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The Road Towards a More Sustainable Flower Bulb Sector in the Duin- en Bollenstreek

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ACCEZ Accelerating Circular Economy Zuid-Holland

greenport DUIN- EN BOLLENSTREEK

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Preface

Sustainability Challenge

This research report has been written by students following the master's programme Governance of Sustainability at Leiden University. Within this programme, the Sustainability Challenge course challenges students to come up with real-life practical solutions for a sustainability problem. The project is commissioned by an external party and supervised by an assigned supervisor. Coming from different academic backgrounds, students are trained to cooperate in an interdisciplinary team and integrate perspectives from both environmental science and governance studies. In order to fulfill the commissioner's deliverables, they are expected to work with relevant stakeholders in the field. The group ultimately presented the findings of this final report to the commissioner and supervisor.

Commissioners

Greenport Duin- en Bollenstreek is a regional cooperative cluster consisting of local governments, producers, education and knowledge institutes with the aim to support a healthy and sustainable horticulture sector in the Duin- en Bollenstreek region.
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The Greenport Hub is a Circular Innovation Hub within the Centre for Sustainability which is part of the strategic alliance between the Leiden-Delft-Erasmus universities. In these hubs, researchers, students and other stakeholders work on sustainable development by linking the academic world with the horticulture sector in South Holland.
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https://www.centre-for-sustainability.nl/the-greenport-hub

ACCEZ Project accelerates the circular economy in the province of South Holland. It does this by finding concrete answers for complex issues requiring a lot of knowledge. ACCEZ combines policy, science and business and is collaborating with the Leiden-Delft-Erasmus universities, Wageningen UR, VNO-NCW and the Province of South Holland.
https://accez.nl

Supervisor

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Executive Summary

The Dutch flower bulb sector is of major importance to the Dutch economy. It delivers around 60% of global supply and controls about 85% of international trade. In addition, the flower fields are considered a cultural landscape and bring in millions of tourists every year. At the same time, the sector is under stress due to its high environmental impact. One of the implications of the current production process is the high usage of chemical pesticides and artificial fertilizers. Chemical residue and nutrient run-off leach into the soil and water bodies, leading to soil degradation, aquatic pollution, and biodiversity loss. Furthermore, land-use change in the form of fragmentation constitutes an important environmental pressure leading to biodiversity loss and general ecological disbalance. For the Dutch bulb sector to maintain its production license and world-leading market position, it needs to become less harmful to the environment. This report focuses on the Duin- en Bollenstreek, which is the traditional centre of bulb cultivation in the Netherlands. It developed a sustainable vision for the sector and provides a roadmap on what is needed from which stakeholder to get there.

The vision we constructed is situated between the two extreme approaches found in our interviews. However, by adding our own elements and synthesizing all the different perspectives into one integrated whole, we argue that this vision is more than just the sum of its parts. It calls for broad system change, restoring the disrupted balance between economic and ecological interests. Maintaining our leading market position means that efficiency should be drastically improved, using less inputs in the form of chemicals, nutrients and land. Focus is on high-value added elements in the production chain with low environmental impact. Part of the production process is moved inside to greenhouses. Open soil cultivation remains concentrated in the Bollenstreek, acknowledging the cultural and touristic value of blooming flower fields. Chemicals remain necessary for an efficient production system, but these are only applied where and when specifically needed.

We developed a roadmap working towards this vision by listing concrete steps needed to be taken. These steps are clearly mapped specifying when it needs to be initiated and which stakeholders should be involved. The long term comprises three pillars that only work if executed simultaneously.

The first pillar is on clean starting material. Less dependence on chemicals starts with the development of more robust and resilient cultivars. When all growers start with clean starting material, the bulbs are practically guaranteed to be virus-free. This means it will be almost impossible to get new infections caused by transmission. We propose to introduce regulations that set a limit on the amount of virus allowed on the field. In order to keep the process efficient and profitable, the juvenile phase

should be shortened and multiplication speed increased by working with tissue culture. When in the future genetically modified bulbs are allowed, bulbs could grow fully resistant to diseases. As this raises an obvious ethical question, strict regulations and further research is required.

The second pillar is on closed production systems. In this new system, cultivation moves from fully open soil towards a partly closed system. In the first growing phase, cultivation is done in greenhouses. As this is a nearly closed system, both chemical usage and residue leakage is controlled and minimized. Furthermore, organic pesticides are more effective inside. Only in its final year, the clean bulb is transposed to open field where it can grow to the desired size. This last phase is concentrated in the Bollenstreek, as flower fields are key for the region's identity.

The third pillar is about introducing stricter regulations for open field cultivation. With the former two pillars in place, a minimal amount of chemicals will be needed on the field. The remaining pesticide application uses techniques from precision agriculture. When a disease emerges, drones can specifically target affected plants. Robots are developed that detect viruses, using artificial intelligence and machine learning. Sustainability scores are awarded to producers based on environmental impacts, such as soil health. Currently, consumers pay indirectly for artificially low priced flower bulbs via municipal and water board taxes. In the future, negative externalities are accounted for more directly in the price. This motivates growers to improve their environmental standards. Growers use systems that allow them to degrade pesticide residues by themselves. Furthermore, lots of research is done on removing phosphate from manure and water. Research into these and other technological innovations should be subsidized as of now in order for them to be widely used in the long-term.

This implies that before we can reach these long-term solutions, a solid foundation has to be built. This report provides readily enforceable actions and policy recommendations that will enable broad system change in the long term. Mandatory research cooperation in the sector will have to take place immediately containing all growers and research institutes that work together in finding sustainable alternatives for production techniques in which knowledge sharing becomes a central support base. Also, in the short term, it is required that the ministry of Agriculture, Nature and Food Quality invests in pilot projects that experiment with technological innovations making the transition from conventional to organic and closed system farming financially feasible.

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1. Introduction

1.1 Problem Introduction

The worldwide flower bulb industry has its roots in the Netherlands. The country delivers around 60% of global supply of flower bulbs, and its trading companies account for about 85% of the international trade in bulbs. The flower bulbs are produced on 27.220 ha of land in several regions of the Netherlands (CBS, 2019b). The Dutch provinces of North and South Holland, Drenthe and Flevoland are the largest production areas. The Netherlands' central location makes it Europe's core for the bulb market industry (Sooke, 2016). In addition to the (global) economic significance of the bulb sector for the Netherlands, flower fields are attributed high symbolic value and are considered a cultural landscape. Furthermore, millions of tourists visit the ''Bollenstreek'' every year to admire the fields in their full glory. The Netherlands produces high quality flower bulbs. However, behind this beautiful product, many chemical pesticides and artificial fertilizers are used in the production process to battle viruses and unwanted weeds. Notwithstanding the remaining environmental impacts of chemicals and fertilizers, the sector has decreased its usage of pesticides by more than 80% since 1995 by using resources that are less harmful for the environment (KAVB, 2019). The KAVB, which is the sector organisation, is even aiming to go further than the standards set by the government. Easy wins have already been achieved. However, the road to decrease pesticides even more comes with big challenges for the sector. Importers demand higher standards than ever, but also domestic consumers will only buy the most perfect blooming flower. Furthermore, increased land use to accommodate this still growing sector is putting more and more pressure on the environment. For the Dutch bulb sector to maintain its production license and world-leading market position, its environmental impact needs to decrease further.

1.2 Problem Statement

Flower bulb cultivation has a high environmental impact. The relative high usage of chemical pesticides and artificial fertilizers, in combination with land use pressures in the form of fragmentation, leads to significant environmental degradation. Most importantly, this includes soil degradation, aquatic pollution, and biodiversity loss (Askari-Khorasgani & Pessarakli, 2019). Numerous sustainable visions exist; both from within the sector as from different layers of the government, but these lack concrete implementation plans. The interests and ideas of producers are not sufficiently considered in the policymaking process, hampering progress towards more sustainable production.

Furthermore, regulation often goes faster than producers can handle. This sometimes leads to the situation where a highly toxic mix of allowed pesticides is used

multiple times in higher dosages to attain the same effect of a single prohibited chemical.

The final problem within the sector is that the switch to fully organic bulb cultivation where no artificial fertilizers and chemicals are used, does not seem to be profitable.

1.3 Environmental Pressures

Sustainability in the context of flower bulb farming consists of various parts and processes. For this research, we focus on the following environmental pressures:

1) **High usage of chemical pesticides and artificial fertilizers** in most phases of the production process, in order to guarantee disease and plague-free bulbs that meet the high quality standards of export markets. Chemical residue and nutrient run-off leach into the soil and water bodies, leading to soil degradation, aquatic pollution, and biodiversity loss.
2) **Land-use change in the form of fragmentation** constitutes an important environmental pressure leading to biodiversity loss and general ecological disbalance.

Sustainability in our definition also includes feasibility because sufficient financial incentives should be available to growers in order to make a switch to new production methods. With this we emphasize that risk takers when it comes to sustainable production techniques should be awarded, and that the responsibility of producing more sustainable should not only be a challenge for the growers.

Governance is another crucial part in the road to more sustainability. We define this concept as an attempt to solve societal problems by a collaboration of both public and private actors (Runhaar et al., 2017). Thus, it goes beyond mere public policy and governmental actors, but it includes a myriad of societal stakeholders who participate in the policy process.

1.4 Demarcation of Research

Led by our problem statement and definition of sustainability, this report focuses on certain parts of the production chain where we think most gains can be made. In short, what sustainable sector interventions can take place to decrease environmental pressure? Which policies and tools should be put in place to enable broad system change to happen? And in which elements of the production chain could new technological innovations make the sector more sustainable in the long term?

Based on our research, the following areas have been identified that are particularly stressful to the environment, and/or where new methods and technological innovations provide major opportunities to make the sector more sustainable.

- Breeding
- Cultivation in the Netherlands
- Processing & Storage

As described in the previous section of this report, the roadmap to a more sustainable flower bulb sector will focus on pollution by excessive pesticide, fertilizer leakage, and land use. We do not focus on stressors like emissions, energy use, and water use because these aspects are not identified as a major problem in bulb cultivation in the Netherlands (Eerdt et al. 2014). Furthermore, this research has a regional scope on the area ''de Bollenstreek'' in the Netherlands (see Annex 1). The interviewees for this research are selected based on conversations with the commissioners of this project and are therefore defined by them as main stakeholders of this study.

1.5 Research Questions

Our commissioners provided us with the following research question:

''What does a sustainable bulb production sector look like in the "bollenstreek" and what is needed from producers and policymakers to achieve that?''

Our main question will be answered by the following sub-questions:

1) How does the sector currently look like and what are the bottlenecks in the production chain in terms of sustainability?
2) What is our vision on a sustainable flower bulb sector?
3) What can improve in the implementation of policies governing the sector, in order to realize our vision?
4) What alternative interventions within the sector can contribute to realizing our vision?

1.6 Reading Guide

This paper proceeds as follows. The second chapter will describe the backcasting methodology steps taken in this study. This is followed by a chapter contextualizing the Dutch flower bulb sector. Chapter 4 describes existing visions for a sustainable bulb sector, our interviewees visions, followed by our own constructed vision. Chapter 5 gives an overview of policy implementation issues governing the sector and chapter 6 looks at alternative sector interventions within the sector. This is followed by our roadmap with short and long term solutions to working towards realizing our vision. We conclude with an extensive discussion on the most important findings and limitations of our research.

2. Methods

In the previous section we provided our research questions. In this section, we will set out in more detail how we answered these questions. With the research questions, we aim to think about what a sustainable flower bulb sector might look like and how we can get there. This will be based on existing visions and ideas, complemented with our own thoughts, based on interviews with experts and insights from (academic) literature. A major challenge in this process is to make sure we provide new insights. If we solely rely on what we hear from insiders or read in policy plans, we will end up with solutions that already exist. Therefore, we use backcasting as our main methodology. It is a normative approach that sets out what is required to achieve a desired outcome. The main advantage of this method is that it starts with a vision, and then the steps towards this vision are constructed (Vergragt & Quist, 2011). Thus, one is more likely to find creative, out of the box solutions instead of building upon current paradigms.

In the next sections, we discuss how the backcasting approach works and how our research questions are embedded within this approach. After that, we will discuss the data selection and how we analysed this data.

2.1 Research Design: A Backcasting Approach

Our main research question consists of two parts. First, we need to envision what a sustainable flower bulb sector looks like. Second, it requires us to identify specific steps both producers and policy-makers can make in order to achieve this. This fits very well within the backcasting methodology, in which one constructs a desired vision and designs solutions and interventions to realize this vision. This, combined with the advantages of starting at a desired endpoint, makes backcasting a well-suited approach for our study. The backcasting approach requires several steps, as outlined by Quist and Vergragt (2006, p.1033). These steps are designed for participatory backcasting, in which stakeholders involvement plays a major role. Our design will involve less stakeholder involvement due to reasons of scope and feasibility. In our research, stakeholders will give input to the process, but will not be participating themselves. Nonetheless, the steps provided by Quist and Vergragt can still give us some guidance as to how we approach our study.

First of all, they suggest that one needs to orient on the problem and develop a vision. This will be a normative vision, on how we think the flower bulb sector should look like. It will be based on several elements. First of all, as Holmberg and Robėrt (2000) propose, we define what we mean with the concept of sustainability. We establish some basic principles of what we think defines sustainability. These are the

basis of our vision and identify desired endpoints. To make them more concrete, we need to know which of these principles are currently lacking in the sector. Thus, we have to find out what the flower bulb production sector currently looks like, and what the problem areas are regarding our definition of sustainability. Thus, we are answering subquestion 1 (*How does the sector currently look like and what are the bottlenecks in the production chain in terms of sustainability?*).

With this, we have the backbone of our vision: The basic principles of a sustainable flower bulb sector. We also need to know in what way we can organise the production process to comply with these principles. We identified several alternative sustainable production systems based on input from relevant stakeholders. We have asked them how they define and foresee a sustainable flower bulb sector. We derived an alternative production system, a hybrid of the alternatives our stakeholders provided, that enables the sector to produce flower bulbs that comply with our principles of a sustainable sector. Finally, we have looked at existing visions. An important note is that we did not summarize or put together all existing visions. They merely provide context and inspiration. We used them to determine whether our vision is realistic and to make sure it does not deviate too much from existing ideas. This together forms our vision on a sustainable flower bulb sector and thus answers subquestion 2 (*What is our vision on a sustainable flower bulb sector?*).

The next step that Quist and Vergragt (2006) mention is the actual backcasting. This means identifying what is needed to realize the vision. They do not specify how to go about this process. Mander et al. (2008, pp. 3759-60) do provide some practical insights. They approach the actual backcasting in three steps. They identified some general critical factors in their visions, being the changes needed to bring about the vision. Then they proposed measures specific to their case to address these critical points. Finally, they find out what policy changes are needed to support these measures. In our report, we will follow a similar logic. Once we have established our vision, we know what the critical points are, since we have determined these in building our visions. First, we will study how policy, and more specific policy implementation, can be improved to support our vision. This will be based on both literature as well as stakeholder interviews. With this, we answer our subquestion 3 (*What can improve in the implementation of policies governing the sector, in order to realize our vision?*).

Next to that, we will look at what specific alternative ideas and practices can be implemented by the sector itself to realize the vision. These practices and ideas will be merely based on stakeholder interviews. With this, we answer subquestion 4 (*What alternative interventions within the sector can contribute to realizing our vision?*).

With this information, we can perform the final step: building a roadmap towards our vision. This roadmap contains interventions that can be applied on both the short- and long term, for both producers and policy makers. From our analysis on

questions 3 and 4, we identify relevant solutions and interventions that either address issues in policy implementation or support transition towards new cultivation practices. For each intervention we specify which part of the vision it targets. We also provide an indication of which actors are responsible, based on their specific expertise or tasks. Finally, we connect these interventions to existing governmental targets and provide an indication of when this intervention should be implemented.

With all this information, we can answer our research question. We have created a vision, and via a backcasting approach identified interventions to realize it, for both policy makers and producers. These interventions will be summarized at the end of our report and together with the vision, will form the main output of this study.

2.2 Methods and Data Collection

In the previous section, we have already hinted at several methods and types of data that we will use to answer the research questions. In this section, we will provide what methods we used, what type of data we collected and how we analysed this data. Broadly speaking, we have used two methods: desk study and semi-structured interviews.

Desk Study

For subquestion 1 on contextualizing the sector and its problem areas, most information was based on recent datasets and reports. Data was collected from the Dutch national statistical office (CBS), other government agencies (e.g.: RVO), and knowledge institutes. Of the former, the most useful data source was Wageningen Economic Research, a research institute part of Wageningen University which is financed by the Dutch Ministry of Economic Affairs and Climate to conduct research on and monitor the performance of Dutch agriculture, including the flower bulb sector. Based on this information, we visualize the production chain and conduct a brief stakeholder analysis. To determine the policy context, we started studying literature by means of snowball sampling. This started with reading the national and provincial government plans regarding sustainable bulb cultivation and the available visioning literature of the flower bulb sector. From this, we identified what specific policies were relevant to provide a broad overview of the policy context.

For subquestion 2 on our vision on sustainable bulb production, a document analysis was necessary. We used certain search terms like *United Nations, SDGs, Europe, Green Deal, Rijksoverheid, pesticides, Omgevingsvisie, Noord-Holland, Zuid-Holland, KAVB, Deltaplan Biodiversiteitsherstel, visions* and *sustainable bulb cultivation*. These search terms resulted in all visions of a sustainable flower bulb culture on a multi-level scale.

For subquestion 3 on the improvement of policy making required a literature review. Using several different search terms (such as *policy implementation,*

sustainable agriculture, obstacles, implementation failure). These terms resulted in several useful papers, in that they either addressed reasons why policy implementation went wrong or how it can be improved, both related to sustainable agriculture. These papers themselves also gave hints and references to new papers, which were added to the sample as well. This provided us with a total of 13 papers, of which 10 were used in the final literature review.

