasks, including decentralisation of practical implementations to lower governments and stakeholders. These outcomes are in line with the results of the current study which show an increased involvement of non-governmental actors and a shift towards collaborative governance.

4.8. Additional research

My study contributes to finding a method that addresses the temporal dimension of ES supply. The used method is found to be effective, however, additional research could improve the validity of the results. Here I give some suggestions for further research.

4.8.1. Improve potential supply assessment

The created ES maps can be improved by taking into account the evaluations that were performed by stakeholders, for example through adding small-scale landscape elements and altering the matrix values where this is appropriate. In my study, experts were not asked to fill in the matrix for Berg en Dal, but the exemplary matrix of (Burkhard et al., 2014) was used. Using a matrix that is specifically made for Berg en Dal could lead to more accurate maps and potential supply values for Berg en Dal. The inclusion of consensus rounds in this process can refine the outcomes (see Jacobs et al., 2015).

The current study assumes constant potential supply values per surface unit, whereas in reality these values may change over time, for example as a result of technological developments in agriculture (see Jiang et al., 2013) or through a decrease in quality of the land or ecosystem. To further improve results, the changes of potential supply value per surface unit could be assessed and corrected to be used in the matrix method.

4.8.2. Improve demand and supply assessment

This study assessed the temporal scale of the potential supply using the matrix method. Temporal changes in demand for ESs are assessed through literature research and from interviews. The results of this study can be improved with assessment of the temporal and spatial scales of demand and supply. However, assessment of demand and supply may require a different approach than using the matrix method in the same way as has been done to map potential supply in the current study (see Section 4.5.). Assessment of supply and (un)satisfied demand requires integration of knowledge about the spatial relationships between potential supply, demand and supply.

5. Conclusions

5.1. Important ESs in Berg en Dal

According to stakeholders the seven most important ESs in Berg en Dal are: water-flow regulation; erosion regulation; crops; livestock; recreation and tourism; landscape aesthetics, amenity and inspiration; and natural heritage and natural diversity. The ESs pest and disease control and pollination were not often selected as important by stakeholders, however, these ESs are relevant to research because of their role in sustainable agriculture. Additionally, the acknowledgement of the importance of natural processes, including pest and disease control and pollination, has increased. Therefore the perceived importance of these processes may increase in the near future.

5.2. Developments in potential supply of ESs in Berg en Dal from 1995 to 2015

The potential supply of water-flow regulation has increased from 1995 to 2005, because many reconstruction projects have occurred through which water-flow regulation improved.

The potential supply of pest and disease control and pollination decreased mostly from 1995 to 2005 due to intensification, with a decrease in natural habitats and an increase in the use of pesticides. At the same time, but mostly from 2005 to 2015, the potential supply increased as a result of developed semi-natural landscape elements in agricultural areas.

The potential supply of crops first increased, as a result of intensification in agriculture and the Landinrichting program. After 2005, the cropland area in Berg en Dal decreased, which resulted in a decrease in the potential supply of crops. Likewise, the potential supply of livestock increased because of intensification and it decreased due to a decrease in surface area used for pastures. The surface area of natural grasslands increased. The contribution of the increase in natural grasslands to the (potential) supply of livestock may be small, because not all natural grasslands are grazed.

The potential supply of recreation and tourism increased, as a result of many factors, including conservation of natural areas and development of facilities for recreation like recreational pathways.

The potential supply of natural heritage and natural diversity increased, due to an increase in natural grasslands, conserved natural areas and improved nature management. Additionally, semi-natural landscape elements were developed in the agricultural area in between 2005 to 2015. Before 2005, natural heritage and natural diversity decreased in the agricultural area, due to intensification and Landinrichting program and the disappearance of many landscape elements.

5.3. Developments in governance that occurred from 1995 to 2015 that affected the landscape of Berg en Dal

The amount of top-down regulations concerning management of nature and landscape management increased. Decentralisation and regionalisation occurred through which the Dutch government delegates responsibilities regarding nature and landscape to provinces and municipalities. The focus of the Dutch government and provinces shifted to taking care of specific aspects that are important to handle on a high governance scale or for a large area. Other tasks that can be handled on lower governance scales were decentralised. Area specific approaches and policies are used more frequently.

An integrated approach to nature and environment is used more frequently, in which different societal goals are combined into one vision. The aim of an integrated approach is to find solutions that have positive effects on different goals or aspects, including nature and landscape conservation and economical aspects. Integral approaches are used on high and low governance levels.

Water management is generally discussed at international level and actual measurements are taken on regional scale, mostly per sub stream area. Decentralisation occurred in water management; responsibility of the dikes is recently delegated from Rijkswaterstaat to the water board. Cooperation and stakeholders involvement increased on all governance levels, which is likely to have positive effects on the process and the results.

Participation and cooperation of local stakeholders concerning nature and landscape development increased. The amount of people and local organisations that are involved in nature and landscape development increased. Decentralisation and regionalisation contributed to the increase, because these developments lead to an increase in use of local knowledge.

The interviewed stakeholders are generally positive about the cooperation among local inhabitants and organisations in Berg en Dal. The presence of involved local stakeholders who cooperate well seems to motivate others to get involved too. The sense of having common goals among local stakeholders plays a role in this. Interviewees were less positive about cooperation with stakeholders on higher governance levels, because stakeholders on higher governance levels are less involved and the cooperation is likely to rely on formal top-down communication.

Generally, collaborative governance approaches are used more frequently, in which all governance levels cooperate to identify area-specific solutions. An increase in involvement of both public and private stakeholders is stimulated, including local stakeholders. Local initiatives are stimulated and are regarded as useful in tackling local problems.

In Berg en Dal the quantity and quality of natural areas has increased as a result of an increase in top-down regulations and in collaborative governance approaches. Top-down regulations are important concerning nature management, agriculture and water management. However, collaboration of multiple stakeholders on the regional or local level is found to positively affect the quality of nature and the landscape.

5.4. Potential drivers of change in ES supply

The supply of ESs results from the biophysical properties of an ecosystem. Therefore, in this study, drivers of change in the biophysical properties of an ecosystem are regarded as drivers of change in supply of ESs. Drivers can be divided into direct and indirect drivers of change. Direct drivers are factors that directly influence the biophysical properties and they can be divided into: ecosystem processes, ecosystem management and external pressures. In this study the focus is on ecosystem or land management, which includes changes in LULC.

Indirect drivers of change in supply are factors that influence the decision-making processes about landscape or nature management. These decision-making processes occur at different levels, which can be divided in: local level; municipal, provincial and national level; and international level. Decision-making processes are part of governance and they are influenced by all drivers that influence the involved stakeholders.

5.5. Demand and its role as driver

The role of demand for ESs is twofold. Demand for ESs is necessary for an ES to be supplied to humans. Demand also influences governance on all scales, through influencing the involved stakeholders. Additionally, the role of demand is linked to the potential supply: the combination of the two can lead to an unsustainable uptake and/or an unsatisfied demand. An unsustainable uptake of ESs and unsatisfied demand and changes therein may be stronger drivers than the demand itself.

Generally, the demand for ESs in Berg en Dal likely increased from 1995 to 2015 as a result of an increase in knowledge about ESs and acknowledgement of their importance. The demand for water-flow regulation and recreation and tourism increased most clearly. The demand for natural heritage and natural diversity likely increased, however, the demand for nature (conservation or development) can also be caused by an increase in unsatisfied demand or an increase in demand for other ESs. The demand for pest and disease control and pollination likely increased, but among farmers the acknowledgement of and the demand for these ESs remains small. The demand for crops and livestock is difficult to determine, because of the complexity of the food system.

5.6. Important drivers of change in ES supply in Berg en Dal

Nature management is largely driven by (changes in) top-down regulations, available funding and the involvement of local stakeholders. Top-down regulations about nature

and landscape have affected the quantity and quality of natural areas in Berg en Dal. Because nature management is costly, available funding is an important factor in determining nature management approaches that influence ES supply. In Berg en Dal, a decrease in public funding has contributed to an increased involvement of and cooperation among local stakeholders, due to which local knowledge was used more effectively. The use of local knowledge about the present ecosystems and involved stakeholders can largely influence the quality of nature and the supply of ESs.