For subquestion 4 as to what extent alternative sector interventions can contribute to realizing our vision, we mainly used output based on our interviews with the main actors in the sector. We were especially interested in how alternative sector interventions would be required in realizing our vision.

Interviews

Next to our desk study, we also conducted empirical research. This consisted of interviews with key stakeholders, as identified in chapter 3. They played an important role in answering sub questions 2-4. The diversity in actors means that we cover most relevant perspectives, from policy-maker to producer and they were chosen through desk study and snowball sampling. In total we held nine interviews. The interviewees can be divided into actors from the policy perspective and actors from the producer perspective. Nonetheless, we have asked them questions on all research questions, and data from both groups were used to answer different research questions.

For the policy perspective, we have interviewed people from four organisations. First of all we interviewed the CTGB; the Dutch board for the approval of crop protection substances. They are an important stakeholder since they are the main authority on crop protection in the Netherlands and could give us more insights on low-risk pesticides and ways on how policy could be improved to get more of these substances approved. Next to that, we interviewed policy makers from the provinces of North and South Holland. The flower bulb region is located in both these provinces. Provinces are responsible for nature conservation, and thus also for pesticide pollution. Additionally, we were interested if there were any differences in regulation and policy making between the provinces. Finally, we have interviewed the Rijnland water board. They are responsible for water quality and deal with water pollution due to pesticide runoff. This makes them an important stakeholder in the flower bulb sector.

For the production perspective, we interviewed five stakeholders. These are Hobaho by Dümmen Orange; an organic flower bulb producer; a Professor at CML; a Researcher at Wageningen University; and the sector association (KAVB). Based on the researchers that work to improve these challenges; a frontrunner when it comes to producing organic; a company that develops resistant flower bulbs; and the sector association we could form a strong vision on alternative methods for producing in comparison to business as usual. Each of the stakeholders form important keystones

when it comes to envisioning and contributing to a new sustainable vision that also makes it tangible for producers to work towards.

The interviews were semi-structured, so that if necessary, questions could be continued to obtain more information. The questions were not standardised, but were slightly adapted specifically per actor. The interviews were in September and October 2020 and all through skype or telephone and lasted approximately 30-60 minutes. Notes were made during the interviews and the interviews were recorded. Agreements have been made with our interviewees not to publish interview data due to privacy considerations and potentially sensitive information. Based on the recordings the interviews were transcribed and manually categorized. All interviews were categorized according to two themes. These are: chances and bottlenecks regarding the use of sustainable alternatives for crop protection substances and the role of growers in making the sector more sustainable. This included categorizing all of the data by means of the colors red (obstacles) and green (opportunities).

3. Contextualizing the Dutch Flower Bulb Sector

In this chapter we answer the question:

''How does the sector currently look like and what are the bottlenecks in the production chain in terms of sustainability?''

The following section (3.1) will give a brief overview of the sector. It starts by outlining the spatial characteristics and visualizing the production chain, followed by relevant information on trade, production methods, environmental pressures, and pesticide usage. Section 3.2 contextualizes the various EU, national, and regional policies that govern the transition to a more sustainable flower bulb sector. Finally, section 3.3 provides an overview of the main actors we identified as playing a key role in making the sector more sustainable.

3.1 Sector Overview

Land Use and Number of Producers

Flower bulb cultivation in the Netherlands covers an area of 27.220 ha (CBS, 2019b). About 60% of this acreage is owned by 1560 specialized growers. The rest is produced by mixed growers that dedicate a part of their land to bulb growing (WUR, 2019). Over the last two decades, the amount of producers has decreased gradually by 42%, while average acreage per producer has more than doubled to 17.44 ha per producer. These numbers indicate a strong trend towards increases in scale, with more flower bulbs grown by less producers (see Figure 1). The increasing trend in overall output also means that producers will have to limit their emissions even more rapidly in order to reach set policy targets (which often consider sector sustainability performance in absolute terms).

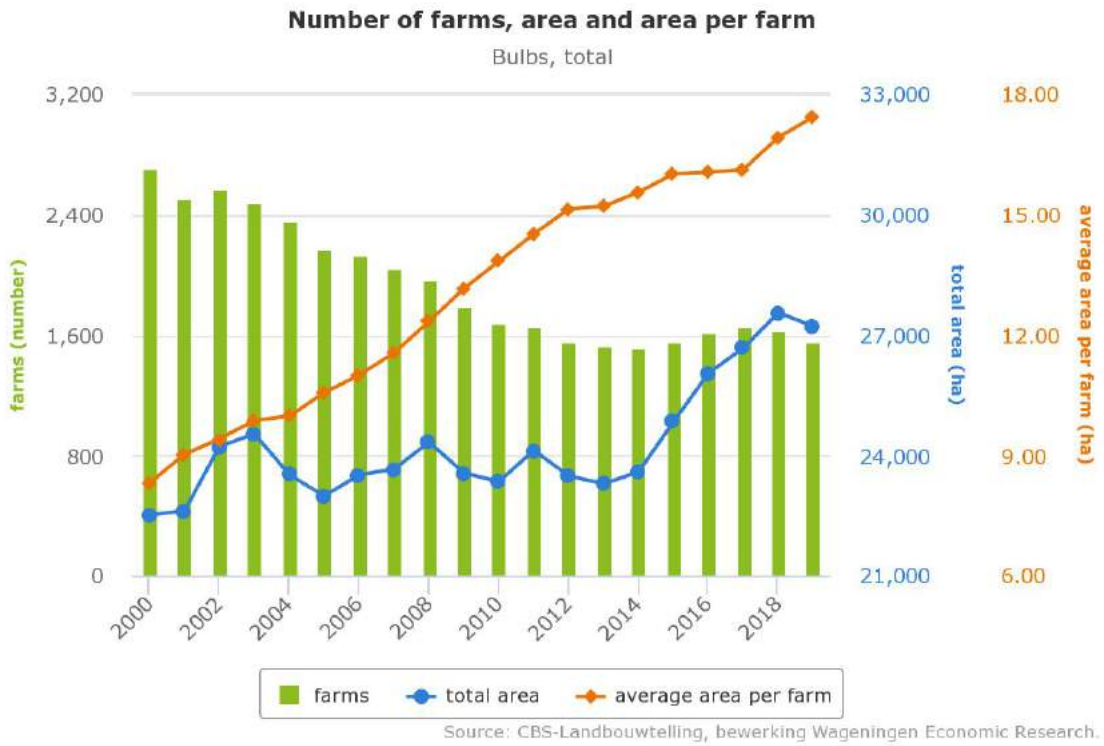


Figure 1. Number of bulb farms, total area of bulb farms and average area per farm

Spatial Distribution

Flower bulb production has a strong concentration in the North-Western part of the country (see Annex 1). Traditionally, important centres for cultivation have been on the fertile sandy soils along the coast, with the Bollenstreek in particular. Nowadays, production has also spread to more heavier soils, such as the clay grounds in West-Friesland and the Noordoostpolder (WUR, 2019). In these clusters, because of its open soil nature, flower bulb cultivation has a defining role in how people experience and value the (cultural) landscape. However, this also means that citizens living in these clusters may be more exposed to harmful chemicals in comparison with non cultivation areas. Clusters are sometimes formed around 'greenports' that organize efficient logistics and distribution.

Production Chain

Below is a simplified overview of the production chain. It is characterized by a strong vertical integration. Large producers are active in multiple parts of the chain, from breeding to trading the final product. A large share of producers are internationally active and have dependencies abroad (WUR, 2019).

Below is an illustration of the production- and (part of the) distribution chain. Most firms in the Dutch flower bulb sector are solely active in cultivation (48%), although a substantial and growing part is involved in both cultivation and hatching (40%). Relatively few firms are exclusively focussing on hatching (RVO, 2018). The majority of flower bulbs are produced in the Netherlands, with only a small portion

being grown abroad. Of those flower bulbs, about 30% is destined for drysale to be used in parks and gardens. The majority goes to hatcheries where the flowers are forced out of the bulbs (WUR, 2019).

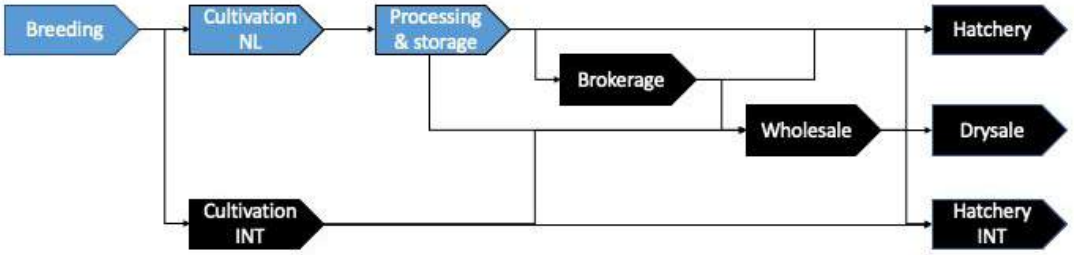


Figure 2. Simplified overview of the Dutch flower bulb production chain. Elements of the chain in blue are the focus of this report

Trade

Dutch trade in flower bulbs is heavily oriented towards export. Export in 2019 was valued at 780.714.000 EUR, of which 37.9% is within the EU and 62.1% outside-EU (CBS, 2019a). The value of imports is negligible. The most important destination markets are the United States, China, the United Kingdom and Germany, together accounting for 45% of export in 2018 (WUR, 2019). In order to ensure traceability on the bulbs, starting in 2019, it is obligatory for all producing companies that export bulbs within the European Union to have a plant passport (BKD, 2019).

Production Methods

Almost all flower bulbs are grown on open soil, often without any form of coverage. This is because most bulbs need several weeks of cold temperatures for dormancy release. Specific propagating material can be grown virus-free under controlled conditions in greenhouses or under tunnels.

Flower bulbs can be distinguished in spring-bloomers (tulips, daffodils, hyacinths) that are planted in the fall and harvested the following spring, and summer-bloomers (lilies, gladioli) which are planted in spring and harvested in autumn. When looking at acreage, tulips and lilies are the most popular flower bulbs. Tulips and lilies are growing in popularity, while interest for gladiolus is decreasing.

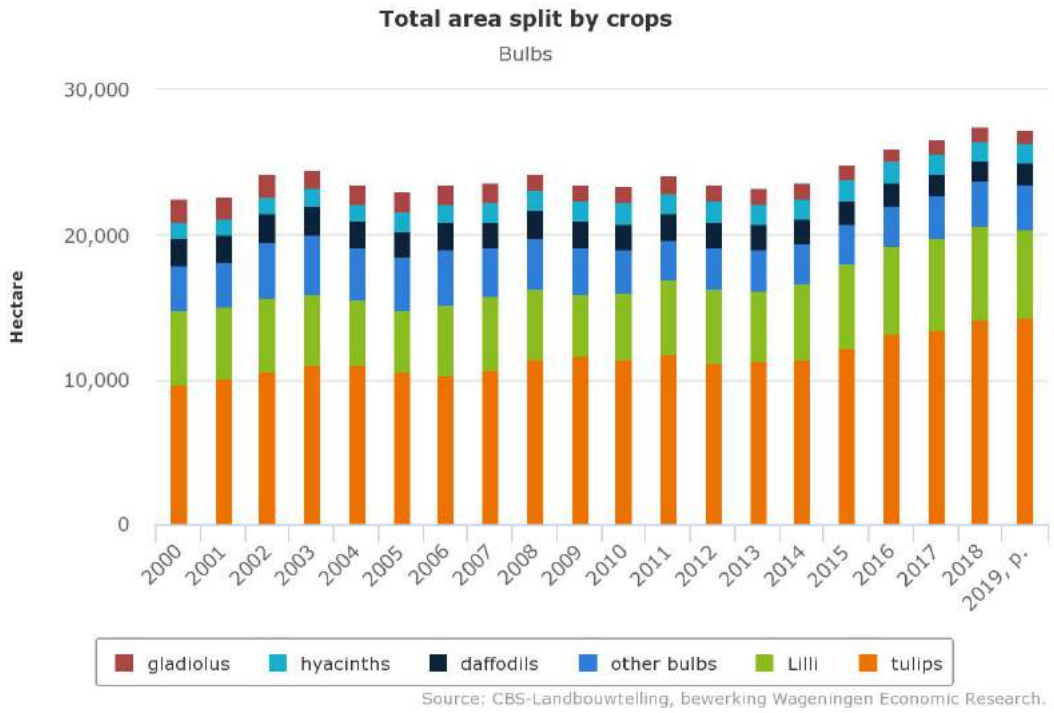


Figure 3. Total area of bulb production split by type of bulb

After harvest, the bulbs are cleaned, sorted, and stored under controlled conditions before distribution or re-planting (WUR, 2019).

Pesticide Use

Customers of Dutch flower bulbs require high quality standards. At the same time, plant health is constantly under pressure. This means that in the current production system, pesticides use remains necessary.

Environmental pressure resulting from pesticides has significantly decreased in the last decade. About 60% of environmental pressure comes from leakage to surface water. For surface water leakage, main stressors are insecticides and soil disinfection (WUR, 2019). Environmental pressure on the soil is 33%. Leakage to groundwater is a small stressor point (8%).

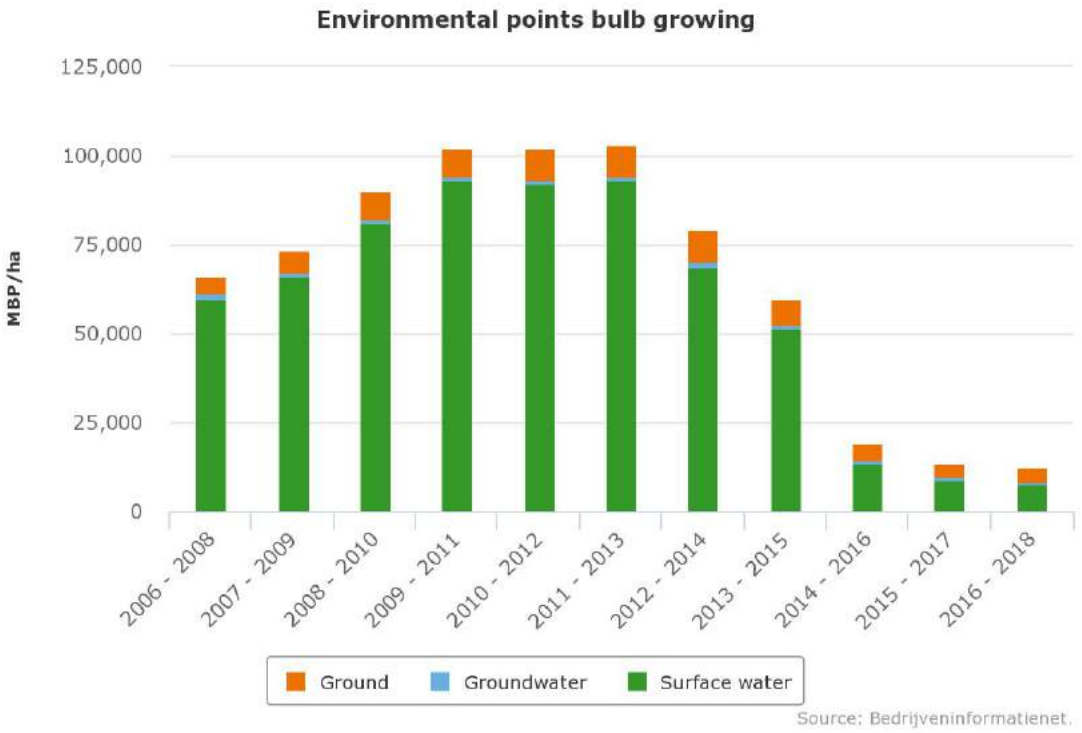


Figure 4. Environmental pressure points of flower bulbs

Stress on the environment decreased more than usage of active ingredients, which has even slightly increased (to 80 kg per ha) in the last few years. One explanation could be the increased usage of mineral oils (categorized as other) to combat the transfer of viruses carried by insects (WUR, 2020).

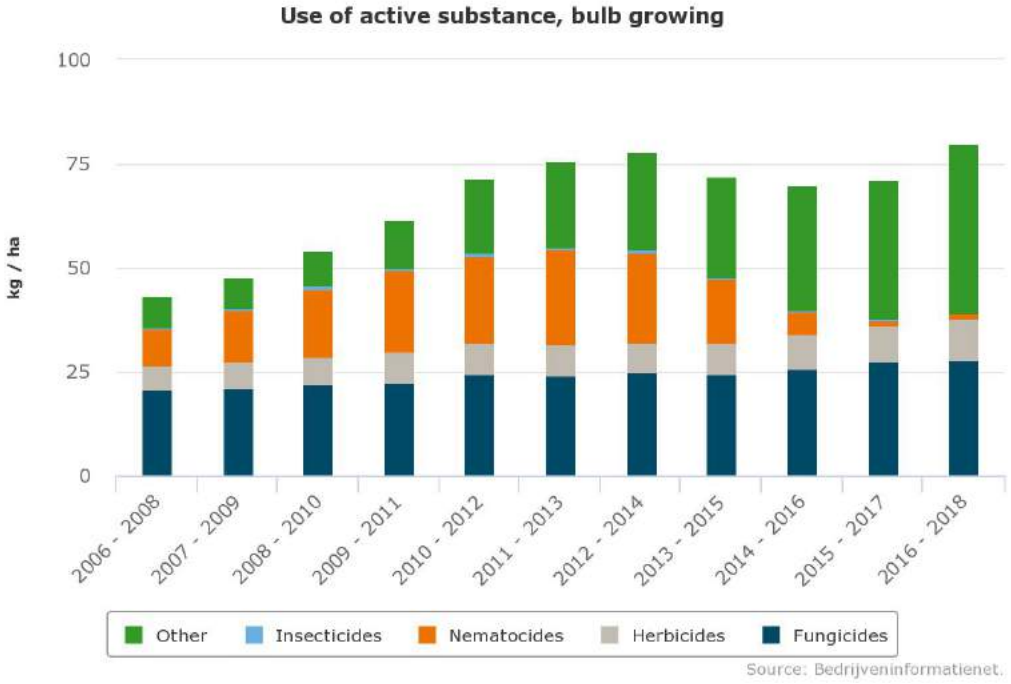


Figure 5. Usage of different types of crop protection in the bulb sector

This suggests that over the past decade, pesticide products have been used that have a less detrimental effect on the environment (such as mineral oils). This is thought to be the result of the prohibition of certain pesticides with high environmental impact, as pesticides differ significantly in toxicity (WUR, 2019). The decrease is most notable in pressure to surface waters.