Occurred changes in management of agricultural land are driven by the trends of upscaling and intensification. The availability and use of chemical pesticides has increased and technological developments have led to the availability and use of more efficient machinery. The mentioned developments contributed to an increase in ES supply of crops and a decrease in most other services.

The production and income of farmers are important drivers of changes in private land management. Low production and income of farmers has a negative effect on willingness of farmers to manage nature on their farm. Additionally, for dairy farmers the possibilities for spreading manure over the land are important factors for land management, because of environmental effects and legislations. The willingness of farmers to invest in nature management is positively influenced by: available subsidies; societal appreciation for nature management; farmers' pride of nature or landscape; low investment when nature is developed in areas that are difficult to cultivate; and an increased interest in natural pest and disease control. In Berg en Dal, the increase of semi-natural landscape elements in the agricultural area is largely a result of a relatively small group of people that are actively engaged with nature and natural processes. The available subsidy schemes (AESs) were major drivers for land-owners to develop these landscape elements.

Changes in high level governance are likely driven by an increase in demand as a result of an increase in knowledge and acknowledgement of nature and landscape and their functions. Alternatively, changes in governance can be driven by an increase in unsatisfied demand as result of a decrease in potential supply. Globalisation plays an important role concerning the spatial distribution of demand for ESs (e.g. food products)

Changes in supply of water-flow regulation are largely driven by the execution of water management projects, which are driven by the (expected) effects of climate change and the (expected) rise in demand for water-flow regulation.

The demand for recreation and tourism in Berg en Dal increased as a result of multiple developments: an increase in population of Nijmegen, development of recreational facilities and promotion of recreation in the area.

The increase in acknowledgement of nature and landscape and the increased demand for ESs stimulated nature development in Berg en Dal. The increase in cooperation

among local stakeholders motivated more stakeholders to get involved with nature and landscape development. Increased cooperation and involvement can drive further development of nature and landscape and an increase in ES supply.

5.7. Effects of governance changes on ES supply in Berg en Dal from 1995 to 2015

The increase in top-down regulations had a positive effect on the quantity and quality of nature and thereby on ES supply. However, the combination of top-down regulations with decentralisation and regionalisation was very influential. The increase of collaborative governance, in which more stakeholders got involved and cooperation among them improved, had positive effects on nature and ES supply.

The inclusion of local stakeholders had positive effects on the results of multiple projects and programs. Local stakeholders have knowledge about the local natural system, about local stakeholders and their wishes and about the local demand for ESs, including the demand for recreation and tourism and natural heritage and diversity. Therefore, the inclusion of local stakeholders can contribute to a better outcome in terms of potential supply and supply.

A multi-level approach in which all governance levels collaborate and all problems or aspects are dealt with on the most appropriate governance level had positive effects on ES supply. An integral vision on nature and landscape benefits ES supply too, because it allows for finding solutions that benefit multiple ESs.

An example of a multi-level governance approach is the approach to water management. Water-flow regulation is coordinated on an international level, which is done through WFD. The actual constructions on water ways can be planned and executed locally, with involvement of local stakeholders. In Berg en Dal the consultation with local stakeholders about water management projects had positive effect on ES supply; it contributed to an increase in recreation and tourism and natural heritage and natural diversity. In Berg en Dal the supply of water-flow regulation has increased due to many constructions which resulted from multi-level governance processes.

An increase in local cooperation and the establishment of a shared vision on the landscape of Berg en Dal were important factors for nature and landscape. The shared vision, that is presented in LOP, represents an integral approach to the landscape. LOP aims to combine multiple societal goals, which allows for the optimisation of multiple ESs.

Farmers generally aim to optimize the supply of crops and livestock on their land. Intensification and the Landinrichting program contributed to an increase in potential supply. Legislations concerning agriculture has certainly affected farming practices and ES supply. The possibility for farmers to participate in nature management has largely

contributed to ES supply in Berg en Dal. Subsidy schemes, AESs, are major drivers in the willingness of farmers to engage in nature management and thereby increase ES supply of many ESs. However, many other factors play a role, including the income of farmers, the sense of cooperation and approval from others. The involvement of local coordinators in AESs improved the results in terms of nature values and the supply of natural heritage and natural diversity.

Pest and disease control and pollination are mainly demanded on croplands. The increase in natural areas and natural landscape elements, which was driven by changes in governance, has contributed to an increase in the supply of these ESs. Legislations concerning the use of pesticides have contributed to an increase in demand for pest and disease control.

Landinrichting not only contributed to an increase in the supply of crops through optimizing croplands, but also to an increase in natural heritage and natural diversity and recreation and tourism through protecting the natural area de Ooijpolder. Much was done to increase the supply of natural heritage and natural diversity and recreation and tourism in Berg en Dal. In Berg en Dal these ESs are partly linked to each other, because many recreants and tourists value the supply of natural heritage and natural diversity.

Recreation and tourism was stimulated by local stakeholders including the municipality, through advertisement and construction of facilities like recreational pathways. These measures were successful. Concerning the supply of recreation and tourism, local stakeholders have an important role. Recreation and tourism is demanded locally. Consequently, local stakeholders can have good insight into which measurements are needed to increase the potential supply or to increase the demand.

5.8. Use of the matrix method to assess temporal changes of potential supply

This study demonstrates an ES assessment method that includes the temporal scale of ES supply. Transforming multiple LULC maps into ES maps is found to be a good method to assess the temporal changes in potential supply. To use generic parameterization of potential supply in the assessment of spatial and temporal dimensions of potential supply in a local study area, is found to be a good approach. However, this method should be combined with expert judgement from stakeholders supplemented with data from scientific literature to validate the found results.

Additional research into the drivers that influenced changes in LULC and ES supply yields valuable information. Knowledge about the drivers of temporal changes in ES supply can potentially be used to obtain a sustainable ES supply in the future.

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Annex 1: Overview of interviewees

Table 5: Overview of interviewees including names and functions.

Name	**Role in the respective case study**
Tiny WIGMAN	Member of Via Natura, which implements the regional landscape development plan of the municipality of Berg en Dal
Bart WILLERS	Member of 'Ploegdriever', an association for landscape management. The association supports the farmers in Ooijpolder and Groesbeek with the management of the landscape and ensures that they receive an appropriate reward for this
Maarten MERKUS	Employee in the municipality Berg en Dal, Department of Nature and Landscape
Zeger STAPPERSHOEF	Farmer, active in agricultural nature management
Eric MARSMAN	Water board Rivierenland: the water board provides clean water and flood prevention in the case study area

Annex 2: Interview guidelines: interview topics

In this Annex the body of the interview guidelines as used in the interviews is presented. Several adaptions are made after conducting the interviews, so to make the guidelines as presented more true to the performed interviews and more useful for future interviews. These adaptions include: shortening of the guidelines through removing questions that were not asked and through removing additional explanations; and reformulating questions into short descriptions of the addressed topic.

The abbreviations marked yellow indicate which stakeholder to address, in which: ALL = all stakeholders; FA = farmer; MU = employee municipality; VN = employee Via Natura; PD = employee Ploegdriever; WB = employee Water board.

1. Begin interview

1.1 Introductie/algemeen ALL

- Beroep
- Bekendheid Berg en Dal
- Motivatie meedoen met onderzoek
- Positief/negatief over landschap van Berg en Dal
- Veranderingen in het landschap vanaf 1995

1.2 Landbouw FA

- Landbouwactiviteiten toegepast door boeren in Berg en Dal
- In hoeverre boeren rekening houden met natuur en landschap
- Verschillende functies van landbouwlandschap
- Welke activiteiten je zelf onderneemt voor natuur en landschap
    - Welke factoren zijn voor jou belangrijk hiervoor
    - Het gebruik van subsidieregelingen zoals SNL of Groenblauwe Diensten

2. Ecosysteemdiensten

2.1 Algemeen

- Ben je bekend met de term ecosysteemdiensten (*ecosystem services*)?
    - Zo ja: wat betekent het voor jou?
    - Kan je voorbeelden noemen? Zijn deze belangrijk in Berg en Dal?