As producers need to use more active ingredients to attain the same effect, average costs of pesticide per ha also increases. This is a notable side effect of prohibiting highly toxic, and thus highly effective, chemicals. As more and more pesticides will be banned, these costs are expected to increase even further.

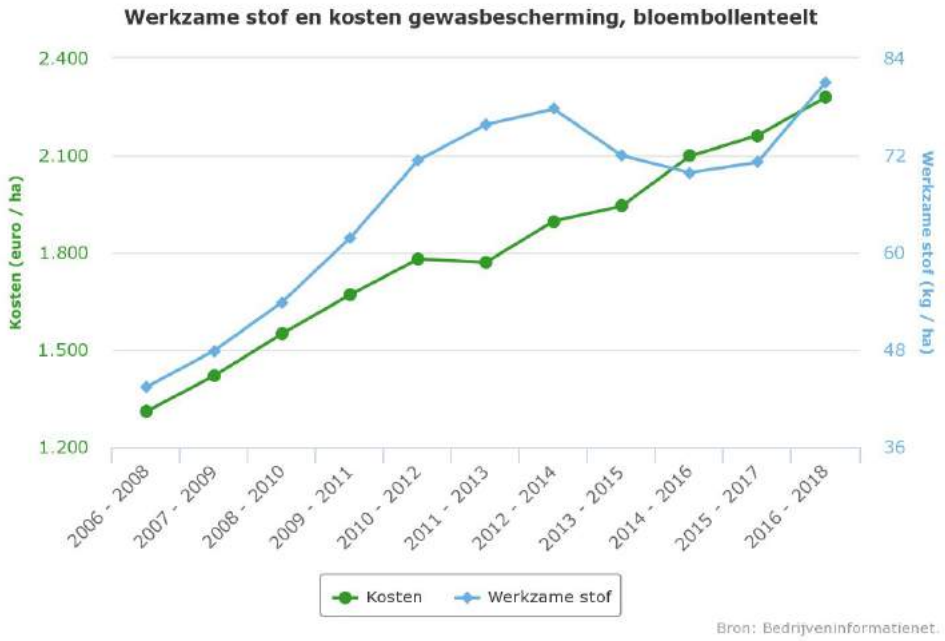


Figure 6. Average costs of crop protection per ha

While great progress has been made, when compared with some other agricultural sectors (2000 mbp per ha) (*MBP = environmental impact points ''milieubelastingpunten'')* environmental pressure by the flower bulb sector is still relatively high (WUR, 2020).

Organic Cultivation

The number of organic growers (Skal certified) is very low, constituting about 0.7% of the whole sector. Considering the supply side, this can be explained by the many hurdles producers need to take in the transformation process from conventional to organic cultivation. The financial investment is significant and organic is more labour intensive. On the demand side, consumers value organic production methods less when it comes to flower bulbs, as compared to food products. Also demand from institutional customers, such as municipalities, for organic flower bulbs is still low (WUR, 2019). Low profitability means that organic cultivation is nearly non-existent in the Netherlands.

Organic production uses fewer inputs than conventional growing. In order to be certified, it is usually also forbidden to use chemical pesticides or artificial fertilizer. However, land use per unit of output is higher than with conventional production (WUR, 2020).

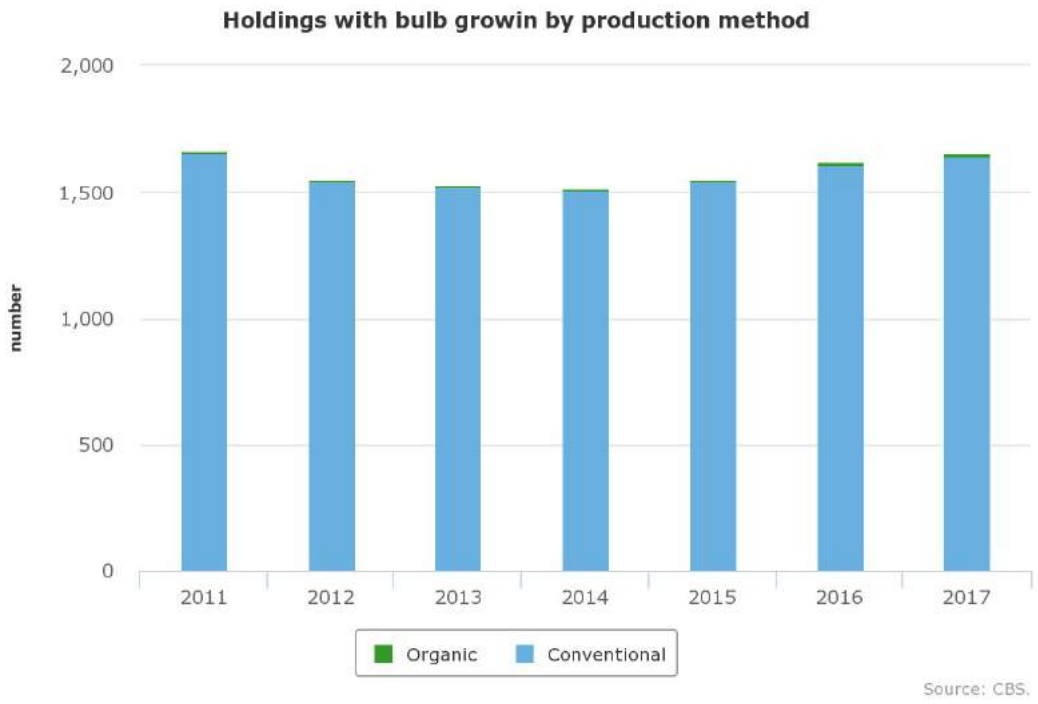


Figure 7. Conventional versus organic growing in the Dutch bulb sector

3.2 Policy Context

There are various EU, national and regional policies on the use of crop protection products and nutrients in the flower bulb sector. These policies are outlined in this chapter.

3.2.1 European Policies

The first European pesticide policies were introduced in 1979 and have evolved significantly over the years, culminating in the adoption of Directive 91/414/EEC on plant protection products, followed by Directive 98/8/EC concerning biocidal products. Since then, all pesticides have to be evaluated and authorized before entering the market. In addition, existing plant protection product legislation focuses on markets and the end of life of such products, but hardly covers the actual use of the substances. If not used carefully, the agents have adverse effects on the environment and because of that, the European Commission has adopted the strategy about the *sustainable use of pesticides*. They were set out in the 2006 Sixth Environmental Action Programme (EAP). The strategy will give an overall approach towards the environmental issue, proposed solutions, and an impact assessment. See Annex 2 for

an overview of the twenty important capstones of this strategy. Other EU policies and legislation also govern the use of pesticides (European Commission, 2007). Especially:

- The Common Agricultural Policy (CAP)
- Regulation (EC) No 396/2005 - on maximum residue levels of pesticides in food
- Directive 2000/60/EC - The Water Framework Directive (WFD)
- Directive 2008/98/ EC - The Waste Framework Directive
- Directive 91/689/EEC - Hazardous waste
- Directive 91/414/EEC - The placing of plant protection substances on markets.
- Directive 2006/42/EC - Machinery

3.2.2 National Policies

A number of policy tools are explained in the implementation program of the national vision *''Toekomstvisie gewasbescherming 2030''* (Ministerie van Landbouw, natuur en voedselkwaliteit,, 2019B) (For the vision see chapter 4.1.3). This document first states that creating a resilient cultivation system with resilient varieties and crops without being affected by diseases, pests and weeds is not possible without the use of biocides and crop protection agents (Ministry of agriculture, nature and food quality, 2019). This action plan is therefore most focused on resilient cultivation systems. It also explains how crop protection agents are authorized and into which categories the plant protection products are subdivided. Admission takes place through a graduated system. This means that it is first assessed at European level whether an active substance can be used safely in a representative European application. If safe use is possible, it is assessed at Member State level whether a crop protection agent can be used safely in the national situation for crops. The regulation distinguishes four groups of means:

1. Active substances that qualify for substitution
2. Active substances
3. Low-risk substances
4. Basic materials.

In support of resilient cultivation systems, it is important for growers that they also have access to an adequate package of crop protection products. To improve the availability of crop protection products for growers, the Ministry of Agriculture, Nature and Food quality has drawn up a number of action points (see Annex 3). There can be various reasons why the available package of measures and resources in a crop is no longer adequate at any time. At that time, another way must be found that allows growers to continue to ensure a good harvest without using the appropriate crop protection product. An issue may arise, for example, if the approval of an active substance or the authorization of a plant protection product is not renewed and is therefore no longer available to growers. Current issues can also arise due to a new disease or plague, by adjusting user instructions, etc. Whatever the background of

such a change or new development may be, it is of great importance for growers that they are able to anticipate in time, for example by making adjustments to the cultivation system to reduce the need for resources or by making use of other, preferably low-risk resources. See Annex 4 for a list of current issues

Implementation Plan Circular Agriculture

The Ministry of Agriculture, Nature and Food quality released a vision on circular agriculture (See chapter 4.1.3), which was accompanied by an implementation plan with policy action plans (Ministerie van Landbouw, natuur en voedselkwaliteit, 2018B). Broadly speaking, they first discuss what is needed for circular agriculture on a more technical level and then go on with socio-economic factors that support the implementation of these technical measures.

The plan aims for all soils to be sustainably managed in 2030. In order to do this, an increase is required in the development of sharing knowledge and having policy instruments that guide growers to sustainable soil management. This includes monitoring systems for soil quality and rewards for those who do well. Related to this, the plan aims to decrease the emissions from fertiliser and crop protection, the latter in accordance with the vision on sustainable crop protection. For fertilisers, the plan also aims to reuse waste from food production in manure. Additionally, more animal manure should be used as an alternative for chemical fertiliser on farm lands. Overall, the goal is to make sure that everything the system produces is reused again at another point in the system. Finally, the Ministry aims to allow as many experiments as possible to test different forms of circular agriculture without regulatory barriers.

Next to these technical measures, the plan sets out several conditions to ensure these technical measures can work. The Ministry will negotiate action plans with several agricultural sectors (livestock, crop production, fisheries etc.) to determine what is necessary for each sector. Next to that, they discuss viable business models and several financial measures to support businesses that want to invest in sustainability. The plan proposes a fund for young entrepreneurs who want to take over a (family) business and more opportunities for growers who lease their land to invest in sustainability. Additionally, the Ministry wants to ensure that there is proper market demand for sustainable products and that growers who produce sustainable products are paid enough for their products. This includes taking into account the hidden costs of food production. Another important goal of the plan is to set out which knowledge is required from universities and businesses, as well as which knowledge is already present.

Green Deal for Crop Protection

Another action plan in this category is the green deal for crop protection. (Werkgroep Green Deal groene gewasbescherming, 2017). It was initiated by the Ministry of Economic Affairs and Climate and the CTGB, the Dutch approval board for

crop protection, in collaboration with businesses and nature organisations. The main point of the Green Deal was to study how more 'green' or low-risk crop protection substances could be approved for the market. Low-risk substances are based on a low-risk active ingredient and have a low risk to harm humans and other organisms. There are two steps to get a green substance approved. First of all, the EU needs to accept the active ingredient on its list of low-risk substances. Then, the CTGB must approve the low-risk substances. During the project, several pilots were initiated to get more active ingredients and substances approved as low-risk. Additionally, The CTGB aimed at bringing back the approval period from 1 year to 120 days. At the conclusion of the project, the CTGB managed to approve 6 substances as low-risk. For several, they managed to do this within the period of 120 days. Progress was made by guiding the applicants in their application and appointing a special committee and other staff members to specifically work with green substances. The Green Deal provides some recommendations for future policy. There are some gains to make in getting green substances easier approved. The government could make it easier and cheaper to file an application for a green substance, for example by tax incentives or subsidies. Additionally, the final report proposes an exemption for a substance when it is absolutely necessary that growers can use it on the short term. Similar to that, the report proposes to provisionally admit a low-risk substance before it is completely approved. However, current legislation does not allow for such things according to the report.

3.2.3 Provincial Policies

In addition to the Dutch government plans, local governments in The Netherlands have some leeway to design their own policy. In the case of sustainable agriculture they are mostly bound by what the government decides. However, they can add their own policies and instruments to support these plans. As said before, the flower bulb region is spread over several local governments. In this section, we will discuss some policy of the two provinces: South and North-Holland.

South-Holland

On March 24, 2020, the Provincial Executive of South Holland adopted the Draft Nature Management Plan 2021. The plan shows the current and intended nature objectives, which is part of the system for subsidizing nature areas, agricultural nature management and landscape elements in South Holland (Provincie Zuid-Holland, 2020). Part of this plan is the "Nature Management Plan" that intends to ban chemical crop protection products from 2021. The well-known "agricultural poison" glyphosate is one of the substances that the province will ban. Healthy nature is the basis for a healthy living environment. The province claims that chemical agents have a disruptive effect and can remain in nature for a long time and that there are other options for managing nature properly. That is why they choose to no longer allow chemical agents to

manage their natural areas (Boerma, 2020). The requirement applies to all nature and agricultural areas that are managed with a subsidy from the province. The county council is also calling on private landowners to avoid insecticides, fungicides and weed control agents (Provincie Zuid-Holland, 2020).

North-Holland

Unlike South-Holland, the province of North-Holland does not provide a vision/action plan on sustainable agriculture on their website. One particular policy on crop protection they have concerns about is the use of Glyphosate. In May 2020, the province decided to ban Glyphosate (also known as Round up) on provincial land (Provincie Noord-Holland, 2020). This means that growers who lease their land from the province, are no longer allowed to use this substance. However, this substance is allowed by the EU on the Dutch market, and will not be reviewed until 2022. The province argued that it did not want to wait for this, and in light of their aim to decrease the use of chemical crop-protection, decided to instigate this ban. Nonetheless, the Province can still allow the use of Glyphosate if they deem it necessary to use and there is no alternative.

3.3 Main actors

The table below shows the main actors we identified to play a key role in making the Dutch flower bulb sector more sustainable.

Table 1. Actors in the flower bulb sector in the Netherlands

Organisation	Description and Role Within the Sector
KAVB	The *''Koninklijke Algemeene Vereniging voor Bloembollencultuur''* (KAVB) is the main sector association for the flower bulb sector in the Netherlands. The majority of companies active in the sector (breeding, trade, cultivation, hatcheries) are members of this branch association.
Hobaho by Dümmen Orange	Hobaho specializes in mediating and auctioning flower bulbs, coordinating growers' associations, managing licenses, breeding and testing.
BKD	The Flower Bulb Inspection Service Foundation (BKD) inspects flower bulbs on behalf of the Netherlands Food and Consumer Product Safety Authority (NVWA). It is responsible for plant health and quality monitoring, thereby facilitating export and import in flower bulbs on the Dutch market.
CTGB	The *''College voor de toelating van gewasbeschermingsmiddelen en biociden''* (CTGB) is the board for the authorization of plant protection products and biocides and it

	assesses whether products are safe for humans, animals and the environment and thus can be sold and used in the Netherlands.
Provinces South & North Holland	The provinces are regional government bodies and act as enforcers and can intervene if necessary, for example in prohibiting certain substances.
The Rijnland Water Board	The water board is a local government that is responsible for water safety, water quality and sewage treatment. They measure residues of chemicals in surface water and make policy on keeping the water clean.
Municipalities in the flower bulb sector	The 'Bollenstreek' is divided over the following municipalities: Hillegom, Katwijk, Lisse, Noordwijk and Teylingen. The municipalities are the implementing organizations in the field of policy in the bulb sector.
Ministry of Agriculture, Nature and Food quality	The Ministry is responsible for agriculture, nature and food quality. They aim for sustainable food production and thriving nature. Part of this is reducing environmental impact from the agricultural sector.
Agrifirm and Bayer	Both companies are the major producers for chemical substances and crop protection products. They are also crop advisors for growers.
Greenport Duin- en Bollenstreek	Regional cooperative cluster consisting of local governments, producers, education and knowledge institutes with the aim to support a healthy and sustainable horticulture sector in the Duin- en Bollenstreek region.
Research institutes	Both CML & Wageningen University are research institutes that are doing independent research in the field of sustainability and agriculture.
Organic farmer (Huiberts)	Huiberts is an organic farmer in the Netherlands, he is seen as the pioneer in the organic flower bulb industry.

4. Creating a Vision

For building our vision, we start by analyzing existing visions (UN, EU, Dutch government, Provinces, sector itself) and the perceptions on sustainability provided by our interviewees. We then construct our own vision by combining elements from all different perspectives. Chapter 4.1 describes existing visions. The interviewees' perceptions on sustainability of the sector can be found in chapter 4.2 and chapter 4.3 contains our own constructed vision based on chapters 4.1 and 4.2. Together this will answer the following research question:

''What is our vision on a sustainable flower bulb sector?''

4.1 Existing Visions

4.1.1 United Nations

The Sustainable Development Goals (SDGs) were established by the United Nations in 2015 as the new global sustainable development agenda for 2030. The SDGs will be in force from 2016 to 2030, and will replace the Millennium Development Goals that expired at the end of 2015. There are 17 goals and 169 underlying targets to operationalize these goals. The goals that are relevant for this research are (United Nations, 2015):

- **SDG 9:** Industry, Innovation and Infrastructure: Generating employment and income through innovation.
- **SDG 11:** Sustainable Cities and Communities: Making cities safe, inclusive, resilient and sustainable.
- **SDG 15:** Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
- **SDG 17:** Partnerships for the Goals: Revitalize strong (global) partnerships for sustainable development.

The corresponding targets of these SDGS can be found in Annex 5

4.1.2 European Union

In 2019, the European Commission published the European Green Deal which is a policy framework with a more sustainable vision for 2030 and the aim to be climate neutral by 2050. The strategy contains twenty-seven aims to reconcile the food system and for the planet's health. The applicable ones for this research are (European Commission, 2020) (Nicolás, 2020):

- Reduce the use of pesticides by 50%;
- At least 25% of Europe's agricultural land should be farmed organically.

4.1.3 National Government

Vision on crop protection

For profitable and high-quality agri- and horticulture it is necessary that there are effective control mechanisms of diseases, pests and weeds. Crops can be protected against this by using crop protection agents. The Dutch Ministry of Agriculture, Nature and Food created the vision *''Toekomstvisie gewasbescherming 2030''* (future vision for crop protection 2030) for a sustainable use of crop protection agents in agri- and horticulture. The vision is: *''In 2030, agriculture and horticulture in the Netherlands will consist of sustainable production with resilient plants and cultivation systems, which means that diseases and pests have fewer opportunities, and the use of crop protection products can be prevented as much as possible. Where crop protection agents are used, this is in accordance with the principles of integrated crop protection, with virtually no emissions to the environment and virtually no residues. This simultaneously becomes a permanent economic perspective for agriculture and horticulture realized. ''* (Ministerie van Landbouw, natuur en voedselkwaliteit, 2019A). This vision is expressed in three strategic goals:

1. Crop protection is an important aspect of cultivation. In 2030, crop protection is based on **resilience**: crops can handle more, and cultivation systems are largely self-regulating. Due to this resilience, pests and diseases are less likely to harm the crops.
2. Connecting agriculture, horticulture and nature is an important part of **circular** agriculture as described in this vision. This means that nature on agricultural and horticultural land will be richer and more resilient in 2030 and that agriculture and horticulture will focus where possible on using nature for pollination, soil fertility and disease and pest control.
3. The existing targets for limiting emissions of plant protection products to the environment will be extended to near zero by 2030. When plant protection products are used, the sector uses innovative emission abatement techniques to implement them. These include precision agriculture, sophisticated formulations and additives, location-specific meteorological forecasts and the correct soil structure. This ensures that fewer pesticides are used and evaporation, leaching or rinsing is avoided as much as possible.

The transition theory is central to the implementation program for this vision. This perspective is based on working on major social issues through accumulating "small wins" (Termeer, 2019). Small wins are small in-depth changes with tangible results for those directly involved. Small wins can be accumulated via three transition paths: upscaling of innovation, applying innovation in other areas and making innovation even more radical. Appropriate legislation and regulations for space to experiment are central to applying new breeding techniques.

Vision on Circular Agriculture

Next to the vision on crop protection, the Ministry of Agriculture, Nature and Food quality also released a vision on sustainable and circular agriculture in general (Ministerie van landbouw, natuur en voedselkwaliteit, 2018A). The main goal of the vision is to provide an overview of what is needed from who to realize circular agriculture. The report states several reasons why this transition is necessary. First of all, the agricultural sector has to significantly decrease its CO_2 output. Next to that, all actors in the production chain need to moderate their use of resources such as soil or water and prevent wasting them, in order to avoid depletion. Also, it is important that business models remain sustainable over time and younger generations are able to take over the business. Finally, the vision states that consumer interest for good products and a thriving biodiversity around farmlands are important values that will help in realising this vision.

The main change they envision is a change from a constant decrease in cost price to maximise profit towards a constant decrease of resource use to minimise environmental impacts. Circular agriculture plays a vital role in this transition. Businesses in the agricultural sector need to use input and waste streams from each other in order to create circular chains with minimal input from outside. Additionally, waste has to be recycled and reused as much as possible and electricity use needs to be decreased to a minimum. Another important pillar is soil use. The soil has to be fertilised with natural manure only, decreasing carbon emissions from the production of artificial fertilizer. Additionally, crop producers need to act in accordance with the principles of integrated pest management. This includes breeding resistant crops and the use of low-risk crop protection.

4.1.4 Provincial

Omgevingsvisie Province North-Holland

In November 2018, the province of North-Holland drew up its *''Omgevingsvisie 2050''* (environmental vision 2050) with the aim that everyone who lives, works and visits the province finds a pleasant living environment now and in the future. In this vision they describe eight most urgent developments in the living environment of North Holland, a number of which are related to the bulb sector, namely soil and water quality and biodiversity. Their ambition is to increase biodiversity, to create sustainable agriculture, and to improve soil and water quality. They want to achieve this by realizing adaptive circular agriculture, which takes more account of the preservation and enhancement of biodiversity and soil and water quality. The province also mentions that specific attention must be paid to reducing pesticides in the soil in order to improve groundwater quality and increase biodiversity (Provincie Noord-Holland, 2018).

Omgevingsvisie Province South-Holland

In Januari, 2019, the province of South-Holland drew up its *''Omgevingsvisie"* with the aim to improve the living environment. The Province describes that climate change, increasing salinization, settlement and the changing use of space (including in the subsurface) require adjustments to choices in the soil and water system, which in many cases affect spatial planning. These choices have the underlying aim that the province of South Holland remains protected and that it remains possible to make better use of water in its many capacities. The quality and functionality of water must be optimal and constantly require improvement and protection (Provincie Zuid-Holland, 2019).

4.1.5 Bottom-up Initiatives

Besides action plans and visions written by public government bodies, there are also examples of plans that arise from public/private or solely private partnerships. These plans are important because they represent our idea of governance: policy is not only made by public bodies, but is also shaped by the private sector.

Delta Plan Biodiversity Recovery

The *''Deltaplan Biodiversiteitsherstel in Nederland''* is a plan to protect biodiversity in the Netherlands (Deltaplan biodiversiteitsherstel, 2018). Currently, due to several factors, of which the overuse of harmful chemical pesticides is one, biodiversity in the Netherlands is decreasing. Having a rich biodiversity contributes, besides having an intrinsic value to society in general, towards a safe and healthy environment for humans. The Deltaplan on recovering biodiversity is a cooperation between several stakeholders from the private sector. These stakeholders envision that in 2030, there will be a rich biodiversity of soil life, plants, insects and farmland birds in the Netherlands. This is achieved by better cooperation between governments, businesses in the agricultural value chain and nature conservation organizations, improved connectivity and management of nature areas, and a transition towards circular agriculture. For the agricultural sector, the plan aims that sustainable production systems have future prospects, are circular and are based on healthy soils in biodiverse landscapes. To achieve these goals, the plan incorporates five overall values or 'success factors'. These are: shared values and viable business models. For business models, the plan proposes that banks can apply lower interest rates on loans, nature conservation organizations can charge lower rental fees on agricultural land leases, and public authorities can ease the processes for permits, tax instruments and subsidies. Next to that, laws and regulation should be consistent and goal-oriented. Finally, there needs to be a focus on knowledge and innovation and collaboration on a regional level to share this knowledge.

4.1.6 Sector

Policies have been drawn up by all kinds of governmental actors about making the flower bulb sector more sustainable. The sector itself also has a picture of how they see this process. The KAVB is the sector association of the flower bulb sector and they have published a vision about a sustainable future, called ''Vitale Teelt 2030''. With this, the flower bulb sector has a vision that is setting course for a robust and sustainable cultivation system. Here, the sector describes that the number of available chemical crop protection products is decreasing rapidly, and retailers are increasingly demanding a guarantee of sustainable production.

Legislation and regulations also force the sector to produce more sustainably. They recognize that change is needed to maintain their solid position as the world market leader in flower bulbs and bulb flowers. They have four aims for the sector for 2030:

1. Export to all countries in the world;
2. Product warranty on every bulb and flower;
3. Sustainable production process is the norm;
4. Production in harmony with the living environment.

The sector also believes that a good soil is the basis for a healthy plant. For this reason, the focus will be more on feeding the soil than on protecting the plant by means of crop protection agents, for example. The use of modern techniques can improve the breeding of the flower bulb sector in a more targeted and faster way on properties that are important for sustainable production. You can think of DNA techniques and mapping the tulip genome and the use of markers. A faster propagation and a faster flowering of bulbs can ensure that new, sustainable varieties are developed more quickly and that the cultivation has a shorter lead time. This saves on raw materials. The industry also believes that precision agriculture will become important in the future, making crop handling increasingly sophisticated. On the basis of data and with the help of GPS, drones and self-driving machines, bulb fields become an example of high-tech precision agriculture (KAVB et al., 2020).

4.2 Interviewees Perceptions on Sustainability

This section outlines how the interviewees perceive a sustainable flower bulb sector within their organization. The organization's perceptions on sustainability could be roughly divided into three categories: organic cultivation, intensification, or hybrid (see Table 2).

4.2.1 Organic Cultivation

The perception of foreseeing a sustainable flower bulb sector that fully consists of organic farming is shared by our interviewees: waterboard Rijnland, organic farmer Huiberts and partly shared by institution CML in Leiden.

Rijnlands perception on sustainability is that activities should have no effect on the environment. And if the bulb sector wants to move in that direction, growers must move towards growing bulbs that are more resistant and require fewer pesticides and nutrients. One of the biggest organic pioneers in the sector is Huiberts and he sets a good example of doing it completely differently when it comes to producing flower bulbs. He said that after he transformed his land and practices to completely organic, he saw his soil becoming more healthy. He thinks the whole sector could benefit from using organic techniques, and he hopes to contribute to this. At the moment he thinks there is a lot of pressure on the sector.

4.2.2 Intensification

Intensifying the sector implying a growth that is necessary to maximize yield, profit in order to maintain the high quality of the flower bulbs and its international trading position. First of all, KAVB acknowledges that less chemicals will be allowed in the near sector. However, in order to remain its position it has to grow more intense for example with closed systems farming. Both research institutes, Wageningen Universiteit and CML also think that the sector can intensify even more. Both institutes provide independent scientific knowledge that will be in best favour of sustainability within the sector.

4.2.3 Hybrid

Foreseeing a hybrid sector that will meet the sustainable standards, it will require taking elements from organic cultivation and from highly intensifying the sector. This is what the majority of our interviewees foresee to happen. Or even, the only way the sector could be maintained.

The sector association KAVB states in their vision that by 2030 we must become less dependent on chemical pesticides and that we must make a great effort to do so. In practice, 50% of the resources will disappear, so growers have to prepare for fewer resources, which is quite a difficult road. "*We have been working from the day it has to be, which is also the only way to get a healthy bulb sector*". Incorporating organic techniques in the sector could be useful.

Also, both provinces South and North Holland prefer a mix of both roads. What the Province of North Holland understands by the word sustainability is actually the people, planet and the profit triangle. For example, whether it is good for the environment; if there is a revenue model, and it must be sustainable for the people that work there. The Province of South Holland actually sees sustainability as an ambition that is dictated by law. One of the drivers behind this is the change we all want *"that we want to make the system more sustainable*": by using less harmful substances and organizing it in a different way**.**

The CTGB for example allows low-risk crop protection substances. The CTGB is therefore one of the 10 parties in the circular vision of the Ministry of Agriculture,

Nature and Food quality. In this, the role of the CTGB is to assess low-risk crop protection substances and they also consider how to deal with techniques that enable treatment at a specific location, so that fewer resources need to be used in total. Their part of sustainability is therefore mainly to use less resources and the release of resources into the environment.

Also, within the sector, breeder Hobaho by Dümmen Orange said they are working on this hybrid sector as they are developing resistant flower bulbs. When you have resistant flower bulbs, the usage of chemical pesticides will be reduced or not even be necessary anymore. By developing resistant breeds, the sector is provided with many sufficient varieties. They want to stay ahead of new emerging pathogens and to continue introducing new varieties to the market that are resistant to pathogens.

Both research institutes Wageningen University and CML in Leiden foresee a hybrid flower bulb sector. The interviewed researcher at WUR said within the institute they do independent research on alternative techniques within the sector. By consistently improving and doing research into alternative means, you are building towards a more sustainable production process. The interviewed professor at CML (Institute of environmental sciences), said they are working on contributing to biodiversity. Building on this, he said it is important that these suggestions are driven by scientific information. Despite which direction you go, it is a fundamental issue, and it depends what values you want to attribute to the landscape.

Table 2. The visions of our interviewees divided into organic cultivation, intensification, or hybrid

Interviewee	Organic cultivation	Hybrid	Intensification
CTGB		X	
Province of North Holland		X	
Province of South Holland		X	
Waterboard Rijnland	X	X	
KAVB		X	X
Hobaho		X	
Huiberts	X		
WUR		X	X
CML	X	X	X

4.3 Constructing Our Vision

We now construct our own vision for a sustainable flower bulb sector by combining elements from all three perspectives. Additionally, it includes ideas that arise from our own conceptualization of sustainability.

The vision is formulated with four key aims in mind. First, minimize the amount of inputs (chemical pesticides, artificial fertilizers, land pressure). Second, when these inputs are used, residue leakage of chemicals and nutrients into the environment should be prevented as much as possible, with surface water in particular. Third, new production methods and techniques are financially viable. In order for producers to make the switch to organic or closed system farming, they should be able to create a healthy business model that can sustain itself over time. Finally, it aims to maintain the world-leading position of the Netherlands in the global flower bulb market.

Complementing Existing Visions

If we want our vision to be realistic, it needs to complement existing visions and commit to certain sustainability targets set by either the government or the sector itself. The visions released by the national government include most of the goals we stated. The vision on crop protection states that by 2030, all crop protection in the Netherlands will have virtually no impact on the environment. The vision on circular agriculture states the same, and includes an entire chapter on making sure the transition is viable for producers. Additionally, they both state that we should transition away from applying chemical fertilisers. However, land fragmentation is not seen as a main priority.

Additionally, we have asked several key stakeholders on their views of a sustainable bulb sector. They mostly agreed that the bulb sector needs change to become sustainable, but there were differences in how that endpoint should exactly look like. The interviewees can be positioned on a spectrum defined by two extremes. On the one hand, there were actors that favoured an approach in which production would become entirely organic. That would mean no chemical pesticides or artificial fertilizers, attention to new production techniques that enhance resilience of flower bulbs and the quality of the soil, and in general promotes the usage of techniques that decrease the use of natural inputs. Others favoured an approach in which the production of bulbs would be intensified. This would mean that more bulbs will be cultivated, but less so on land.

Our constructed vision is situated between those two extremes. However, by adding our own elements and synthesizing all the different perspectives into one integrated whole, we argue that our vision is more than just the sum of its parts.

Our Constructed Vision

The balance between economic and ecological interests has to be restored. Our world leading position has been built on heavy chemical application and intensive land use. In order to decrease this dependency and achieve our environmental targets, a broad system change is required. Maintaining our hegemony means efficiency should be drastically improved, using less inputs in the form of chemicals, nutrients and land. Our historical deficit in chemical usage means that, besides reducing source emissions, focus should be on the effects of already polluted soil and water bodies. Furthermore, land use change is more recognized as an important driver behind biodiversity loss.

Switching to fully organic cultivation will make the Netherlands lose its position as global market leader. The focus is on high value-adding elements in the chain with low environmental pressures, this is important being the breeding of more resilient cultivars. This also means some production capacity could move to more rural parts of the country or even abroad, given scarcity in available land in (the Western region of) the Netherlands. The open soil stage of cultivation is concentrated in the Duin- en Bollenstreek. Flower fields constitute a national cultural landscape and form an inherent part of the region's identity. Furthermore, the blooming fields attract tourists from all over the world.

Negative externalities are better accounted for, reducing the artificial price gap between bulbs with differing environmental impacts. This allows consumers to pay a fair price for their flower bulbs. On the producer side, enough incentives and policy tools are available for growers to switch to either closed system or organic cultivation. Legislation grants enough possibilities for technical innovations in the field. Low-risk pesticides are given priority over conventional pesticides in the admission process. Profitability is included as a key factor within our conceptualization of sustainability. In order to make the transition to a sustainable flower bulb sector work, producers should be able to create a viable business model for the future.

Producers have already drastically reduced reliance on harmful chemicals. With low hanging fruits achieved, focus switches to small wins. Chemicals remain necessary for an efficient production system, but these will be applied only where and when specifically needed. Growers make use of technological innovations that enable them to automate production processes and give the producer complete control to adjust to optimal conditions - all with minimal human input. The Dutch flower bulb sector does not only aim to remain the producer of the world, but also exporting knowledge on creating sustainable agricultural production systems all over the world.

5. Improvements in Policy Implementation

In this chapter, we will explore what is necessary from policy-makers to realise our vision. This will be focused on the issue of policy implementation. We thus provide answers to the question:

''What can improve in the implementation of policies governing the sector, in order to realize our vision?''

To answer the question, we need to specify several things. First of all, we provide a brief discussion of some theoretical insights on policy implementation. After that, we determine to what extent these were mentioned in our interviews with policy makers, to determine whether these issues are also at play in the flower bulb secor. Finally, we will evaluate the implementation plans of three of the visions discussed in the previous chapter. We will determine which issues have been covered, as well as what is missing. We will use these results as input for our roadmap in chapter 7.