Belangrijke ecosysteemdiensten in Berg en Dal

- Selecteer van de lijst van ecosysteemdiensten 4-5 ecosysteemdiensten die het meest belangrijk zijn. Meer dan 4-5 ecosysteemdiensten selecteren mag ook als dat beter klopt. Licht toe waarom deze ecosysteemdiensten belangrijk zijn. **ALL**
- Is dit veranderd sinds 1995? Hoe? **ALL**

- Heb je verschillen in levering/aanwezigheid van ecosysteemdiensten (of natuurlijke processen) sinds 1995 opgemerkt die relevant zijn voor landbouw? **FA**

2.2 Vragen per ecosysteemdienst

Gewassen en vee(producten) FA

- Waar worden lokale producten verkocht en gebruikt? (lokaal, regionaal, verder weg)
- Is de vraag naar lokale producten veranderd sinds 1995?
- Gebruiken bewoners van Berg en Dal in het algemeen lokale producten?
- Is de vraag van de bewoners van Berg en Dal naar lokale producten veranderd sinds 1995?

Waterstroomregulatie, overstromingspreventie (water-flow regulation) FA WB MU

- Komen overstromingen van de Waal voor in Berg en Dal?
    - Zo ja: hoe vaak komt overstroming voor?
    - Is het overstromen seizoensgebonden?
    - Is de intensiteit van de overstromingen regelmatig en voorspelbaar? Is de intensiteit toegenomen de afgelopen 20 jaar?
- Welke gevolgen hebben overstromingen in Berg en Dal? Heeft het ook positieve effecten?
- Hoe worden overstromingen gereguleerd of beheerd in Berg en Dal?
- Wat vind je van het project Ruimte voor de Rivier in de Millingerwaard? Is het succesvol?
- Zijn de huidige maatregelen voldoende om ernstige schade te voorkomen?
- Zijn er, naast overstromingen van de Waal, nog verdere belangrijke aandachtspunten w.b. waterstroming in Berg en Dal? Gaat dit goed? Zoals (problemen met) afwatering (na hevige regenval). **WB**
- Denk je dat natuurlijke landschapselementen een positief of negatief effect hebben op het voorkomen of reguleren van overstromingen? **FA**

Gewasbestuiving FA

- Hebben jouw gewassen bestuivers (insecten) nodig? En zo ja, welke gewassen?
- Maak je gebruik van honingbijen?
- Zijn er wilde bestuivers actief op je boerderij en dragen ze bij aan je productie?
    - Kan je schatten hoe belangrijk wilde bestuivers zijn voor je productie?
- Zie je trends over tijd w.b. wilde bestuivers in het gebied? Zijn de aantallen (van populaties of hun habitats) toegenomen of afgenomen in de afglopen 20 jaar?

Natuurlijke plaag- en ziektebestrijding FA

- Is er natuurlijke plaag- of ziektebestrijding (zoals predatie) op je land? En is dit belangrijk?

    - Welke maatregelen neem je om natuurlijke plaag- en ziektebestrijding te faciliteren/bevorderen (zoals landschapsinrichting, landschapselementen)?
- Zie je trends over tijd (afgelopen 20 jaar) w.b. natuurlijke plaag- en ziektebestrijding in het gebied? Is het toe- of afgenomen (populaties of hun habitats)? Waarom denk je dat dat zo is?

Natuurlijk erfgoed en natuurlijke diversiteit (biodiversiteit) FA

- Heb je ruimte/habitats voor beschermde, bedreigde en zeldzame soorten op je boerderij/land?
    - Zo ja: welk type en hoeveel?

Recreatie en toerisme FA MU

- Zijn specifieke delen van het landschap of specifieke ecosystemen bijzonder populair onder toeristen en recreanten? Kan je deze delen aangeven op de kaart?
- Wat zijn de trends qua aantallen toeristen en recreanten over het jaar/de seizoenen? Wanneer zijn de pieken?
- Waar komen toeristen voornamelijk vandaan? Zie je hier trends in?
- Welke activiteiten worden uitgevoerd? Hoe varieert dit over het jaar?
- Veroorzaken deze activiteiten schade of stress voor de natuur/natuurlijke processen? Heeft dit gevolgen in termen van ecosysteemdiensten of biodiversiteit?
- Zijn er conflicten tussen toerisme en andere landgebruiken (zoals landbouw)?
- Wat zijn verwachtingen voor de toekomst in termen van (natuur)toerisme en –recreatie in Berg en Dal?
- Zijn er extra investeringen voor bepaalde toerisme- en recreatiefaciliteiten nodig?
- Welke investeringen/ontwikkelingen hebben plaatsgevonden tussen 1995 en 2015 die toerisme en recreatie hebben beïnvloed?
- Wat waren de doelen en resultaten van deze investeringen?

Educatie (knowledge systems) PD

- Zijn de educatieve activiteiten van Werkgroep Milieubeheer Groesbeek (WMG) alleen gericht op bewoners van Berg en Dal of ook op toeristen?
- Zijn er naast WMG nog meer organisaties of initiatieven rondom educatie van bewoners en toeristen?
- Zo ja: wat dan?
- Zijn de educatieve activiteiten vooral gericht op kinderen of ook op volwassenen?

Cultureel erfgoed en culturele diversiteit FA

- Is de omgeving belangrijk voor cultuur-historische beleving?

- Wordt het cultuur-historisch erfgoed gewaardeerd door lokale bewoners en toeristen?
- Is deze waardering veranderd vanaf 1995?

3. Validatie van ecosysteemdienstkaarten

3.1 Ecosysteemdienstkaarten ALL

Per kaart/ecosysteemdienst:

- Wat vind je van de ecosysteemdienstkaart? Geeft hij een goed beeld van waar in Berg en Dal in 2012 de geselecteerde ecosysteemdienst wordt geleverd?
- Wat vind je van de verdeling van de waarden 0-5/de spreiding?
- Komen de gebieden met de hoogste waarden (4-5) overeen met jouw verwachting/inschatting van waar deze zouden liggen in 2012? Wat komt wel/niet overeen?
- Als je dat kan inschatten, benoem of wijs de gebieden aan waarvan jij verwacht dat de (potentiële) ecosysteemdienstlevering het hoogst is, nu en/of in 2012.
- Heb je verder nog opmerkingen? Zijn er dingen die je opvallen aan de kaart?

Landgebruik

- Denk je dat landgebruik een goede indicatie is voor potentiële ecosysteemdienstlevering? Waarom wel/niet?
    - Verschilt dit per ecosysteemdienst? Zo ja, waarom denk je dat? Kan je een voorbeeld geven?
- Hebben er na 2012 nog belangrijke ontwikkelingen plaatsgevonden w.b. landgebruik? Zo ja, welke ontwikkelingen?
    - Zijn deze ontwikkelingen belangrijk geweest voor ecosysteemdienstlevering?

3.2 Ontwikkeling ecosysteemdienstlevering 1995-2015 ALL

- Zou je kunnen aangeven of de potentiële ecosysteemdienstlevering van de geselecteerde ecosysteemdiensten is afgenomen (-- of -), gelijk gebleven (0) of toegenomen (+ of ++) in de periodes: van 1995 t/m 2005 en van 2006 t/m 2015?
- Waarom denk je dat?

3.3 Kleine landschapselementen VN PD

Deze vragen gaan over de grafieken die het berekende effect van de landschapselementen van het Groenblauwe Diensten-programma weergeven.

- Wat vind je van het weergegeven effect qua veranderingen in potentiële ecosysteemdienstlevering? Denk je dat het klopt met de werkelijkheid? Komt het overeen met je eigen ervaring?

- Is Via Natura tevreden met de resultaten? In termen van ecosysteemdiensten en natuur.

4. Governance en landgebruik

Governance ('sturing') van landgebruik MU WB VN

- Is de bemoeienis van de EU in landschapsinrichting sterk veranderd tussen 1995 en 2015? Heeft dit zich geuit in regelgeving?
- Welke regelgeving vanuit het Rijk is belangrijk voor landgebruik in Berg en Dal?
    - Hebben hierin belangrijke veranderingen plaatsgevonden vanaf 1995?
    - Hebben deze veranderingen tot veranderingen in landgebruik geleid?
- Wat was voor 2014 de rol van de provincies? Hadden zij eerder ook al verantwoordelijkheden binnen EHS?