5.1 Theoretical Issues

We have seen that there are a myriad of visions and ideas on sustainable farming, all with different ideas, goals and conceptualisations. Furthermore, it is not always clear how these should be implemented in practice. Especially ways to ensure farmers' cooperation are not always clear. These are important, because a transition is only possible if all farmers participate and cooperate. In this section, a brief overview of the literature on obstacles of policy implementation is presented, based on which a categorisation of implementation issues will be constructed.

A starting point to discuss implementation of sustainable policy is Howes et al. (2017). They conducted a comprehensive literature review on papers that studied the implementation of policies related to sustainability in a general sense. They found three reasons why implementation fails. First of all, they mention structural causes such as favouring economic outcomes over environmental benefits, or social resistance to change (Howes et al, 2017, p. 6). Secondly, they identified more technical, policy related 'implementation traps'. One could think of vague goal descriptions, conflicting objectives and lack of incentives to comply (Howes et al., 2017, p.8). Finally, they discuss issues with knowledge and scope. These include a lack of knowledge among policy makers, too narrow a scope of the policy and a lack of proper monitoring and evaluation mechanisms (Howes et al., 2017, p. 9-10).

These findings provide an interesting starting point, but remain very general. Especially the structural causes are very broad and generalised. Moreover, these factors highly rely on political choices and what is valued in society. Thus, these issues

are difficult to tackle for policy-makers and implementers (producers). The other issue howes et al. focus on is the technical wording of the policy and the scope. A paper that discusses this issue is Siebrecht (2020). He outlines several obstacles to the implementation of policy related to sustainable agriculture. Those are: Theoretical, methodological, personal and practical obstacles. Theoretical obstacles relate to issues such as the definitions of sustainability and the relationship between research and practice. Methodological issues focus on issues such as the assessment and operationalisation of sustainable agriculture (Siebrecht, 2020, pp.4). Thus, we can already identify that for good implementation, it is necessary to properly conceptualise what is meant with sustainability and sustainable agriculture and link this with clearly and well formulated goals to achieve this.

However, these insights only deal with the technical part of drawing up legislation. Implementation also depends on the targeted subjects of the policy, i.e. the farmers. Siebrecht (2020) distinguishes here between personal obstacles, dealing with individual practices and characteristics of farmers, and practical obstacles, relating to more societal barriers towards implementation (Siebrecht, 2020, p.4). Regarding personal obstacles, Siebrecht argues that knowledge is a main issue. Sustainable agriculture requires complex knowledge. This means that a farmer should know how to implement sustainable agriculture or which decisions and adaptation will lead to sustainable production. Thus, to achieve sustainable production farmers need information, knowledge, and assessment results in order to change farm management and planning processes (Siebrecht, 2020, p.13). This focus on knowledge is shared by several authors. Howes et al., (2017) already mentioned knowledge as a key factor in the success of policy implementation. Papadopoulos et al. (2015) studied which components of the EU Common Agricultural Policy contributed most to the implementation of these measures by farmers. They found that, among others, training and the providing of information about sustainable practices contributed towards implementing the goals of the EU CAP.

Van Eerdt et al. (2014) discuss several reasons why farmers will or will not take up integrated pest management, a set of measures to apply crop protection in a more sustainable way. Reasons for no adoption are that farmers are uncertain whether new methods will result in the same yield (van Eerdt et al., 2014). The authors recommend increasing information sharing amongst farmers and by the government, especially since IPM can be complicated and there is uncertainty among farmers about the effectiveness of the measures. Additionally, Runhaar et al. (2017) propose a set of conditions that lead farmers to adopt and implement nature conservation measures. One of these is to what extent they possess the right knowledge and skills. From all this, we see that having the right knowledge to participate in and implement sustainable practices among farmers is a key factor. When farmers know how and why

they need to implement these practices, they will be more likely to do it and do it properly. Policy action plans need to incorporate ways to provide knowledge and mechanisms for farmers to share knowledge between themselves.

Besides knowledge, there are other practical obstacles Siebrecht (2020) puts forward, such as financial and economic issues. Changing towards a sustainable agriculture can incur high costs for farmers, whereas market demand for these products could be low. This can lead to higher prices and lower competitiveness, which can be a reason for farmers to not comply with policy. De olde et al. (2017) observed similar challenges in their research on pioneers in the agricultural sector. They argue that pioneers can function as role models in the sector and prove that innovations can work. The pioneer farmers that were studied struggled to get their new business models working. They were confronted with production costs and regulatory barriers. This can demotivate others to pick up these innovations, slowing the speed of transition. De Olde et al. (2017) put forward several recommendations to improve this. One thing they argued is that these pioneers need to be compensated by governments for their high costs and uncertainty inherently present in innovation. A similar argument is given by Tilman et al. (2000). In their paper on making intensive agriculture more sustainable, they argue that subsidies, payments and other financial aid are important tools to incentivise farmers to implement sustainable agriculture. Concluding, we can see that financial viability and having the right resources by farmers are important factors in policy success. Additionally, these plans need to incorporate proper financial and economic incentives to guide farmers in the right direction.

Nonetheless, even when farmers have all the knowledge and resources they need, there is still a possibility that they do not implement sustainable practices. Siebrecht (2020) and Runhaar et al. (2017) both agree that motivation of farmers is an important factor. Siebrecht (2020) argues that if a farmer is advised to adopt more sustainable working practices, the manner in which the farmer is advised is important. If the farmer feels they are being patronized, it can make them feel uncomfortable or even aggressive (Siebrecht, 2020, p.15). Psychological literature also provides us with some insights on motivation. Bopp et al. (2019), writing from a psychological perspective, looks at the effectiveness of monetary incentives for farmers to go sustainable at different levels of intrinsic motivation. Intrinsic motivation is seen here as the willingness to do something without external rewards, but from an innate desire to do so (Bopp et al., 2017, p. 321). They found that external motivations, such as monetary incentives, only work when farmers' have a low intrinsic motivation to go sustainable (Bopp et al., 2017, p. 326). Thus, monetary incentives are not necessarily effective. It could be cheaper and perhaps easier to include a focus on non-monetary incentives in a vision. However, Bopp et al. do not discuss specific ways to do this in

practice. Lokhorst et al. (2010) provide some insights into this. They found, in an experimental context in the Netherlands, that certain interventions could lead to higher motivations of farmers to improve the environmental quality of their farmlands. When farmers were told beforehand what the consequences of their current practices were and they were provided with tailored information as to how they could improve, their motivation to implement sustainable practices increased. Additionally, making a public commitment to do this strengthened the effect found in the study (Lokhorst et al., 2010). Overall, we see that a good policy action plan needs to include measures and instruments that motivate farmers to take up sustainable practices. This needs to take into account both external/financial motives as well as intrinsic motivations of farmers.

From this brief overview we can take away four important factors for good implementation. First of all, policy action plans need to be properly formulated and important concepts need to be conceptualised consistently. Secondly, it is important that farmers have enough knowledge to participate in and implement sustainable practices and that policy takes this into account. Thirdly, we have seen that a policy action plan needs to include measures and instruments that motivate farmers to take up sustainable practices. Especially targeting intrinsic motivations of farmers can be important. Finally, financial viability and having the right resources by farmers are important factors in policy success. Table 3 summarises these categories. In the next section, we will apply these insights to the interviews we conducted with policy makers. There, we will see to what extent these policy makers mention whether these issues are present in policies related to the flower bulb sector.

Table 3. Categories for policy evaluation

Category	**Explanation**	**Sources**
Knowledge/expertise	knowledge and expertise among farmers on sustainable production techniques necessary to properly implement policy. Lack of knowledge/expertise among policy makers on what problems farmers are facing.	*Howes et al, 2017* *Siebrecht, 2020* *Runhaar et al., 2017* *Van Eerdt, 2014* *Papadopoulos, 2015*
Costs/ financial security	Policy needs to ensure that high costs of innovation and transition are being accounted for.	S*iebrecht, 2020* *de Olde et al., 2017* *Runhaar et al., 2017* Tilman et al., 2002
Motivation	Policy needs to motivate farmers to take up sustainable practices. This needs to take into account both external/financial as well as	*Siebrecht, 2020* *Runhaar et al., 2017* *Bopp et al., 2019*

	intrinsic motivations of farmers	*Lokhorst et al., 2010*
Technical/ conceptual	Policy needs to be clear on the use of concepts, methods and how it will be monitored/evaluated.	*Siebrecht, 2020* *Howes et al., 2017*

5.2 Issues That Arose from Our Interviews

In this section, we will gain an overview of the problems surrounding policy implementation in the flower bulb sector, based on interviews with policymakers, policy experts and sector representatives. These are the CTGB, the two provinces, the water board and the KAVB. For each interview, we evaluated to what extent the categories of implementation issues we identified previously (see Table 3), are at play in the sector.

Technical/Conceptual

Most of the interviewee's responses fitted in these categories. Especially the CTGB proliferated in this category. One of the issues they mentioned is that current legislative frameworks to approve crop protection are designed for chemical substances. This means that it is difficult to get low-risk substances approved under the same framework. Part of this is that it is difficult to monitor residues in the environment. Most low-risk substances are based on an active ingredient that is naturally present in the environment. Thus, the CTGB signals that since chemicals are going to be banned due to stricter laws and regulations, there might not always be a green alternative. The interviewee from the province of North-Holland (NH) recognises this problem as well and states that a number of substances are prohibited. If there is a sustainable alternative, it is not always approved, creating imbalance. One further issue the CTGB mentions is that policy does not always follow the latest innovations. For example, crops in the Netherlands may not be sprayed by plane/drones because of the aviation legislation.

Other actors argue that current policy is not enough or well-suited to solve the issues the sector is facing. The interviewee from Rijnland states that current laws and regulations for crop protection products and nutrients are adhered by most growers, but they are simply not enough to get the water quality in good condition. The representatives from the province of South-Holland (SH) stated that the chain around crop protection products and nutrients is not set up to change towards sustainability. Finally, the KAVB argued that strict laws and regulations do not permit certain innovations. Flower bulbs have to be absolutely perfect, there is little room to experiment with disease-resistant bulbs.

Costs and Financial Security/Motivation

Another category that emerged several times in our interviews were problems with the costs and financial risks of transitions. Often, this had to do with financial incentives. The interviewees from SH stated that the financial support is not enough to encourage growers to make their business model more sustainable, whereas Rijnland mentioned that the bulb sector is increasingly moving towards producing organic bulbs, but growers cannot sell them because they are too expensive. This is shared by NH, who says that consumers do not care about the origin of products, and thus implies that they are not willing to pay more for organic or locally-grown products. These financial barriers can decrease growers' motivations for a transition. Next to that, our categorisation of motivation also includes non-financial motivation. This topic was also addressed in several interviews as an issue. The interviewee from NH argued that providing money is not always satisfactory: once the growers have used up their subsidy, the enthusiasm often disappears. They can revert to their old practices and no change is generated. Also, it was mentioned that it is difficult for growers to have a positive perspective on the future. They are faced with many sustainability problems. If the government does not offer them a clear and decent outlook with good alternatives, conflicts can arise. Finally, the KAVB representative stated that although there are innovative frontrunners in new technology, the majority are waiting because switching in a conservative sector is difficult. This shows that even with pioneer role models in the sector, it is difficult to motivate the majority of growers to participate.

Knowledge and Expertise

Our final category on knowledge was also mentioned several times in the interviews. The representatives from CTGB argued that new cultivation techniques to replace chemical crop protection require a lot of knowledge and expertise. They stated that since low-risk crop protection substances work less well than the chemicals, other methods are needed to supplement them. Thus, a sustainable sector requires more expertise and knowledge from growers and users, and it also demands more enforcement. Also, there is an obstacle for producers to create a market to develop products that growers want to use. Additionally, NH states that the sector is left with many questions about if they are not allowed to use a substance, which they can use instead. Finally, the KAVB argues that the sector is increasingly moving towards technology, and you have frontrunners in this part, but that the majority is waiting.

Overall, we see that the technical and conceptual category emerges in all interviews and is also the most common. What often comes back is that current policy is not always suited to deliver sustainable outcomes in the ways the interviewees interpret sustainability. Also, new innovations and alternatives are difficult or even impossible to implement due to policies designed to fit the status-quo. The other categories were mentioned less often, but it nonetheless became clear that these

categories are important issues in the flower bulb sector. We have seen that there is not always enough funding or the right funding for a transition. Furthermore, it is important that growers are also motivated in other ways than money. Finally, having the proper knowledge is also necessary with the complicated nature of alternative cultivation methods. Thus, our roadmap should address these issues.

5.3 Evaluating Existing Visions

In the previous sections, we have seen that the implementation issues identified in the literature are also present in the sector. Additionally, it would be interesting to see to what extent existing visions tackle these issues. Thus, in this section we will evaluate three visions: the vision on crop protection, circular agriculture and biodiversity recovery. These are chosen since they contain a full implementation plan. We will assess to what extent the four criteria are dealt with and which ones are missing. If there are already concrete measures for some categories, we can use them in our roadmap. If they are missing or not complete enough, we need to come up with our own alternatives in the roadmap.

Technical/Conceptual

If we start with the technical/conceptual category, a first thought is that the vision on crop protection conceptualize and specify many concepts from the vision and set several goals. In order to reach these goals, they have proposed action points for specific stakeholders. A point one could make is that no timeline or endpoint is given for these action points themselves. Other than that, the vision performs well in this category. The vision on circular agriculture also performs well in this category. It pays a lot of attention at describing what circular agriculture is and what is needed (on the technical side) to achieve this. Moreover, each chapter is accompanied by several policy intentions. For these actions, it is specified which actor should pick it up, and for most it also includes clear end goals in terms of time. The same goes for the biodiversity action plan. They have very clear goals on what they think biodiversity in The Netherlands should look like, especially in the short term. They formulated overall goals, and very specific sub-goals. These sub-goals have concrete end-points (e.g. from 2022, 60% of farmers have to work with other land users towards biodiversity). Next to that they have specific actions for their associated stakeholder with a set time.

Costs/Financial Security

The crop protection vision only has a few measures on costs and financial security. It proposes that when experiments with new techniques fail, the business will be financially compensated. Furthermore, the plan explicitly states that farmers should get the financial means necessary to make the transition. To realise this goal, it proposes new instruments to support farmers with effective but for now unprofitable cultivation systems. Furthermore, the Ministry will explore to see whether existing or

new subsidies can support farmers in the transition. All these points are very interesting, but not very detailed. It is said that new instruments will be developed, but there is hardly any explanation on what these could be. The plan on circular agriculture has some more elaborate ideas and intentions on financial measures and the viability of business models. For example, the plan proposes a fund for young entrepreneurs who want to take over a (family) business and it wants to ensure that there is proper market demand for sustainable products and that farmers who produce sustainable products are paid a fair price for their products. The biodiversity action plan views business models as an important success factor. They aim that business models of farmers contributing to biodiversity improvement will have a competitive advantage in the market in 2021. The business models will be based on rewards from stakeholders, based on the public services such as biodiversity improvement the farmers provide. For example, nature conservation organizations can charge lower rental fees on agricultural land leases based on the biodiversity performance of land users. Thus, this plan mostly aims at rewarding land users for their performance instead of subsidizing them upfront for changing their practices.

Motivation

Motivational issues are quite often overlooked by the visions. There is little to no attention given to this issue in the crop protection plan. The small section on motivating farmers to adopt new cultivation systems mostly explores ways of sharing knowledge. Overall, this vision has very little attention for this issue. In the circular agriculture plan it mostly relates to financial incentives. A point that is not mentioned as a non-financial incentive but can very well be one, is consumer appreciation for farmers. The plan aims that consumers will appreciate the efforts farmers make for cultivating healthy and sustainable food. This appreciation can provide farmers with the positive motivation they need to pursue new cultivation techniques. The biodiversity action plan also mentions a measure that implicitly addresses the issue of motivation. For monitoring their plan, they propose to use biodiversity indicators. Land-users who have a good score, can be rewarded for their performance. It does not specify what these rewards can be, but the mechanism itself is an interesting point.

Knowledge/Expertise

Turning to the knowledge category, we see that the crop protection plan has some action points related to this. They first discuss what type of research is needed, and then devote some action points to knowledge sharing with and between farmers. They propose to set up knowledge networks. In these networks, small groups of farmers from the same sector share their knowledge on best practices, or they will receive new information on best practices from research institutes. Furthermore, if consultation is needed on an individual level, the plan proposes transition coaches and advisors. The circular agriculture vision deals with knowledge and expertise

throughout the plan. There are several policy intentions that relate to this. This plan also proposes to set up networks to share knowledge between farmers. Furthermore, the plan aims to set out which knowledge on best practices is already present at farmers, as well as what should be investigated by research institutes. The biodiversity action plan specifically mentions knowledge as an important success factor to encourage land users in addressing biodiversity. However, they mostly refer to academic knowledge, and including new insights into education. They aim to learn from current research in living labs and initiate new ones. However, the plan does not specify what knowledge is needed for land users to adopt the ideas of the action plan, nor how they are planning to share this knowledge with these land users

5.4 Conclusion

In this chapter, we have identified four categories of issues related to policy implementation. There are issues with the actual policies itself: inconsistencies, conceptualisations and conflicting goals. Furthermore, the lack of knowledge, proper financial support and intrinsic motivation are also factors that can negatively affect policy implementation. From our interviews, we have seen that these are also important issues in the flower bulb sector. They are thus issues we need to adress in our roadmap.

The discussion on existing visions provides us with insights on action points for our roadmap to address these issues. In the technical category all visions do okay, it reminds us that it is important to have clear goals and actions. In the knowledge category we see that all visions aim to increase and share knowledge. Knowledge networks are often mentioned, but the idea could be developed further, which we will do in our roadmap. The cost/financial security category has some nice ideas. It becomes clear that there is some attention for covering risks and providing financial incentives. Moreover, the biodiversity plan showed that it is also possible to financially reward those who perform well on sustainability. We will use these ideas in our roadmap and supplement them with our own. The motivation category is underdeveloped in most visions. There are some ideas that implicitly address intrinsic motivation, such as consumer appreciation and reward systems. Systems such as these will also be proposed in the roadmap.

6. Alternative Interventions Within the Sector

Based on the results of the interviews with the producers; sector association; and researchers, this chapter is conducted. In the first section, there will be explained why the usage of pesticides in the flower bulb sector is under pressure. After the pesticide discussion, alternatives will be presented that the sector can obtain from the interviews. The first alternative: going organic, is clearly elaborated with a case study of one of the frontrunners in organic flower bulb farming. Other alternatives such as: technology expansion, production changes and true pricing will be argued. Feasibility of the announced alternatives will be discussed for the sector. Finally, the importance of collaboration will be stressed. This chapter will answer the following research question:

''What alternative interventions within the sector can contribute to realizing our vision?''

6.1 Call for Change

There is a high amount of pressure on the usage of pesticides in the bulb sector. The cause of the high pressure is because many researchers claim insect decline is linked to the use of crop protection agents. Also, the government wants to reduce the usage of chemical agents. Moreover, because of the statements and concerns in the media, consumers want to know what is being sprayed over the products they are buying, or even have questions when they live near a bulb grower. Chemicals are also seen as a bad image for the flower bulb sector.

At the moment, chemicals are still being used in the bulb sector as it prevents weeds taking over the yield, or preventing lice from entering the crops. Considering bulbs grow outside, all experts agreed that it is more difficult to control insects entering the crops in comparison to greenhouses where you have a controlled environment.

Besides government action plans and concerns in the media, are in the end the consumers that demand a certain quality standard and according to the sector association, will the consumers not buy a tulip that has green stripe on its leaf or other bulb crops that have an imperfection like a spot in the flower. This makes a demand for high quality bulbs, which is possible with the use of pesticides. The concern in the sector is that in order to meet this demand, chemicals are still required at the moment.

6.1.1 Re-evaluating Chemicals

Considering the claims that insect decline is linked to chemical pesticides, the process of getting chemicals approved should be re-evaluated. In order to approve a chemical agent; are most studies performed in the lab and are executed with one specific chemical. This specific chemical is then tested on one specific species that can

survive in a laboratory environment. In this situation, the species are often not stressed in comparison to the environment. Also, in the environment there is not just one chemical and not just one species. There are mixtures of chemicals that end up in the soil and ditches influencing large communities of species. A professor at CML argued therefore, that the species decline in the bulb sector cannot be certainly linked to just chemical usage, there are also other factors such as fragmentation and land use change.

On top of that, the professor at CML argued that due to eutrophication, insect communities are less sensitive to chemical pesticides. This is because due to eutrophication, there are more nutrients in the water that are not limiting for growth and therefore seems to work as stress relief causing an insensitivity for chemicals. This is an unforeseen effect, and can face issues when eutrophication disappears. This does not take away that many pesticides are highly polluting the environment, and many researchers have caused chemicals to disappear and become forbidden in the sector. There are also still new chemicals appearing on the market which have similar chemical structures to the ones that have become forbidden. One could dispute that these chemicals should not even get through the application.

Continuing with business as usual will not be an option for the future, therefore in the following sections we discuss different alternatives for the use of pesticides in the flower bulb sector.

6.2 Alternative for Chemicals: Going Organic

As claimed by an organic bulb grower, who invested many years to transform its land to organic with high biodiversity and no use of chemical pesticides and artificial fertilizer: "*Without healthy soil you cannot grow flower bulbs. You must first get your soil life in order*". Researchers stress that the production process finds itself in a vicious cycle. This is because the starting material (young bulbs) already contain diseases, and when you plant them on the field, you have to spray again with chemicals. When there is a low soil life, your crop also becomes more sensitive to diseases and pests and then you also have to use more chemical pesticides.

When it comes to effectiveness, it is not always the case that an organic pesticide works better than a chemical pesticide. On top of that, an organic pesticide is often more expensive, and when it is unable to prove its effectiveness, it will disappear again from the market.

Going fully organic involves adjusting the entire production chain to grow organic flower bulbs without using any chemical pesticides. To get a better understanding of the difficulties the frontrunner has faced, we present a case study on Huiberts, a company who transitioned entirely to grow organic flower bulbs.

6.2.1 Case Study on Organic Farmer

The biggest organic flower bulb grower in the Netherlands is located in Sint Maartensvlotbrug. In 2013, the company started with a more sustainable flower bulb cultivation. In previous years, it became increasingly clear to Huiberts that not all diseases and pests could be controlled with chemical pesticides, because resistance occurred, which caused diseases to recur.

The first starting point is that the soil in which flower bulbs grow must be healthy. To achieve this, it is important not to disturb what nature builds up. The different layers of the soil each have their own soil organisms that consist of worms and microorganisms. When the land is normally plowed, the soil layers turn. The useful components of the top layer are thus worked downwards, and the bottom layer is placed on top. In this way, both layers are destroyed by flipping them. As an example, some organisms that live in the top layer cannot live in a bottom layer. To keep the layers intact, Huiberts applies non-inverting tillage. This is something that has been on the rise in agriculture for some time. If it is inevitable that plowing has to be done, they will do that very shallowly, to not disturb the soil life. Huiberts states that: ''*A good soil structure is not created by tillage, but by the processes of living biomass in the soil*.''.

As a second point, Huiberts uses mixed green manure so that organisms in the soil remain healthy and plants can grow. They strive to sow the land as soon as possible after the bulbs have been harvested with a mixture of green manures (these are plants that benefit the fertility of the soil). All plants release substances to the soil through their roots. These substances serve as food for the micro life in the soil, thus creating a collaboration between fungi and plants. When given the opportunity to develop, the fungi form networks that support and protect the plant during growth processes. Each type of plant root releases different substances, each with its own properties. Biodiversity in a green manure crop is therefore very beneficial for soil fertility. Huiberts use a mixture of 11 different types. This ensures that organisms in the soil are vital and that the resistance in the ground is optimized and that the disease pressure decreases.

Thirdly, Huiberts has sown flowering field margins. This flower mixture blooms in the summer when the other flowers are no longer blooming. Nectar and pollen from the flowers are an important food source for bees and other insects. The flowering field margins are the place where natural enemies can develop.

Fourthly, Huiberts also mentions that the use of good compost on the soil is the basis of a healthy soil life. They produce their own compost within the company. Their bulb waste is mixed with slightly woody material, rock flour and special organic additives for this purpose.

6.2.2 Successes and Pitfalls of Going Organic

Changing the entire production process to fully organic farming comes with successes and pitfalls. The success of becoming organic is often mentioned by organic growers. They claim that the air is much cleaner than before, and more birds are returning. You become independent when it comes to production of flower bulbs without chemical pesticides, and without artificial fertilizer. Transitioning your field to organic means in the long run that you have a higher biodiversity, and better soil life. Using more organic fertilizer instead of artificial fertilizers, increases organic carbon in the soil. The advantage is that your water retention capacity is much higher. In this situation, not everything is washed down immediately in a wet season, but also, when water is retained in the soil there is no need to irrigate in a dry season.

Despite if the sector will become organic or not, there are many organic techniques that could be used in the sector that could be beneficial for all growers.

The pitfalls of going organic are that the prices of flower bulbs are much higher for the consumers, this is because the production process is more difficult when it becomes detached from chemical pesticides. In the end, there is less land for production, and higher cost price resulting in a higher market price. The danger is that if the company grows below cost price, it cannot survive. It also takes about 7 years to change the land and become profitable, and when there are no other types of income, there is a risk that the company will no longer exist. Another unexpected negative side effect of organically grown flower bulbs is that without the use of artificial fertilizer, your flower bulbs become much smaller. Only when this is sold in comparison to non organic flower bulbs, the difference is considerably. Whether consumers are able to pay more for an organically grown flower bulb is not always the case, especially when there is a choice between common grown flower bulbs, which are cheaper than organic flower bulbs.

6.3 Alternative: Rapid Investment in Technology and R&D

When aiming for a sustainable production process of flower bulbs without the use of chemicals, cultivated flower bulbs with resistance for diseases could be a solution. These bulbs will then prevent a transfer of disease caused by the lice entering the flower bulbs. Many of the important chemicals used in the sector are to prevent lice on your bulbs. As lices are the flying pathogens that transfer diseases, developing bulbs that are resistant for diseases, would ensure no chemicals to prevent lice. The experts also claim that it depends on the cultivars' sensitivity. Some cultivars are more sensitive than others, according to the sector association there is expected that these cultivars will no longer survive when chemicals disappear.

To increase your starting material in a rapid time span, tissue culture could serve for great benefits. For doing this, it is important that you start with clean

material, otherwise your starting material is already infected. The cleaner your starting material is, the less chemicals you have to spray in your crop.

The sector association works with the university of Wageningen to find out if bulbs could be grown inside with LED light in layers. In this situation, bulbs are grown in a controlled environment. The bulbs are then multiplied in a much smaller time period, and would only go outside on the field in the final year. In this way, the bulbs are clean from viruses. It is important that everyone does this otherwise you could still get viruses of a neighbouring company. But when everyone has clean material, in principle, lice can no longer transmit viruses. Resulting that no pesticides will be needed on the field to combat lice. This requires a more heavily system change in the flower bulb sector. By doing so, the landscape in the flower bulb sector will be changed. Indicating that perhaps less land will be needed to produce flower bulbs, and more greenhouses will be used for cultivating bulbs.

According to one of the interviewed breeders, the technology could be faster developed when Crispr Cas would no longer be seen as a GMO in the flower bulbs. Despite the long time span of producing resistance cultivated flower bulbs, it does give hope for the sector to be no longer dependent on chemicals. As technology will not be a problem in the future, at the moment it is still trial and error, it is the question whether it will be in time for the flower bulb sector to fully rely on resistance cultivated flower bulbs.

6.4 Alternative: (Partly) Moving Production (Abroad)

Growing flower bulbs inside, or even partly moving production to another place is part of the intensification of the production process. More efficient, cost saving but also a more sustainable way of producing flower bulbs. It would immediately decrease, perhaps even reduce the chemical pesticides to zero when flower bulbs would be grown inside. No more pollution in the environment is a sustainable solution. However next to the extreme high costs, it also changes the landscape of the flower bulb area. The flower bulb area is often associated with the Dutch culture, and attracts many tourists in the flowering season. The location of the flower bulb area is not only attracted by many tourists, it is a very popular location to live among many Dutch citizens. Changing the landscape as a result of going more intensive also changes cultural values that are often not taken into consideration. Considering the landscape change, the sector association said it is important that we have Keukenhof, and we can always plant more bulbs around the area for visitors but the bulbs are not for visitors. He agreed that it creates a positive image for the sector, but in the end it is about the viability of the sector.

6.5 Alternative: "True Pricing"

Transitioning to a more sustainable production process does not only mean less chemicals, better soil life, but also greener energy. Based on the interviews, it seems that more businesses would want to make use of windmills at their farm. Unfortunately, regulation does not always allow this to happen.

Perhaps, the production of flower bulbs are overloading the market. Implying that there are more flower bulbs than demand can take. This also causes low prices, and high competition. When there is a high competition for a low production price, there is a risk that chemicals are highly indispensable for maintaining low prices. One of the arguments of the organic flower bulb farmer was that: "*We are not expensive, normally grown flower bulbs are just really cheap*". Also, the amount of Co2 that is released by producing artificial fertilize is not included in the price of the flower bulbs. Taking greenhouse gases into account in the price, could in the end result in a more sustainable and fair price for flower bulbs.

Perhaps certification could help growers to receive a fair price and to stimulate reducing their emissions and carbon footprint. When no more chemicals are used, when fragmentation is reduced and a better soil life which attracts more birds, it is in best favour of the environment. When growers actively contribute to these ecosystem services, there could be some form of reward in return so it also becomes attractive to contribute even more. It is important to take all stakeholders into consideration when promoting sustainable practices. When there is less pollution, ditches are also cleaner, indicating that a waterboard has to purify less water. It is important to understand all stakeholders in the chain, and how each stakeholder can be stimulated and motivated to work more sustainably.

6.6 Working Together on a Sustainable Sector

Whether all alternatives will be incorporated in the sector, one aspect should always be involved and that is finding a system that allows stakeholders in the sector to collaborate. In the past there was a research institute specific for the flower bulb sector. All flower bulb growers paid a fair amount of money to the research institute for research and experiments on the field. Eventually, the growers would receive information that would be of great value because it decreased challenges that growers were facing. This research institute is no longer existing, causing different small groups of growers doing research independent from each other. Not only is this time consuming and less efficient, it also hampers the transition towards a more sustainable flower bulb sector. Formalizing a new institute in which all growers are part of could be of great potential for the sector. Many researchers and stakeholders are already working on how to shape this kind of structure. What role the stakeholders and researchers will play within the structure is still discussed. Nonetheless, it is of high importance that all companies are obliged to participate in financing the research

institute. In this situation, cohesion is strengthened and awareness is created among the companies. Only in this situation results of the studies can be commonly utilized and soil life can actually be improved in all fields that are used to grow the flower bulbs.

6.7 Conclusion

Based on the findings contributed by our interviewees, we take our conclusions that we cannot continue with current practices without taking new alternatives into our vision. We believe a change is required to ensure high-quality bulbs without depending on pesticides. It is important to focus on targets that will ensure a sustainable sector that is resilient for the future. In order to ensure a resilient sector for the future, it is important to act immediately. Therefore, we filter certain alternatives from this chapter that we find most important to visualize our vision and building on that, our roadmap. We do not believe in fully organic farming, however, organic techniques will play a major part in our vision. A system change involving closed system farming could be a requirement on the long-term. We also agree that conventional bulbs are very cheap and not take the environmental footprint into account, this should be more fairly regulated. Eventually, we truly believe that a solid long lasting collaboration will be in best benefit of all involved in the sector.

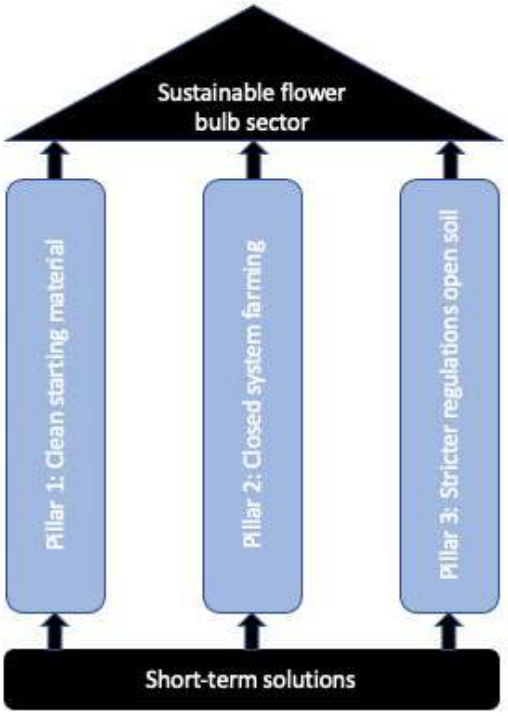
7. Roadmap

The roadmap consists of projects that will require a longer time period (>10 years) to be implemented and immediate actions (<5 years) to be taken by the sector and by involved actors. The table in this section gives a concise overview of all necessary steps. For each measure the relevant stakeholders are listed, as well as the timeframe and the target it aims to achieve.

Figure 8. Visual overview of the roadmap

7.1 Long Term

Considering our hybrid vision as presented in chapter 4, we present 3 elements that are required for a sustainable flower bulb sector that is resilient and long lasting. For the long term solution, a radical system change is required that consists of 3 pillars that only work if they are executed simultaneously.



Pillar 1: Clean Starting Material

Less dependence on chemicals also means more attention for the development of more robust and resilient cultivars. It is important first of all, that growers start with clean starting material to begin with. It could also be a regulation to propose that bulbs planted on land should not contain more than a certain percentage of virus for example. In this way, it is stimulated to use the currently developed techniques on quickly multiplying your starting material. This could be done by shortening the juvenile phase or by multiplying on tissue culture, which is already done with lilies. When all growers start with clean starting material, there will be no virus in their tulips. In this situation it will be almost impossible to get new infections caused by transmission.

To go a bit further, we discuss a more ethical situation that perhaps may play a major role in the sector in the future. It is possible that in a few years time, many cultivars on the market are resistant to viruses, trips, fungi's and other causes that would otherwise require chemicals with the usage of genetically modified flower bulbs. At the moment much research is done to find the DNA markers of the tulips. It would be very wise to do more research into the long term effects of the Crispr Cas technique. When this technique becomes allowed by the government, at least the sector is prepared and knows what parts of the tulip are responsible for certain traits.

The government is still discussing whether this is the way to go or not. Allowing Crispr Cas could open doors to other sectors, which one of them include the food sector, and this is not ideal. It could be the solution for the flower bulb sector as it seems that no chemicals will be needed anymore on the land. Much research and strict regulations will prove whether it is the right solution.