Meer regie voor lokale spelers

- Klopt het dat er meer verantwoordelijkheid is komen te liggen bij gemeente en andere lokale spelers?
- Wat is de rol die de gemeente Berg en Dal inneemt als het gaat om landgebruik?
- Welke partijen spelen een belangrijke rol bij het nemen van beslissingen/het maken van beleid w.b. landschapsinrichting/landgebruik?
    - Welke rol spelen de verschillende partijen?
    - Is dit veranderd na 1995? Hoe is dit veranderd?
- Welke factoren spelen een belangrijke rol bij beslissingen w.b. landschapsinrichting/landgebruik?
- Zijn er (veel/vaak) conflicten w.b. landschapsinrichting/landgebruik?
    - Zijn er terugkerende conflicten?

Decentralisatie en regionalisatie

- Denk je dat decentralisatie leidt tot verbetering van het landschap in Berg en Dal?
- Denk je dat regionalisatie leidt tot verbetering van het landschap in Berg en Dal?

Uitvoering beheer

- Door wie wordt natuur-/landschapsbeheer uitgevoerd in Berg en Dal?
    - Zijn deze beheerders ook betrokken bij het nemen van beslissingen w.b. landschapsinrichting?

Gemeente/Landschapsontwikkelingsplan (LOP) MU VN

Visie Gemeente Berg en Dal

- Rond 1995, hoe was toen de visie op natuur en landschap vanuit de gemeenten die nu de gemeente Berg en Dal vormen?
    - Is deze visie veranderd tussen 1995 en 2015?

    - Zo ja, wat heeft deze veranderingen veroorzaakt?
    - Heeft het samengaan van de drie gemeenten hierin een rol gespeeld?
- Heeft het samengaan van de gemeenten voor veranderingen gezorgd w.b. natuur- en landschapsbeleid en –beheer?
- Delen de bewoners van Berg en Dal de visie van de gemeente?
- Is de betrokkenheid van bewoners bij het landschap in Berg en Dal veranderd?

Uitvoering LOP

- Zijn de betrokken partijen tevreden over de uitvoering/de resultaten van LOP 2004?
- Zijn er ook partijen ontevreden? Waarom?
- Werd er tijdens de uitvoering/de tijdsduur van LOP 2004 veel aandacht besteed aan reflectie/evaluatie?
- Was dit waardevol? Was het genoeg?

Participatie

- Is de gemeente Berg en Dal tevreden over de participatie van verschillende belanghebbenden?
- Hoe was de participatie van bewoners en organisaties tussen 1995 en 2005?
- Zijn er naast de uitvoering van LOP 2004 nog andere factoren of ontwikkelingen van grote invloed geweest op de participatie van bewoners en organisaties vanaf 1995?
- Heeft het afsluiten van LOP 2004 en het opzetten van LOP 2015 veranderingen teweeggebracht qua beleid, beheer en landschap? Zo ja, welke veranderingen?
- Wordt er al veel gedaan met LOP 2015?

Subsidiestelsel Natuur en Landschap (SNL)/Ploegdriever PD

- Wat is de rol van Ploegdriever qua landschap in Berg en Dal?
- Wat is de rol van Ploegdriever voor de uitvoering van het SNL? Is Ploegdriever een beheerderscollectief?
- Klopt het dat SNL ten dienste staat van de EHS/NNN?
- Hoe worden de subsidies vanuit de provincie uitgekeerd aan subsidieaanvragers/-beheerders? Welke partijen zijn hier nog meer bij betrokken, naast Ploegdriever, landeigenaren en -beheerders?
- Vanaf geldt de SNL? Is dit vanaf 2010?
- Vanaf wanneer worden er vanuit SNL subsidies gegeven aan beheerders in Berg en Dal?
- Klopt het dat er in 2016 18 contracten zijn in Berg en Dal, en dat er in 2017 nog 13 contracten bij komen/zijn gekomen?
- Welke typen SNL-contracten zijn er in Berg en Dal?
    - Wat zijn de verschillen tussen de verschillende typen?
- Werkt SNL en de uitvoering ervan goed? Wat gaat goed en wat niet?
- Zijn de betrokken partijen tevreden?

- Is er frictie tussen (de uitvoering van) SNL en andere regelingen (zoals Groenblauwe Diensten)?
- Gaan SNL en Groenblauwe Diensten goed samen? Lopen de regelingen naast elkaar of is er een vorm van communicatie of samenwerking?
- Worden er m.b.v. SNL-subsidies en –contracten veranderingen in het landschap aangebracht of gaat het vooral om het behouden van al aanwezige natuur?

Groenblauwe Diensten/Via Natura VN PD FA

- Wat is de rol van Via Natura?
- Hoe werkt de Groenblauwe Diensten-regeling van Via Natura?
- Welke partijen zijn erbij betrokken en hoe? Wat is de invloed van deze partijen? Wat zijn hun motivaties?
- Hoe nemen boeren beslissingen w.b. landgebruik (binnen Groenblauwe Diensten)? In hoeverre zijn ze vrij om te kiezen welke landschapselementen ze aanleggen en waar? Welke factoren hebben de meeste invloed op deze beslissingen?
- In hoeverre, hoe en in welke stadia waren/zijn (in het bijzonder) boeren actief betrokken in het programma (bijv. door bijdragen aan en vormgeven van de regeling/Groenblauwe Diensten)? Hoe zag en ziet de deelname van boeren er uit? Zijn boeren en andere stakeholders tevreden met hun level/manier van deelname?
- Is het ook wel eens misgegaan?
- Kun je hier iets meer vertellen over de verschillende fases van het Groenblauwe Diensten-programma? Over waarom er in fases werd gewerkt en hoe dit is gelopen?
- Komen er nog meer landschapselementen bij onder het Groenblauwe Diensten-programma?
- In hoeverre waren de elementen al aanwezig of zijn ze nieuw aangelegd?
- Zijn de landschapselementen binnen Groenblauwe Diensten onderdeel van de EHS/NNN?

Fondsen

- Wat was de bedoeling van Via Natura als landschapsfonds en wat waren de beperkingen? Is het nu op een andere manier opgelost?
- Het Groenblauwe Diensten-project is gesponsord door de Postcodeloterij. Hoe is dit verlopen? Gaat het om een éénmalige financiële bijdrage?
- Hoe is het programma gefinancierd?

Waterschap Rivierenland WB

- Wat doet Waterschap Rivierenland zoal in de gemeente Berg en Dal?
- Met welke partijen/belanghebbenden werkt Waterschap Rivierenland samen?

- Welke ‘projecten’ van Waterschap Rivierenland zijn in Berg en Dal uitgevoerd tussen 1995 en 2015?
- Zijn deze projecten in samenwerking met andere belanghebbenden uitgevoerd? Wat waren andere betrokken partijen?
- Hoe zijn deze projecten verlopen? Wat waren de drijfveren, de doelen, de resultaten, etc.

Betrokkenheid bij landschapsinrichting Berg en Dal

- Is het Waterschap betrokken bij landschapsinrichting of –beheer in Berg en Dal?
- Speelt waterbeheer in Berg en Dal een grote rol in landschapsbeheer?
- Wat was de rol van het Waterschap bij het uitvoeren van LOP 2004?
- Had het Waterschap oorspronkelijk andere intenties dan wat het uiteindelijk heeft bijgedragen/uitgevoerd? Is de communicatie met andere belanghebbenden goed?

Governance in Berg en Dal w.b. water en landschap

- Hoe is de rol van de EU, het Rijk, de provincie en de gemeente in waterbeheer?
- Zijn deze rollen veranderd vanaf 1995?
- Is er decentralisatie plaatsgevonden in waterbeheer?
- Of regionalisatie?
- Wat is de rol van Europese Kaderrichtlijn Water (KRW)?
- Wat is de rol van het Bestuursakkoord Water?
- Zijn er nog andere belangrijke afspraken of ontwikkelingen geweest die van invloed waren op het landschap in Berg en Dal?

Landschapsontwikkelingen (Ooijpolder, Millingerwaard & Erlecom) WB MU

- Welke ontwikkelingen hebben plaatsgevonden in de Ooijpolder, Millingerwaard en in/bij Erlecom?
- Wat waren de doelen van de ontwikkelingen en zijn deze doelen behaald?
- Welke partijen/belanghebbenden waren betrokken?
- Welke regelgeving (regionaal, provinciaal, nationaal, EU) was van invloed?
- Hebben er nog meer belangrijke landschapsontwikkelingen plaatsgevonden vanaf 1995 in Berg en Dal?

Ruilverkaveling en bedrijfsgrootte FA MU

- Heeft er veel ruilverkaveling plaatsgevonden in Berg en Dal? Wanneer gebeurde dit? Ook na 1995?
- Wat waren de effecten van ruilverkaveling? Heeft dit geleid tot grotere landbouwpercelen?
- Is de gemiddelde grootte van gewaspercelen veranderd (vanaf 1995)?
- Heeft er schaalvergroting plaatsgevonden in landbouwbedrijven in Berg en Dal?

- Wat zijn de effecten van schaalvergroting op het voorkomen en beheer van semi-natuurlijke landschapselementen?

Annex 3: LGN to CLC conversion table

Table 6: LGN classes (LGN3plus/4/5 and LGN6/7) occurring in Berg en Dal and corresponding CLC classes. Based on (lgn1-5-legend-overview.xls), which is an addition to the LGN database (Hazeu, 2013), and Hazeu (2014). 'n' means 'class not used'.

* These classes were chosen from several CLC classes corresponding to the same LGN class

** Words in red were added for clarity

*** Fresh water should ideally be split up into two CLC classes: water bodies and water course, but in the maps the class water courses is used

LGN code	LGN3plus/LGN4/LGN 5 - English	LGN6/7 - English	CLC class code	CLC class name
1	grass	pasture	231	Pastures
2	maize	maize	211	Non-irrigated arable land
3	potatoes	potatoes	211	Non-irrigated arable land
4	beets	sugar beet	211	Non-irrigated arable land
5	cereals	cereals	211	Non-irrigated arable land
6	other agricultural crops	other agricultural crops	211	Non-irrigated arable land
8	greenhouses	greenhouses	211	Non-irrigated arable land
9	orchards	orchards	222	Fruit trees and berry plantations
10	bulb cultivation	flower bulbs	211	Non-irrigated arable land
11	deciduous forest	deciduous forest	311	Broad leaved forest
12	coniferous forest	coniferous forest	312	Coniferous forest
16	fresh water	fresh water	511	Water courses ***
18	continuous urban area	urban built-up areas	112	Discontinuous urban fabric *
19	built-up in rural area	semi urban built-up areas	112	Discontinuous urban fabric *
20	deciduous forest in urban area	forest in urban built-up areas **	141	Green urban areas
21	coniferous forest in urban area	n	141	Green urban areas *
22	built-up area with dense forest	forest in semi urban built-up areas **	141	Green urban areas *
23	grass in built-up area	grass in urban built-up areas **	141	Green urban areas *
24	bare soil in built-up area	bare soil in (semi) urban built-up areas **	133	Construction sites
25	main roads and railways	main roads and railways	122	Road and rail networks and associated lands
26	buildings in rural area	built-up areas outside (semi) urban areas **	112	Discontinuous urban fabric
28	n	grass in semi urban built-up areas **	141	Green urban areas *
35	shifting sands	drifting sands/river sandbanks	331	Beaches, dunes and sands

36	heathlands in dune areas	heathland	322	Moors and heathland
37	heathlands with minor grass influence	grassy heathland	322	Moors and heathland
38	heathlands with major grass influence	very grassy heathland	322	Moors and heathland
41	miscellaneous swamp vegetation	other swamp vegetation	411	Inland marches
42	reed swamp	reeds	411	Inland marches
43	forest in swamp area	forest in swamp areas	311	Broad-leaved forest
45	herbaceous vegetation	natural grasslands	321	Natural grasslands
46	bare soil in natural areas	n	331	Beaches, dunes and sands *
61	n	tree nurseries	211	Non-irrigated arable land
62	n	fruit cultivation	222	Fruit trees and berry plantations

Annex 4: Difficulties in converting LGN maps to CLC maps

Classifying the urban area in LGN

The two classification systems have a different approach for classifying urban areas. Table 7 shows the classes used in LGN3plus/4/5 and in LGN6/7 for the urban area. The original Dutch class names are given, as well as the English names as used by Hazeu (2014) in Table 18.6. There is also a column showing English class names suggested by me. In the following paragraphs the different approaches of classifying the urban area and the problems with the English translation of Hazeu (2014) are explained.

In LGN3plus/4/5 a distinction is made between urban area, rural area and built-up. The terms urban and built-up are used in different ways. In class 18 urban means built-up, whereas in classes 20 and 21 urban means the centre of a city or village. The distinction between built-up in rural area (19) and buildings in rural area (26) is unclear.

In LGN6/7 the classification of urban areas and built-up rural areas is renewed. Urban areas are subdivided into built-up and semi built up areas (in Dutch: 'primair bebouwd gebied' and 'secundair bebouwd gebied'). However, Hazeu (2014) uses the English terms built-up and (semi) urban still inconsistently. The classes urban built-up area (18) and semi urban built-up area (19) are used. Therein, the term built-up area is used for an area which is primarily covered in buildings. Following, the land-use types grass and forest are divided in distinct categories for forest and grass in built-up and semi built-up areas (20, 22, 23 and 28). Additionally, buildings in rural areas (26 in LGN3plus/4/5) is replaced by built-up areas outside urban areas (26). The use of the terms built-up and urban in class 26 contradicts the use of these terms in the before mentioned classes.

In Table 18.2 in Hazeu (2014), different class names are used than in Table 18.6: the terms primary and secondary built-up are used for urban built-up areas and semi urban built-up areas. Also, the terms forest in primary and secondary built-up, grassland in primary and secondary built-up and bare soil in built-up are used.

Here, I propose to use the terms urban and semi urban to distinguish between primarily built-up areas and secondary built-up areas, whereas the term built-up means covered with buildings. Hereafter these terms are used in this report.

Table 7: LGN classes used in LGN3plus/4/5 and LGN6/7 for urban areas.
* from land-use class overview (lgn1-5-legend-overview.xls) which is an addition to the LGN database (Hazeu, 2013)
** terms used in Table 18.6 in Hazeu (2014) for LGN6
*** thematic definition of class strongly differs between LGN 3plus/4/5 and LGN6/7

LGN class	LGN3PLUS/4/5 Dutch *	LGN3PLUS/4/5 English *	LGN6/7 Dutch *	LGN6/7 English **	LGN6/7-e English suggested

18	stedelijk bebouwd gebied	continuous urban area	bebouwing in primair bebouwd gebied	urban built-up areas	urban built-up areas
19	bebouwing in buitengebied	built-up in rural area	bebouwing in secundair bebouwd gebied	semi urban built-up areas	semi urban built-up areas
20 ***	loofbos in bebouwd gebied	deciduous forest in urban area	bos in primair bebouwd gebied	forest in built-up areas	forest in urban areas
21	naaldbos in bebouwd gebied	coniferous forest in urban area	n	n	n
22 ***	bos met dichte bebouwing	built-up area with dense forest	bos in secundair bebouwd gebied	forest in semi built-up areas	forest in semi urban areas
23	gras in bebouwd gebied	grass in built-up area	gras in primair bebouwd buitengebied	grass in built-up areas	grass in urban areas
28	n	n	gras in secundair bebouwd gebied	grass in semi built-up areas	grass in semi urban areas
24	kale grond in bebouwd gebied	bare soil in built-up area	kale grond in bebouwd buitengebied	bare soil in built-up areas	bare soil in (semi) urban areas
26	bebouwing in agrarisch gebied	buildings in rural area	bebouwing in buitengebied	built-up areas outside urban areas	built-up areas outside (semi) urban areas

Converting the urban area from LGN to CLC classes

Most of the difficulties arose in the urban area, because several LGN6/7 classes correspond each to multiple CLC classes. Table 8 shows to which CLC classes the urban LGN classes 18, 19, 22, 23 and 28 correspond (LGN class names used as suggested in Table 7).