Pillar 2: Closed System Farming

Building on the starting material, we propose the following element that requires a more severe system change that will dramatically change the scenery of the beautiful "bollenstreek" sector. In this situation, the flower bulb farm moves from open farming towards a partly closed system. This involves greenhouses with vertical farming, led lights in where no to a minimum amount of chemicals are used. In the first stage of the bulb growing process, cultivation is done in greenhouses under led lights. As this is a nearly closed system, both chemical usage and residue leakage is controlled and minimized. Furthermore, organic pesticides are more effective inside. Only in its final year, the clean bulb is transposed to open field, where it can grow one more year until final harvest. This system substantially reduces acreage needed. Currently, this system is still being researched on how to make sure the bulbs grow as good as on the field, but also, on how to make this profitable. For this heavy system change, it is required to collaborate with greenhouse horticulture to gain more expertise and latest technology experiences. The question arises however, what will happen to the scenery of the sector. As the bollenstreek serves as cultural pride, it could be expected that the amount of land will decrease.

Pillar 3: Stricter Regulations for Open Soil

When bulbs are clean, and when the majority is grown inside greenhouses, a limited to zero amount of pesticides are expected to be needed on the field. However, this does not mean that there are no major wins to obtain when it comes to sustainability. Producers can learn from organic methods to maintain a healthy soil. However, limited chemical and nutrient treatments remain useful to prevent excessive land use. Integrated Pest Management is used to prevent leaching of chemical residues and nutrients by specifically targeting pesticide and nutrient application where needed and automation, for example by drones that apply pesticides. If it is necessary to use some crop protection substances, a drone can help to treat specific locations parts on the field of a bulb very spot-wise and this precision farming can be used when a disease emerges, but in order to use drones there will be a change in aviation legislation necessary. Also, to achieve more precision agriculture, there can be robots that detect viruses programmed by artificial intelligence which learns and adapts to plant behaviour.

As part of the already compulsory 'plant passport', scores should be awarded based on sustainability score. In this situation, wherever the flower bulbs may go,

customers can at any time check where the bulbs come from and what score it has been granted for its performance indicators. Thus, consumers are enabled to make an informed decision about buying sustainable bulbs. With this quality assurance, it becomes easier to market the bulbs as an environmentally friendly alternative. This can make it easier for growers to work on their biodiversity and soil health. Such a scheme has to be devised by an external regulator. They have to decide on indicators and criteria for these indicators. These so called performance indicators should be developed with the sector association, environmental scientists, universities and the government. When a protocol is developed, all flower bulb companies will be screened based on the indicators. Growers can be audited for their use of crop protection. Points can be rewarded for those that use no chemicals, or only low-risk substances, or correctly apply forms of integrated pest management. Furthermore, there have to be criteria for soil health. Possible measurements include the amount of pesticide residue, the biodiversity of soil life and the presence of excessive nutrients. All this data together can be used to award a score to the environmental friendliness of the bulb. This can be visually similar to energy labels for homes and household appliances. The important thing is that this score is visible to consumers, in order for them to make an informed decision. It is possible to extend the amount of indicators for this plant passport to water quality and biodiversity. The water board already monitors the presence of chemicals in surface water. In the biodiversity action plan, there are ideas to implement a monitoring scheme for biodiversity. Such a scheme can be applied in the flower bulb sector and added to the plant passport.

There are still pilots being done for filtration systems on site, at the moment, in the sector, different growers already have an phytobac in where you can release your residue pesticides. It was possible to get subsidized for these inventions a few years ago. However, this already stopped, and at the moment it is very expensive for a grower to invest in such. It would therefore be wise to start subsidizing these inventions, and to start researching with other filtration systems on site. Researchers are also busy with taking phosphate out of manure, but also with systems that decrease the amount of phosphate released in the surface water. When such systems become available for growers, it would make companies self-sufficient in their water drainage and filtration. In this situation, growers can use more manure without putting additional phosphate in the soil. Using more manure, and by that, less artificial fertilizer and more attention for a healthy soil life (shallow plowing), increases biodiversity and will retain more water in wet and dry seasons.

It is important that these stricter regulations for open soil are obligatory and facilitated in order to be effective. Especially in line with clean starting material and closed systems which both minimum to exclude the amount of chemicals used. When all three pillars are executed simultaneously, the environmental footprint of the sector will be reduced while it remains a high quality and profitable sector.

7.2 Short Term Actions Underlying All Three Pillars

Before we can reach these long-term solutions, a solid foundation has to be built. This section provides those readily enforceable actions and policy recommendations that will enable broad system change in the long term.

First of all, it would be highly recommended to start as soon as possible with mandatory research cooperation. In their visions on sustainable agriculture, the Dutch government proposes knowledge networks between growers and research institutes for the development of new production techniques and sharing of knowledge. However, in the past, these types of collaborations ended when the government stopped to invest in them. By ensuring growers mandatory cooperation in these projects, they can make a credible, long-term commitment. They share the costs, but also the benefits. By benefiting from economies of scale, more money will be available for joint, independent research. Furthermore, by making these collaborations mandatory, a long-term commitment can be made to ensure the future of these projects after funding ends. The focus should lie on pilot projects with organic techniques, green pesticides and mechanical weed management. Research institutes can use these corporations to easily test their latest innovations in the field. Governments can monitor these projects. By knowing what the latest or most promising developments are, the government can amend or create policy that enables these developments to be used. Thus, it also addresses the issue of policy lacking behind innovation.

Learning from the mistakes in the past, and using the synergy from collaborating, knowledge in the sector will be improved. Making sure every grower has the appropriate knowledge to initiate a transition, and creating networks to share this knowledge between growers, is a vital part for a successful policy implementation. Thus, these ‘‘testing fields’’ (proeftuinen) will also be a place where knowledge on sustainable production methods is gained and shared. Based on the fact that tulips are the Dutch pride of the Netherlands, the government should invest from a cultural perspective in the collaboration as well. As we do not expect that the solution lies in fully organic flower bulb farming, it should be emphasized that the sector must learn from the pioneers that grow bulbs organically. Within this collaboration, the knowledge that is gained from organic farming should be practiced by traditional growers as well. This includes shallow plowing and more usage of organic pesticides instead of chemical pesticides. But also, decreasing pesticides by working even more with crop rotation, mixed crops.

Announcing when a chemical becomes forbidden currently happens one year before a pesticide goes off the market. One year is often too short to develop and research into a good working alternative, it would therefore be wise to announce this 2 to 3 years before a pesticide will be banned. At the moment, when a certain

chemical becomes suddenly forbidden, growers have to use chemicals more often and at higher dosages to achieve similar results, resulting in a higher environmental impact. More time between the announcement that a chemical will be banned, will give producers more time to invest in developing another substitute, a more green pesticide. Furthermore, chemical products are only allowed on the market when they have a significantly high effectiveness. Distinctions in acceptance criteria are in place to favour low-risk products.

We also discussed earlier that governments should properly invest in the transition. As also mentioned in several government action plans, we believe that the government should also make it easier to provide financial incentives for growers that want to experiment with sustainable measures within their company. When a grower decides to become organic or to switch to closed system farming, growers should be granted with a financial incentive in the transition time. Rewarding growers that transition to organic by paying them for providing certain ecosystem services, such as water filtration and facilitation pollination. Next to that, we propose a fund or insurance that can cover the risks of initial transition. If a new business model fails to come off the ground, the fund can compensate for the financial damage. This fund can be co-funded by governments, research institutes and growers themselves as a form of insurance. Funds are available for producers that would like to switch to different production systems, but are coping with historical pollution in their soil and water bodies.

Finally, organic cultivation should be awarded with a fair price to create a healthy market, which consists of more than only institutional demand. Currently, consumers pay indirectly for artificially low priced flower bulbs via municipal and water board taxes. These public bodies use that money to clean the environment. It would be more efficient and fair to account for negative externalities more directly in the price. This means that flower bulbs that are cultivated via the traditional way, should be made more expensive. Or to elaborate on this, the bulbs should be more fairly priced taking the environmental footprint into account. This can be done via an additional environmental tax or increased VAT. Here, perhaps a distinction can be made between organic and conventional bulb cultivation. For example, higher environmental taxes for bulbs that were produced using more chemical pesticides and ranked a lower sustainability score. In the end, the effect should be that consumers pay a fair price for every bulb, whether this is organic or not. This makes the market for sustainable bulbs more attractive and will motivate growers on working on their environmental footprint.

However, financial incentives are not completely satisfying. As one of our interviewees noted, interest in projects usually dwindled once funding ran out. Thus, as discussed earlier, it is necessary that growers are also intrinsically motivated to participate in the transition. For a transition to happen, it is vital that it can only be made when growers realize the importance of it and part of this is the acquiring and

distributing of knowledge. One could think of educating producers within the compulsory collaboration on the negative consequences of their current cultivation practices, and/or explain what their role will be in a sustainable production process. Finding the right tone here is very important; if it is too condescending or overly negative you are not likely to inspire the growers. Another interesting idea is to increase consumer attitudes towards growers, as proposed in the vision on circular agriculture. Measures have to be taken to ensure that consumers value growers' efforts to produce high-quality, low-impact products. One could think of awareness campaigns, farm tours or local food/bulb festivals. High valuation and appreciation for growers' efforts can be rewarding for growers and can encourage them to continue their efforts. Finally, the monitoring scheme we proposed for an improved plant passport can be used to reward growers who do well. Not only can it be rewarding for growers to be acknowledged for their efforts by a good score, but one could also think of rewards. For example, the biodiversity action plan proposed that public authorities can ease the processes for permits, tax instruments and subsidies for growers who perform well.

Table 4. Roadmap

Pillar 1: Clean starting material			**Pillar 2: Closed system Farming**		
Action	**Actors**	**Vision/policy target**	**Action**	**Actors**	**Vision/policy target**
Develop regulation to propose that bulbs planted on land should not contain more than a certain percentage of virus	**Ministry of Agriculture, Nature and Food quality** *Develop and propose regulation* **BKD & KAVB** *Develop/determine workable minimum levels of virus for policy*	*Focus is on high value-adding elements in the chain with low environmental pressures, an important one being the breeding of more resilient cultivars.* **Vision**	Explore the technical possibilities of greenhouse cultivation of flower bulbs. Share experience with greenhouse horticulture	**Wageningen University** *Further develop greenhouse bulb cultivation* **Greenport** *Facilitate knowledge sharing*	*Maintaining our hegemony means efficiency should be drastically improved, using less inputs in the form of chemicals, nutrients and land.* **Vision**
Further research into the long-term effects of the Crispr Cas technique.	**Hobaho** *Further development of resistant flower bulbs* **Research institutes** *Further research on Crispr cas*	*Agriculture and horticulture in the Netherlands will consist of resilient plants and cultivation systems* **Toekomstvisie gewasbescherming**	Develop business models based on greenhouse cultivation. Establish to what extent sector is willing to undergo this transition	**KAVB & Greenport** *Explore potential, possibilities and support from sector* **Ministry of Agriculture, Nature and Food Quality** *Develop financial support for this transition*	*In order to make the transition to a sustainable flower bulb sector work, producers should be able to create a viable business model for the future.* **Vision**

Further research/discussion on the desirability of such a technique on ethical grounds	**Research institutes** *Discuss/research ethical desirability of genetic modification* **Ministry of Agriculture, Nature and Food quality** *Discuss political desirability/feasibility of genetic modification*	*Legislation grants enough possibilities for technical innovations in the field.* **Vision**	Preserve the large cultural aspect of the flower bulb region, including possibilities for tourism	**KAVB & Greenport** *Ensure to maintain open cultivation in the 'Bollenstreek'* **Greenport** *'Facilitate activities (for tourists) that focus on cultural importance of sector'* **Ministry of Economic affairs and climate** *Invest in activities that preserve the cultural heritage of the Bollenstreek*	*The open soil stage of cultivation is concentrated in the Duin- en Bollenstreek. Flower fields constitute a national cultural landscape and form an inherent part of the region's identity.* **Vision**

Pillar 3: Stricter regulation for open soil			**Short term actions underlying all three pillars**		
Action	**Actors**	**Vision/policy target**	**Action**	**Actors**	**Vision/policy target**
Integrated Pest Management is used to prevent leaching of chemical residues and nutrients	**KAVB & Greenport** *Encourage members to use IPM, facilitate learning and knowledge sharing on IPM* **Rijnland** *Monitor and evaluate the presence of chemicals in open water*	*Growers make use of technological innovations that enable them to automate production processes and give the producer complete control to adjust to optimal conditions* **Vision** *Where crop protection agents are used, this is in accordance with the principles of integrated crop protection, with virtually no emissions to the environment and virtually no residues.* ***Toekomstvisie gewasbescherming***	Mandatory research collaboration between actors in the Bollenstreek.	**Ministry of Agriculture, Nature and Food quality** *Provide regulations to make this possible. Monitor innovations and prepare policy for smooth implementation of innovations* **Greenport & KAVB** *Initiate, facilitate and support these research and knowledge networks* **Research institutes** *Cooperate with growers to ensure newest and most relevant innovations are being tested*	*Growers make use of technological innovations that enable them to automate production processes and give the producer complete control to adjust to optimal conditions* **Vision** *Relevant stakeholders are working together to increase the diversity of species in Dutch nature* **Deltaplan Biodiversiteitsherstel**
Develop technology and amend legislation to enable precision-farming	**Responsible Ministry** *Amend existing legislation to allow*	*Legislation grants enough possibilities for technical innovations in the field.* **Vision**	Provide appropriate financial support to growers for them	**Ministry of Agriculture, Nature and Food quality**	*In order to make the transition to a sustainable flower bulb sector work, producers should be able*

	growers to use drones **Research Institutes** *Further develop this technology to ensure it meets policy standards*		to realize the transition	*-Financial incentives for growers that experiment with sustainable measures.* *-Rewarding growers that transition to organic by paying them for providing ecosystem services* *-A fund that can cover the risks of initial transition.*	*to create a viable business model for the future.* **Vision** *At least 25% of Europe's agricultural land should be farmed organically* **Europe Action Plan Pesticides, 2020**
Developing regulation to introduce sustainability indicators as part of the already compulsory 'planten paspoort'	**Ministry of Agriculture, Nature and Food quality** *Develop regulation* **KAVB** *Provide input to policy process to ensure policy has sector support*	*Enough incentives and policy tools are available for growers to switch to either closed system or organic cultivation.* **Vision**	Ensure a fair price for both organic and conventional flower bulbs	**Ministry of Agriculture, Nature and Food quality** *Provide regulation that accounts for negative externalities in price of unsustainable products.*	*Negative externalities are better accounted for, reducing the artificial price gap between bulbs with differing environmental impacts.* **Vision**
Develop sustainability indicators next to the already existing "planten paspoort"	**BKD & NVWA & KAVB & CTGB** *Develop targets for sustainable use of chemical crop protection* **BKD & NVWA & Rijnland**	*Product warranty on every bulb and flower,* *Sustainable production process is the norm (KAVB)* **Vitale Teelt 2030**	Provide non-financial incentives for growers to enhance their intrinsic motivation to take up the transition	**Greenport** *Organize activities aimed at increasing consumer appreciation for growers.* **Ministry of Agriculture, Nature and Food quality & KAVB &**	*Enough incentives and policy tools are available for growers to switch to either closed system or organic cultivation.* **Vision**

	Develop targets for soil health and water pollution		**CTGB & Rijnland & provinces** *Include non-financial, motivational rewards in monitoring the system of developed sustainability indicators to reward growers who do well.*	
Develop monitoring and reward systems for the sustainability indicators/scores	**Ministry of Agriculture, Nature and Food quality & KAVB & CTGB & Rijnland & Provinces** *Develop reward system*	Ensure a ban on chemical substances is announced earlier to make sure there is more time to develop alternatives	**Ministry of Agriculture, Nature and Food quality & CTGB** *Provide regulation that ensures this time period* **Bayer/Agrifirm & CTGB** *Establish decent time periods to develop and approve alternative substances*	*Legislation grants enough possibilities for technical innovations in the field.* **Vision**
Research and funding for new techniques that filter excessive nutrients/chemicals from soil	**Ministry of Agriculture, Nature and Food quality & Provinces & Rijnland** *Provide financial support for growers using these techniques* **Research institutes**			

Further R&D these techniques	

8. Discussion

In this study, the way towards a sustainable bulb sector in the Bollenstreek was investigated. It sought to generate a deeper understanding of alternative production methods and improvements regarding policy implementation to realize our vision. Our research contributes to the ongoing debate about the role of future bulb growers in sustainable development because the results show three long-term pillars, clean starting material, closed system farming and stricter regulations for open soil, and a short-term solution for the future of sustainable bulb cultivation.

It was expected that a hybrid future vision stands out from our research and interviews because there is not one strategy that fits all. Taking all elements into consideration as presented in the roadmap, it might be possible that the time scale might differentiate. This is because there is no certainty as to when and to if certain legislation might be enforced. Building on this, a limitation of the outcome of the study implicates that a hybrid vision might not be a pathway that is desired and feasible for all flower bulb companies, and other stakeholders involved in the sector. However, in our vision this hybrid sector that we foresee will be a possibility for the sector to maintain its high quality standards and profitability while farming more sustainably and facing more stricter regulations towards the near future. Considering sufficient support, we interviewed the sectors association which represents its growers, but it is possible that perhaps not all growers relate to our proposed vision. An unexpected outcome of our results is that based on our roadmap, it could be possible that part of the sector will move abroad when the stricter regulations find place and system changes are inevitable. It could also be possible that smaller companies that perhaps do not have succession to take over the business might stop sooner due to the stricter regulations and demands.

A limitation of this research is that we only interviewed nine out of our fourteen main actors. The findings and visions of the other five actors have therefore not been included in our constructed vision. This might overshadow visions that the other actors would have on a sustainable bulb sector and this could lead to the loss of maybe interesting and valuable understandings. Ideally, more interviews is desirable however due to privacy and time constraints this was not possible. More interviews however would increase our solution's feasibility and validity. We also acknowledge that as a limitation of our roadmap is that it is difficult to name the stakeholder for each concrete action (see Table 4), this is because it is a prediction of actions in the future and therefore it gives a less certain overview of stakeholders.