Table 8: LGN6/7 classes occurring in Berg en Dal that each correspond to several CLC classes according to Hazeu (2014). CLC classes in red do not occur in Berg en Dal. CLC classes marked yellow are chosen to be used in this study.
* class names used as suggested in Table 7
** corresponds to only one CLC class according to Hazeu (2014), given here for completeness

LGN6/7 class *		Corresponding CLC classes	
18	Urban built-up areas	112	Discontinuous urban fabric
		121	Industrial or commercial units
		123	Port areas
		124	Airports
19	Semi urban built-up areas	112	Discontinuous urban fabric
		142	Sport and leisure facilities
		121	Industrial or commercial units
		123	Port areas
		124	Airports
20**	Forest in urban areas	141	Green urban areas

22	Forest in semi urban areas	141 142	Green urban areas Sport and leisure facilities
23	Grass in urban areas	133 141 142	Construction sites Green urban areas Sport and leisure facilities
28	Grass in semi urban areas	124 131 132 133 141 142	Airports Mineral extraction sites Dump sites Construction sites Green urban areas Sport and leisure facilities

Converting fresh water into CLC classes

The LGN maps show the class fresh water. The 'conversion table', based on Table 18.6 of Hazeu (2014), suggests to use the CLC class water courses for the LGN class fresh water. However, there are also water bodies in Berg en Dal. For practical reasons, in the land-cover maps each LGN class is converted to one CLC class. The class water courses is used on the maps, because the Waal river has slightly more surface area than the remaining fresh water in Berg en Dal. In further analysis a correction is made to distinguish the surface area of water courses and water bodies and the potential supply thereof.

Distinguishing between water bodies and water courses

The dataset is made more accurate through separating the CLC classes 'water courses' and 'water bodies', which are originally together in one category (see Section 2.3.3.). The surface area of the Waal river within the municipality of Berg en Dal is determined, using a water type layer file based on 2008 (*Watertypekaart*, 2008).

The water type layer is a polygon layer with polygons for the different water surfaces/surface types in the Netherlands in 2008. The layer was cut to the case study area of Berg en Dal. The water type layer was compared to LGN6 of 2007. The total water surface in Berg en Dal as depicted in both layer files is comparable: 7,246,368m^2 in the water type layer and 7,300,625m^2 in LGN6. Also, the water bodies overlay well in the maps; no significant dissimilarities are observed.

The water layer file includes five distinct classes of water surfaces present in Berg en Dal. Following the CLC classification system, the class langzaam stromende rivier (translated: slowly streaming river) should be classified as the CLC class water courses, whereas the other classes should be water bodies. There are five polygons with the classification slowly streaming river and these all belong to the Waal river in the north. One polygon covers the largest part main stream, whereas the other four cover small pieces which are cut off of the main stream on the map.

The Waal river looks very similar on the five LGN maps and has approximately the same surface area in the maps. Of the five polygons that are classified as slowly streaming river, three polygons are present on all five LGN maps. Polygon 329 and 359 are small and it is unclear if these river parts are present on the different LGN maps. Concluding, the slowly streaming river polygons of the water type layer are not a perfect match with all LGN versions. However, using their combined surface area for the CLC class water courses and the rest of the fresh water surface of the LGN maps for the CLC class water bodies leads to an improved accuracy of the data set.

The total surface area of slowly streaming river in Berg en Dal in the water layer file is 3,098,627m^2 and this surface area is used as the area of the CLC class water courses in further analysis. Table9 shows the surface areas of sweet water of the LGN versions and the surface areas of water courses and water bodies in the different LGN versions that are used in further analyses.

Table 9: Surface area of sweet water in LGN maps and surface areas of the CLC classes water courses and water bodies as used in further analyses.

	Surface area (m^2)				
LULC class	LGN3plus	LGN4	LGN5	LGN6	LGN7
Water courses (CLC class)	3098627	3098627	3098627	3098627	3098627
Water bodies (CLC class)	3987623	3884498	3866998	4201998	4422623
Total fresh water (LGN class 'fresh water')	7086250	6983125	6965625	7300625	7521250

(Semi) urban built-up areas

The LGN classes 18 and 19 are used for built-up areas. CLC distinguishes built-up areas, which makes that classes 18 and 19 can correspond to discontinuous urban fabric, industrial or commercial units, port areas or airports, and additionally for class 19: sport and leisure facilities. LGN does not distinguish between different types of buildings or built-up areas in the same way as the CLC system does.

For the classes 18 and 19 the corresponding class 112 discontinuous urban fabric was used. Sport and leisure facilities and industrial or commercial units do occur within the LGN classes 18 and 19, but the assumption is used that discontinuous urban fabric takes up more surface area than the other two mentioned classes. Port areas and airports do not occur in Berg en Dal.

Grass and forests in (semi) urban areas

For the classes 22, 23 and 28, the conversion table includes several options, of which green urban areas and sport and leisure facilities are expected to take up the largest surface area. Construction sites, mineral extraction sites and dump sites may occur on areas classified as grass in (semi) urban areas, but I assume that their surface areas are relatively small compared to the surface area of the classes 23 and 28.

Green urban areas and sport and leisure facilities are classes that contain a wide array of more specific land-use types. The definition of green urban areas is: *'Areas with vegetation within urban fabric. This class is assigned for urban greenery, which usually has recreational or ornamental character and is usually accessible for the public'* (Kosztra & Arnold, 2014). According to the definition and further explanation the CLC class green urban areas would include the LGN classes forest in urban areas and grass in urban areas. However, forests and grass in semi urban areas would not fall under green urban areas, because these are not situated within urban fabric. These two categories can be classified as sport and leisure facilities, which '*is assigned for areas used for sport and recreation purposes'*, with the given examples of: *'Camping grounds, sports grounds, leisure parks, golf courses, race-courses etc., formal parks not surrounded by urban areas*' (Kosztra & Arnold, 2014). These conversions of LGN classes to CLC classes are in line with the conversion table of Hazeu (2014).

However, the LGN categories for forests and grass in (semi) urban areas are different for the different LGN versions (see section 2.4.2.), which makes it difficult to distinguish between urban and semi urban areas. For forest and grass in (semi) urban areas, in LGN3plus/4/5 no distinction is made between urban and semi urban area, whereas this distinction is made in LGN6/7.

Using the same classification system for all maps enables comparison of land use and potential supply of ESs among the different maps. Therefore, in this study it is best to use the same CLC class for all forest in (semi) urban areas classes and the same CLC class for all grass in (semi) urban areas. Following from Kosztra and Arnold (2014) and

Hazeu (2014), the classes green urban areas and sport and leisure facilities can be used. Visual evaluation of the LGN maps is performed and the surface areas of the LGN classes are considered to determine which CLC classes to use.

From LGN3plus to LGN4 and from LGN4 to LGN5 there are small increases in the surface area of grass in urban areas. The surface area of grass in (semi) urban areas on LGN6 and LGN7 is much larger than on LGN5, which is mostly a result of the fact that the LGN6 map is more detailed. Surface area that was previously, in LGN3plus/4/5, classified as urban built-up area only, is now more accurately classified as urban built-up area interspersed with grass in urban areas. In LGN6, there are two relatively large areas near the floodplains newly classified as grass in semi urban areas, which are classified as natural grasslands and bare soil in LGN7. In these areas the land-use type has probably changed due to landscape development. Therefore, at the time of LGN6, they may have been used as construction sites or dump sites.

There is a golf course in the area, Golfbaan Het Rijk van Nijmegen, which was classified as grass in semi urban areas in LGN3plus/4/5 and as grass in semi urban areas with patches of forest in semi urban areas in LGN6/7. The golf course has a relatively large surface area and its size remains relatively stable from LGN3plus to LGN7. Judging from LULC maps, the golf course may have increased in size, but it is unclear if this is the case and how the land was used before the change. The possible increase in area size relatively small compared to the whole golf course. Golf courses should be classified as sport and leisure facilities (Kosztra & Arnold, 2014).

The current study aims to analyse changes in land use and the effects thereof in terms of potential supply of ESs. Changes in grass in (semi) urban area are largely a result of different classification systems used. In LGN3plus/4/5 all grass in (semi) urban areas is classified in the same category and most of the surface area is located outside urban areas. In LGN6 and LGN7, grass in urban areas has a larger surface area than grass in semi urban areas. As mentioned, a large part of this surface area is used as a golf course which is relatively stable in size. Based on these facts, I chose to use the class green urban area for grass in semi urban area and for grass in urban area.

Concerning forests in (semi) urban areas, Hazeu (2014) suggests to use the class green urban area for forest in urban areas, whereas forest in semi urban areas can be classified as green urban area and as sport and leisure facilities. To choose between these categories, the potential supply values given by Burkhard et al. (2014) for the ESs that are considered in this study (see Section 3.2.) are considered. These values show that green urban areas have a wider variety of ESs they can supply, whereas sport and leisure facilities have a more narrow variety, but have a maximum potential supply of recreation and tourism. The potential supply values of broad leaved and coniferous forests are relatively high for regulating and cultural services, including the ESs that are used in this study. Green urban areas generally have higher potential

supply values than sport and leisure facilities and this seems more accurate for forest in (semi) urban areas, therefore I chose to use the class green urban areas.