The findings of this study have generated further insight in a future view on a sustainable bulb sector. For this we used the backcasting method and this method is

generalizable for highly profitable sectors that face large sustainability issues. While our interviews allow for a profound understanding of the viewpoints of our main actors, the results do not generate generalizable results. The results elaborate on the visions of the actors in great detail but they cannot be used to hypothesize on the visions of other actors of society. The results obtained are specifically for agricultural sectors that rely on open soil in the production process (with chemical and nutrient leakage risks) and to generalize this for other sectors, further research would be necessary. More further research will contain how the compulsory collaboration will be visualized. Also, more specific research should be done on how growers could be motivated in joining studies and other pilot projects that will lead to transitioning to a more sustainable sector. The final limitation of our study is that we specifically focused on the "bollenstreek". By only focusing on this specific part of the Netherland, we do not generalize the entire outcome of this study for the entire flower bulb sector.

9. Conclusion

In today's society, the demand and need for sustainability is growing enormously. This also applies for the adverse effects on the environment of pesticides and excessive nutrients that are used in agriculture, especially in bulb cultivation. This means that a sustainable vision for the future is necessary in order to preserve the sector's importance in the Dutch economy.

This study contributes to the existing literature by looking at how a sustainable bulb sector looks and what it takes from producers and policymakers to achieve that. These are highly valuable insights because currently there is a gap between innovation and policy implementation. Therefore, by interviewing the main actors in the sector and other experts related to the topic, we constructed our own vision. Our own vision is situated between the two extremes found in our interviews. However, by adding our own elements and synthesizing all the different perspectives into one integrated whole, we argue that this vision is more than just the sum of its parts. It calls for a broad system change, restoring the disrupted balance between economic and ecological interests. The environmental impact of the flower bulb sector is minimized. At the same time, the transition from conventional to organic or closed system farming is financially viable which enables producers to make the switch.

To achieve our vision and by making clear what is needed from producers and policymakers to get there, we have created a roadmap where we have specified actions and processes that are necessary to realise our vision (see Table 4). The roadmap involves long, and short-term actions we believe based on our vision will be the pathway towards a sustainable flower bulb sector. The short term actions are enforceable steps that could be taken immediately, whilst enforcing the short term steps, the long term actions are researched and developed. It is also important that the long term steps are executed simultaneously in order to be effective. Both the short and the long term actions will shape how the sustainable bulb production sector will look like.

We have indicated what is required from producers and policymakers in order to execute the steps proposed in the roadmap. Usually, these actions go together. For example, we propose a mandatory research cooperation in the sector containing all growers, and research institutes that together work in finding sustainable alternatives for production techniques in which knowledge sharing becomes a central support base. In order for this to work, we do not only need cooperation in the sector, but also involvement from policymakers to make it happen. For the long term, it is important that breeders expand their research when it comes to the development of resistant flower bulbs as it is very crucial that growers start with clean starting material containing no viruses. Building on this, a heavier system change from growers could

be required. This involves partly closed system farming where bulbs are grown inside and are transposed to open fields in its final year. When bulbs are altered to open fields for one more year it is important to apply pesticides (if necessary) with most precision. However, to make this happen, the ministry of Agriculture, Nature and Food Quality should undertake changes in aviation legislation to ensure precision agriculture with drones to be possible. Another possibility to promote sustainability within companies, is to award scores for performance or biodiversity indicators next to the already compulsory "planten paspoort". In this situation, a zero to minimum amount of chemicals will be required to grow sustainable flower bulbs. This requires action not only from policy makers and growers, it needs input from all relevant stakeholders in the sector to make it work. This signals that, although we have specified our roadmap for producers and policymakers, all stakeholders in or near the sector need to be involved.

Nonetheless, policy makers have an important role. They have to pay attention to the factors that may hinder smooth implementation of this vision. Thus, they have to ensure proper financial support for the transition. We acknowledge the importance of the "bollenstreek" as an important cultural aspect of the Netherlands, and therefore should be financially compensated by the relevant Ministry in order to promote sustainable flower bulb farming. Also, in the short term, it is required that the ministry of Agriculture, Nature and Food Quality invests in pilot projects that experiment with sustainable measures, such as pilots with alternative production methods. There are also other critical factors that influence growers' ability and motivation to participate in the transition. Both policy makers and actors in the sector need to ensure that growers have the right knowledge for new techniques. Furthermore, It is important that the growers are intrinsically motivated to participate in a transition and change their cultivation practices. In the end, we rely on them to bring the flower bulb sector into a sustainable future.

Recommendations for Our Commissioners

Greenport, in association with ACCEZ, have asked us to envision what a sustainable flower bulb sector would look like, and what is needed from important stakeholders to achieve it. This has resulted in our vision and roadmap. Our vision brings together several insights, and combines them in one meaningful endpoint. Thus, instead of having several different visions, we have provided one. Greenport can use it to focus or demarcate their activities. Furthermore, our roadmap provides some more concrete steps for the elements of our vision. Although they function best as a whole, it is possible for Greenport to first develop and study only one of the pillars, to find out its potential. Next to that, we have devoted some specific action points in the roadmap to Greenport. If they decide to further explore one pillar or a part of a pillar, these could be starting points.

Pillar 1

Greenport could prioritize research on clean starting materials. In cooperation with research institutes and private companies they could find out which techniques work best, as well as discuss with actors whether genetic modification is a desirable alternative.

Pillar 2

Greenport could determine whether growers and other relevant actors in the sector are open to move part of their cultivation to greenhouses. Greenport could also study, together with existing greenhouse horticulture, how a transition to closed system cultivation could work best for flower bulbs. Greenport could also think of events that preserve the cultural heritage of the Bollenstreek.

Pillar 3

Greenport could assist growers in becoming more adept with integrated pest management, as well as further encourage usage of IPM. Greenport could also study to what extent growers would be open to an expanded 'planten paspoort' based on sustainability indicators. Furthermore, they could study how such a system would work in more detail.

Short Term Actions for All Three Pillars

Greenport could investigate how a mandatory research cooperation could be realised, as well as facilitating this cooperation in their role of broker between the sector, research institutes and government. Greenport could also think of events and projects that enhance the intrinsic motivation of growers.

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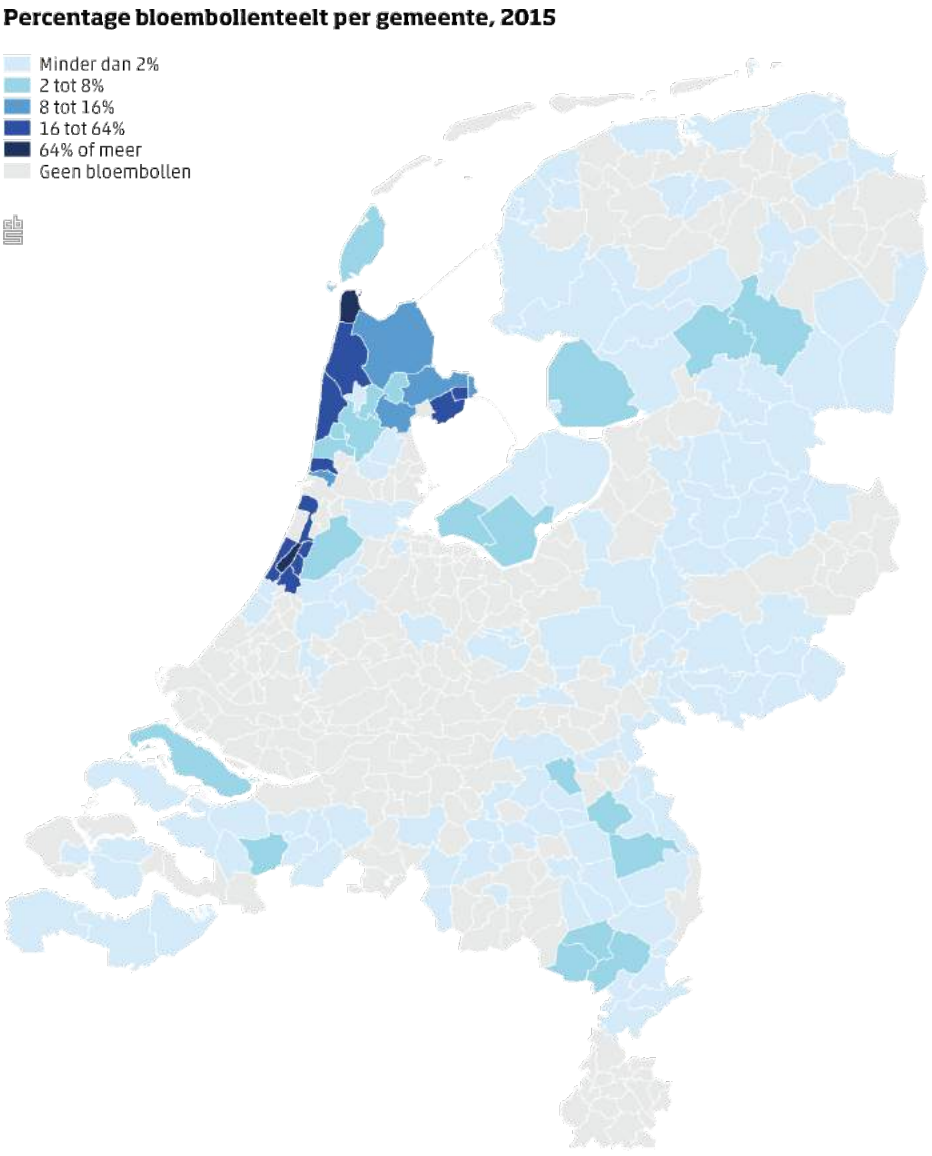
Annexes

Annex 1. Map of the Flower Bulb Sector



Annex 2. Building Blocks of the EU-Strategy on the Use of Pesticides

These building blocks are based on possible elements of National Action Plans:

1. Procedures for giving the public effective opportunities to participate in developing, implementing and monitoring the National Action Plan and any revisions.
2. Setting individual targets for hazard and risk reduction. Member States may identify priority crops, activities, or active ingredients where trends are worrying, and may establish use reduction targets.
3. Training distributors, advisors and professional users, including certification schemes.
4. Awareness-raising campaigns to inform the general public and non-professional users about the hazards and risks associated with the use of pesticides.
5. Organisation of effective structures to provide independent and objective advice to professional and non-professional users on the most appropriate pest control solutions.
6. Regular inspection of pesticide application equipment.
7. Specific measures regarding the general ban on aerial spraying, and possible derogations.
8. Specific measures regarding the protection of the aquatic environment from pollution by pesticides.
9. Designating areas of reduced and/or zero use of pesticides, in particular areas used by the general public or children, or in connection with Natura 2000.
10. Collecting used packaging and obsolete pesticides.
11. Introducing safe storage, handling, mixing and cleaning procedures.
12. Establishing the necessary conditions for implementation by growers of general standards of Integrated Pest Management that will become mandatory as of 2014, and promoting farming methods with low input of pesticides, such as organic farming.
13. Checking that professional users comply with legal requirements concerning pesticides.
14. Monitoring environmental media (in particular water) for the presence of pesticides, their residues or metabolites.
15. Monitoring and reporting cases of poisoning with pesticides involving users, residents, bystanders, consumers, or wildlife.
16. Promoting research activities to reduce the risks linked to the use of pesticides, including in particular developing and using non-chemical alternatives with less impact on the environment.
17. Considering the application of standard VAT rates to pesticides (where reduced rates are still applied).
18. Collecting data on the distribution and use of plant protection products, and calculating risk indicators at local, regional and national level.

19. Reporting and publishing the effects of National Action Plans, including activities and results based on indicators.
20. Financing National Action Plans. Member States might consider levying taxes or fees on products or activities, with differentiated rates to encourage users to select lower-risk products.

Annex 3. Action Points from the Implementation Program of the 2020 Prop Protection Vision of the National Government

(Agrodis et al., 2019)

- Continuing to demand attention for the development of low-risk substances and products from developers of crop protection products. Nefyto is taking the initiative for this.
- At a European level, efforts are being made to accelerate the approval procedure for active substances with a low risk, so that products based on these substances become available to agricultural entrepreneurs more quickly. The Ministry of Agriculture, Nature and Food Quality is taking the initiative for this.
- The Ministry of Agriculture, Nature and Food Quality is drawing up a "position paper" with a risk-oriented approach as a starting point. This "position paper" forms the starting point for the Dutch commitment to the negotiations in the Council following the yet to be published REFIT document of the European Commission. The "position paper 'discusses the following aspects:
    - Adaptation of the necessary data requirements for the approval of low-risk substances (including substances of biological origin, such as micro-organisms)
    - Consideration of the principles of integrated crop protection and risk mitigation measures in the approval and authorization procedure
    - Further harmonization in minor uses (definition, mutual recognition)
    - Criteria and guidelines for cumulative exposure (for humans, animals and environment) and neurological disorders and coherence with other relevant regulations, such as Regulation (EC) 528/2012 (biocides).

  The above commitment is based on improving and changing the implementation of the Regulation within the current frameworks, because this is the fastest way to take steps that contribute to the transition as envisaged in the Future Vision on Crop Protection 2030. This also ties in well with the findings of the report commissioned by the European Commission in October 2018 and the expected reluctance on the part of the European Commission to amend the regulation. This does not alter the fact that if the European Commission nevertheless submits proposals for amendments, a new situation will arise in which a new assessment can be made. The Ministry of Agriculture, Nature and Food Quality is taking the initiative for this.
- There will be an overview of potential low-risk substances that can become available to the agricultural entrepreneur via mutual recognition or via the railway of small applications. Nefyto is taking the initiative for this.
- There will be an overview of potential basic materials that may become available to the agricultural entrepreneur. For these substances, a plan is drawn

up and implemented for the rapid authorization of these substances. LTO Nederland is taking the initiative for this.

- Focus on including innovative application techniques in the European approval procedure for active substances. The Ministry of Agriculture, Nature and Food Quality is taking the initiative for this.
- Identifying and subsequently utilizing the options for applying a recipe system, custom regulations, controlled distribution, system authorization, exemption and provisional authorization of crop protection agents if related to resistant plants and cultivation systems. The Ministry of Agriculture, Nature and Food Quality is taking the initiative for this and coordinating this with current actions.
- In order to promote the authorization of low-risk substances and agents, it is important that there is an understanding of the possibilities available to use files from (OECD) countries outside the European Union to apply for the approval of an active substance or the authorization of a product. The Ctgb is taking the initiative for this.
- A low-risk substance does not always result in a low-risk substance. The product must also meet certain criteria in order to be authorized as a low-risk product. Member states now deal with this differently, which creates an uneven playing field. The EU is working on a guideline to promote harmonization. The Netherlands is committed to a rapid completion of this guideline. The Ctgb takes the initiative for this.
- Exploring the scope of pilot exemptions and pilot projects. The Minister of Agriculture, Nature and Food Quality is taking the initiative for this.
- More biological substances / resources need to be made available because they are very important as part of resilient plants and cultivation systems, provided they fall under the low risk category. Producers of plant protection products strive to develop new biological substances / products that will fall into the low risk category. Artemis is taking the initiative for this.
- To make an inventory of how other EU countries, such as France, are taking initiatives (organizational and financial) to accelerate and cost-effectively register biological resources for the applicant and make them available to the grower, and check whether such instruments are also suitable for the Netherlands. Artemis is taking the initiative for this.

Annex 4. Current Issues from the Implementation Program of the 2020 Crop Protection Vision of the National Government

(Agrodis et al., 2019)

- Current issues are an obstacle to realizing the goals of the implementation program. Insight into the development of the number of current issues and their causes is therefore important. A widely supported system for mapping current issues is being developed and applied. Where possible, use is made of information sources that are already available, such as the EUMUDA database for minor applications and the early warning system for substance renewals (see next action). The vegetable sector organizations are taking the initiative for this.
- An "early warning" system has been developed for the possible loss of active substances as a result of European decision-making. The plant sector organizations take the initiative to identify possible current issues on the basis of this and to resolve them in a timely manner.
- If an equivalent alternative is not available in time, growers must be helped to bridge the time in between. The sector, government and other relevant parties, such as authorization holders, are looking for an adequate solution for each issue in joint consultation. A Plan of solutions is drawn up as a basis for this; the plant sector organizations are taking the initiative for this. The plan of solutions includes possible solution routes and associated instruments for both the short and long term. This is explicitly viewed broadly and may include, for example, new or additional research into alternatives, the removal of barriers to the application of alternatives (financial, legal or otherwise) as well as more short-term solutions such as exemptions and (trial) exemptions. With alternatives and solutions, it is paramount that they do not entail unacceptable risks for humans, animals and the environment.
- The plant sector organizations have compiled a selection of 22 current issues that require an urgent solution. These concrete cases are introduced and discussed in or under the flag of the working group on current issues. The joint ambition is to find solutions for these issues by 2020, from which lessons can be learned to address emerging issues in the period thereafter.
- The effectiveness and efficiency of the available instruments for solving current issues are regularly evaluated and discussed with the parties involved. If necessary, the available instruments and their use will be further optimized on this basis.

Annex 5. Relevant SDG's and Associated Targets of Our Research

SDG 9: Industry, Innovation and Infrastructure: Generating employment and income through innovation. With the corresponding targets:

- 9.2: Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances
- 9.4: By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities
- 9.5: Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending

SDG 11: Sustainable Cities and Communities: Making cities safe, inclusive, resilient and sustainable. With the corresponding targets:

- 11.a: Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning
- 11.b: By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change

SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. With the corresponding targets:

- 15.1: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
- 15.5: Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species

SDG 17: Partnerships for the Goals: Revitalize strong (global) partnerships for sustainable development. With the corresponding targets:

- 17.16: Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries

- 17.17: Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships

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