Annex 5: Developments in governance of nature and landscape from 1995 to 2015

Here an overview of the identified developments in governance of nature and landscape from 1995 to 2015 is given. Developments that occurred on all governance levels are included: from international governance to local governance. This overview does not necessarily include all developments in governance that occurred, merely the developments that were found to be relevant.

New engagement of the EU in nature policy

The EU already introduced the Bird Directive (Vogelrichtlijn) in 1979, but became more influential in the second half of the 1990s. The Habitat Directive (Habitatsrichtlijn) was introduced in 1994, after which the EU demanded that the Bird Directive and Habitat Directive got properly integrated into Dutch legislation. Pressured by the EU, the directives were incorporated into the revised *Natuurbeschermingswet* (Nature Protection Act, 1998) and the revised *Flora- en Faunawet* (Flora and Fauna Act), in respectively 2005 and 2002. The Natuurbeschermingswet protects specific habitats and the Flora- and Faunawet protects specific species. (Arnouts, 2010)

New engagement of non-governmental actors in nature management

In 2000, a successor to the NBP is presented, in which the EHS is presented as a success (Arnouts, 2010). Additionally, the Ministry of Agriculture, Nature and Fisheries *'wants to increase the involvement of the general public and new non-governmental actors and calls for a more integral approach, acknowledging that nature has a much broader societal function, for example as living environment, recreational facility or economic commodity.'* (p. 7 in Arnouts, 2010) Around that time, a transition takes place in the form of governance: it changes from focusing on purchasing existing natural areas to engaging non-governmental actors in nature management (Arnouts, 2010). This change in governance comes forth of difficulties with the implementation of EHS. Agrarians and land-owners refused to sell their lands and were reluctant to engage in nature management activities (Boonstra, 2004; in Arnouts, 2010).

Programma Beheer (2000)

In 2000 the subsidy scheme Programma Beheer (Management Program: PB) that formally recognized farmers and private owners as nature managers was implemented (Arnouts, 2010; Wiertz et al., 2007). Through PB public and private nature managers could obtain subsidy for the maintenance of nature, agricultural nature and landscape. In 2010, the SNL replaces Programma Beheer.

Water Framework Directive (WFD) (2000)

In 1980 the first binding quality targets for drinking water were set by the EU. From 1988 onwards, the European Commission was pressured to fundamentally change the EU water policy and to take a more global and integrative approach. An extended consultation process led to the conclusions that '*the current water policy was fragmented'* and that there was a '*need for a single piece of framework legislation to resolve these problems*'. In response, the Water Framework Directive (*Kaderrichtlijn Water*: WFD) was proposed and was implemented in 2000. (Source: http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm, accessed on: 23-06-2017.)

The aim of WFD is to achieve that all surface waters and groundwater are of good quality by 2015. Water will be managed per river basin, the geographical and hydrological unit, and a combined approach of emission limit values and quality standards will be used. (Source: http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm, accessed on: 23-06-2017.)

Another key aim of the WFD is to extent public participation. On the basis of this is the realisation that the interests of various groups need to be balanced and therefore the affected people need to be involved in the process. Transparency throughout the process also contributes to better results. (Source: http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm, accessed on: 23-06-2017.)

Nationaal Bestuursakkoord Water (NBW) (2003)

In 2003 the Nationaal Bestuursakkoort Water (translated: National Management Agreement Water, NBW) is implemented. In line with the WFD, the NBW has the aim of organising the Dutch water system until 2015 and improving cooperation between involved parties. NBW uses an approach in which separate visions are created per sub stream area, following the approach of the WFD. The visions are established in cooperation of all involved parties. An integral approach is used in which is considered whether the new vision and plans are in line with other provincial policy plans or regional plans. The NBW is made in concordance with Ruimte voor de Rivier, which is discussed next. ("Het Nationaal Bestuursakkoord Water," 2003)

Ruimte voor de Rivier (implemented: 2009 – 2015)

Ruimte voor de Rivier is a program that aims to increase safety in the river area and to make the area more attractive as living environment. At over thirty places along offsets of the Rhine reconstructions take place to give more space to the river. The program was prepared from 2004 to 2006, the plans were made from 2006 to 2009 and it was implemented from 2009 to 2015. The program is initiated by Rijkswaterstaat and is executed through a cooperation between provinces, municipalities, water boards and Rijkswaterstaat. (Source: https://www.ruimtevoorderivier.nl/over-ons/, accessed on: 13-11-2017.)

Nota Ruimte and the establishment of National Landscapes (2004)

The Nota Ruimte is established by the Ministry of VROM in 2004 and it is focused on landscape development decentralisation of landscape management. The Nota Ruimte introduced the concept of National Landscapes, which are attractive landscapes that are of high value for het recreational industry (source: https://gldanders.planoview.nl/planoview/admin/viewer/default, accessed on: 26-06-2017). The Nota Ruimte includes rules concerning the conservation and further development of the landscapes that are designated National Landscapes. The National Landscape Gelderse Poort, which is situated in Berg en Dal, was established in 2005.

Nationaal Waterplan (2009-2015)

Nationaal Waterplan (National Water plan) was established in 2009 for the time period of 2009 to 2015 and it replaced de Vierde Nota Waterhuishouding from 1998 and all previous additional notes about water management. Nationaal Waterplan is based on the Waterwet that goes into force in 2009. Nationaal Waterplan has the status of structure vision concerning the spatial aspects that are included. (Source: https://www.rijksoverheid.nl/documenten/rapporten/2009/12/01/nationaal-waterplan-2009-2015, accessed on: 10-07-2017.)

Subsidiestelsel Natuur- en Landschapsbeheer (SNL) (2010)

Subsidiestelsel Natuur- en Landschapsbeheer (translated: subsidy scheme nature and landscape management, SNL) is a subsidy scheme through which provinces grant subsidies for nature management in places where the nature contributes to the EHS or Nature Network. SNL came into effect in 2010 and it replaces Programma Beheer. New in SNL is that the provinces have determined in which areas and for which specific nature development and management activities they will grant the SNL subsidies. Each province has created a Natuurbeheerplan (Nature management plan) in which the specific requirements are given. (Source: http://www.portaalnatuurenlandschap.nl/themas/subsidiestelsel-natuur-en-landschapsbeheer/over-het-subsidiestelsel-natuur-en-landschapsbeheer/, accessed on: 27-06-2017.)

In SNL, there are three distinct grants: Natuurbeheer (SNL-N) for nature management in a natural area; Agrarisch natuurbeheer (SNL-A) for management of nature on agricultural lands; and Kwaliteitsimpuls (Quality impulse: SKNL) for realising nature, increasing the quality of existing nature or for changing land function from arable land to nature. For selected areas the province has determined that the management plans need to be coordinated by a local coordinator. In those areas it is only possible to participate in a collective management plan.

Natura 2000 network by EU (2011)

In 2011, the EU introduces a new strategy to protect biodiversity: Natura 2000, a European network of natural areas in which important flora and fauna occur, from a

European perspective. Natura 2000 comes forth of the European Bird Directive and Habitat Directive and in the Dutch legislations, Natura 2000 is incorporated in the revised Natuurbeschermingswet of 1998. (Source: http://www.natura2000.nl/pages/wat-is-natura-2000.aspx, accessed on: 22-06-2017.)

Decentralisation of nature management

Decentralisation of nature policy took place from 2010 to 2014. Many involved parties agreed that nature policy had been too much focused on protecting internationally important species and habitats and that consequently the societal side of nature had been undervalued. A new approach was needed that considered the human experience of nature, including the effects of nature on happiness, health and economic well-being. Decentralisation allows for combining regional nature with other societal development goals. A regional approach allows local knowledge about the current challenges and the stakes of involved actors to be used to determine optimal solutions.

Since nature policy was seen as a regional responsibility, the State and the provinces signed an act to decentralise nature policy in 2011 (source: http://www.ipo.nl/beleidsvelden/natuur, accessed on: 22-06-2017).. The formalisation of this act resulted in the Natuurpact in 2013, which '*can be seen as the closing piece of the decentralization*' (*translated*) (source: http://www.ipo.nl/beleidsvelden/natuur, accessed on: 22-06-2017). Through the Natuurpact, the State and the provinces agreed to establish 80,000 ha of nature until 2027 (Source: http://www.ipo.nl/beleidsvelden/natuur/ontwikkelopgave-ecologische-hoofdstructuur-ehs, accessed on: 22-06-2017.). From 2014 onwards the provinces are the first responsible authority of the EHS or Natuurnetwerk Nederland (Nature Network), whereas before the State was responsible (source: https://www.groeneruimte.nl/dossiers/ehs/home.html, accessed on: 22-07-17.).

Structuurvisie Infrastructuur en Ruimte (SVIR) (2012)

In 2012 the State published the Structuurvisie Infrastructuur en Ruimte (Structure Vision Infrastructure and Space: SVIR) in which plans for infrastructure and space are set out. The State aims to improve policy regarding spatial planning and infrastructure through handing over responsibilities to the provinces and municipalities. The State narrows its focus to 13 specific national interests, whereas the regional authorities get more responsibilities and thereby freedom in implementation. This is a clear example of decentralisation. ("Structuurvisie Infrastructuur en Ruimte," 2012)

Concerning nature and landscape, important developments were: The State hands over responsibility for the policy regarding landscape on land to the provinces, including the responsibility of the National Landscapes the Nature Network, which is a renewed version of the EHS. The provinces should prioritize the international obligations that come forth out of the Natura 2000, WFD and protected species. The State aims to only intervene when a province is negligent in realising international goals. The State now legally protects UNESCO world heritage sites, including the

Limes which are situated in Berg en Dal, and which were part of the National Landscape Gelderse Poort. ("Structuurvisie Infrastructuur en Ruimte," 2012)

The approach to the EHS or Nature Network has changed. The distribution of species will occur via semi-natural elements in agricultural fields and other private lands. The State aims to provide subsidies to land-owners who contribute to the connectedness of natural areas. To this end, the Common Agricultural Policy gets renewed to include these subsidy opportunities. The State also aims to solve conflicts between infrastructure and the Nature Network. In the realisation of the Nature Network other stakes will be taken into account, including the recreational value, cultural historical value and the contribution to the goals of the WFD.

The policy paper Kiezen voor Karakter, Visie erfgoed en ruimte (*Choosing for Character, Vision heritage and space)* is an addition to SVIR, in which the state advocates: to conserve and strengthen the cultural, historical character of the Netherlands on a regional scale; and to connect the care for cultural heritage to other spatial issues that have to do with the economy, safety and sustainability. This approach is not merely focused on conserving cultural heritage, but it is a more regional approach in which the character of the region is central. ("Achtergronddocument LOP 2015-2024," 2015)

Ecological Focus Area in CAP (2014)

From 2014 onwards CAP includes a green direct payment, which is granted to farmers who: diversify crops; maintain permanent grassland; and use 5% of the farm area as an Ecological Focus Area (EFA). Additionally, requirements concerning environment and animal friendly operation, the cross compliance, need to be met. Although these regulations are relevant for the landscape, there are so many exceptions to the rules which causes that in the Netherlands most farmers do not have to establish EFAs to obtain the green direct payment. Therefore, in Berg en Dal the change in CAP is not expected to lead to changes in landscape. ("Achtergronddocument LOP 2015-2024," 2015)

Omgevingsvisie of the province of Gelderland (2015)

The province of Gelderland established the Omgevingsvisie (*Environmental vision*), in which is written which aims and qualities of the landscape are important in Gelderland and should be taken into account in development of the landscape. The addressed themes are: transportation, water, nature, environment and spatial planning and the most important goals are working towards a sustainable economy and a safe living environment of high quality (source: https://www.gelderland.nl/omgevingsvisie, accessed on: 22-06-2017). The Omgevingsvisie contains the general aims and the associated document the Omgevingsverordening (*Environmental regulations*) sets rules for the implementation.

The Omgevingsvisie and Omgevingsverordening came into effect on January 14, 2014 and they integrate and replace five separate plan documents that were in effect until then (Bijlage I, "Achtergronddocument LOP 2015-2024," 2015). The content of the Omgevingsvisie is created in collaboration with inhabitants, businesses and the water boards (source: https://www.gelderland.nl/omgevingsvisie, accessed on: 22-06-2017). One of the purposes is to encourage participation of stakeholders, private and public, to contribute to a sustainable economy and to the quality and safety of the living environment (Bijlage I, "Achtergronddocument LOP 2015-2024," 2015).

The Omgevingsvisie and Omgevingsverordening provide a binding framework within which the municipalities in the province can operate. Municipalities use a 'bestemmingsplan', which is a destination plan in which for the whole surface area of the municipality the purpose is registered. This destination plan includes rules about the ways in which certain buildings or ground areas can be used and where (re)constructions can take place. The destination plan is binding for everyone, e.g. companies, institutions, inhabitants and the municipality. (Source: https://www.bergendal.nl/inwoners/bestemmingsplannen_45797, accessed on: 22-06-2017.)

The Omgevingsvisie includes the following valuable areas that are defined in Berg en Dal: Gelders Natuurnetwerk (GNN); Groene Ontwikkelingszone (GO); Ganzenfoerageergebied; Nationaal Landschap Gelderse Poort; Waardevol open gebied (Valuable open area); Romeinse Limes; Natte landnatuur; Beschermingszone natte natuur; HEN-wateren; SED-wateren; Zoekgebieden nieuwe natuur ("Achtergronddocument LOP 2015-2024," 2015; Gelderland, 2014). These areas are considered to be valuable because of landscape characteristics, including present species and cultural heritage. For these areas rules are established about which developments can take place and which developments are prohibited.

Waardevol open gebied is an area in which openness of the landscape is regarded as a valuable characteristic that should be sustained (source: https://gldanders.planoview.nl/planoview/admin/viewer/default, accessed on: 26-06-2017). Consequently, there are strict rules about developments in this area, including the prohibition of placement of new buildings and high landscape elements.

General trends in regulations concerning agriculture

A general trend in regulations about agriculture is an increase in administrative tasks for farmers. Administration and planning has become required for: the amount of livestock animals present on the farm, the amount and handling of fertilizers and manure, the use of pesticides and the amount of medicines used. Especially manure regulations have become more strict because of environmental reasons. The overall feel among farmers is that the requirements become more strict and that this is not always useful. The required digital administrative tasks regularly change, e.g. the exact methods or programs that are used, as a result of which farmers have to invest time in

learning how to comply. Most farmers will dislike these developments, since they prefer to work on their farm instead of performing additional tasks that are meant to check whether they are doing their job well.

An additional comment is that many regulations are implemented from the top. This results in the fact that farmers are checked and corrected by employees of instances that are physically and psychologically far from the farm. This leads to a one-sided, impersonal way of communicating.

Developments in governance that occurred after 2015

Wet natuurbescherming

From January 1, 2017, onwards the new Wet natuurbescherming (translated: Law nature protection) protects natural areas and animal and plant species. The Wet natuurbescherming replaces the Flora- en faunawet, de Natuurbeschermingswet 1998 and the Boswet (translated: Forest law). The aim of this development, replacing three separate laws by one law, is to simplify the rules and thereby making the law easier to apply. According to the Wet natuurbescherming the provinces now determine what is and is not allowed in natural areas. The State remains responsible for the policy regarding large surface waters and international policy. (Source: https://www.rijksoverheid.nl/onderwerpen/natuur-en-biodiversiteit/wetgeving-voor-natuurbescherming-in-nederland, accessed on: 28-06-2017.)

Nationale Omgevingswet and Omgevingsvisie 2019

From 2019 onwards a the Nationale Omgevingswet (translated: National Environmental Law) will be in place. Along with this law, the Nationale Omgevingsvisie will be established, in which a national environmental vision is presented. This vision will include the aims of realising: a sustainable economy, climate resistant and climate neutral society, sustainable living and working environment, and a valuable living environment. The State recognises that using an approach in which these themes are addressed in an integrated way can be beneficial. In the process of establishing the Nationale Omgevingsvisie, provinces, municipalities, water boards, companies and institutions are involved. (Source: https://www.rijksoverheid.nl/onderwerpen/omgevingswet/nationale-omgevingsvisie, accessed on: 07-07-2017.)