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Consumers' perception of precision agriculture's advantages and challenges and their intention to buy precision agriculture products

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Abstract

Agricultural technologies have a significant impact on the agricultural sector. Research was conducted to determine growers' characteristics affecting precision agriculture adoption rate, yet consumers' perception of precision agriculture has received little attention. This study analyses consumers' perspectives of precision agriculture products and their intention to buy them. First a systematic literature review was conducted to identify precision agriculture's advantages and disadvantages followed by an online experimental survey to collect data about consumers' opinions. The sample consisted of 100 respondents living in the Netherlands and consuming vegetables. Data were analysed by using statistical analyses. For the identification and interpretation of the relationship between the advantages and disadvantages of precision agriculture and consumers' perceived benefits, descriptive statistics have been applied, and a cluster analysis was made to identify groups of consumers with the same opinions. A regression analysis followed to determine what influences consumers' intention to buy precision agriculture products. The results show that consumers have a positive perspective of precision agriculture's influence on the products yielded and particularly their intention to buy is influenced by the products' taste, appearance and healthiness. Furthermore, the findings of this study can be useful to support policy in the agricultural sector, the agricultural suppliers', cooperatives' and growers' marketing strategies.

Contents

Chapter 1: Introduction

Theoretical developments have illustrated that growers face many challenges during and after the production process. The production costs are getting higher and there are demands for higher production both in quantity and quality, with minimal environmental damage. These demands exert pressure on the production supply chain (Ofori et al., 2020). In the past several decades, innovations have played a major role in dealing with the challenges of the agricultural industry.

Among the marketing challenges that growers face is creating and retaining more added value for their end customers. Particularly, the development of new technologies collecting, monitoring and controlling data from the farms introduced the concept of precision agriculture, which supports growers' decision-making (Kamilaris et al., 2017). One of the major topics to be investigated is how growers can take advantage of innovations and how new technologies can address the challenges facing the agricultural sector by supporting growers towards more sustainable practices.

Precision agriculture can be defined as an agricultural management process, through which growers use such technologies as monitors, sensors or other equipment to acquire data from multiple sources and spots of the fields, thereby enhancing their profitability, sustainability and resource performance or efficiency (Blackmore et al., 2003; Shibusawa, 1998). The objective of this process is for growers to use their resources such as water, soil, seeds and fertilizers efficiently by reducing expenditures or production risks (Venter, 2020). Precision agriculture has multiple advantages. First, the data contribute to both the technical level, i.e. production techniques and methods and the business level, i.e. business management by creating value from raw information (Wolfert et al., 2017). Second, the data derived from precision agriculture influence the efficiency of the growers and of the entire agricultural supply chain. (Wolfert et al., 2017). Finally, society greatly benefits from precision agriculture, which necessitates research to further implement precision agriculture technologies (Grebitus et al., 2017). A challenge, though, is that despite such innovations being marketed and proven effective for a few years their adoption rate is still quite low (Ofori et al. 2020; Griffin and Yeager, 2018; Pierpaoli et al., 2013). The key problem with precision agriculture is that it demands high investments and is financially risky for the growers, resulting in the adoption of less risky cultivation techniques. From the growers' perspective, they can gain extra values such as profits, yet traditional agriculture can ensure the profits earlier than with more innovative techniques (Yigezu et al., 2018; Pannell et al., 2006). Moreover, growers' lack of expertise and skills in new technologies account for the implementation difficulties (Leonello et al., 2019; Robert, 2002), leading to uncertainty as for the future opportunities that these technologies can bring (Eastwood et al., 2017; Kutter et al., 2011).

Even though precision agriculture can give growers advantages, such as resource efficiency, profits, and sustainable processes, with the technology being the distributor of these advantages, growers are still not convinced of the improvements they can have to the production procedure when they integrate these innovative techniques and technologies.

One of the drivers for the growers to adopt precision agriculture is its value as perceived by the consumers. When growers recognize the external advantages of their production in terms of their prospective consumers, they will take advantage of the added value of the innovative techniques and technologies and finally be more willing to integrate those (Hunt, 2007). Given the various challenges that both growers and consumers face as their decision-making is influenced by the complexities of demand and supply (Tantalaki et al., 2019), consumers' behavioural characteristics can influence growers' decision making. When growers know that precision agriculture is highly valued by the consumers, then they will be most likely motivated to adopt it (Tantalaki et al., 2019).

Despite research to identify growers' motivation to adopt precision agriculture or its adoption rate, there is still insufficient research on how consumers may take advantage of precision agriculture and add extra value to the products yielded. A different approach to precision agriculture's low adoption rate is to investigate whether and how consumers perceive the added value of precision agriculture or whether they intend to buy precision agriculture's products.

The aims of this research are twofold: First, to investigate the added value from the precision agriculture to the growers and second to research its recognition by the final consumers and their intention to buy such products. From a systematic literature review, the added value of precision agriculture will be investigated and a theoretical framework with the objective of merging growers' and consumers' perceived benefits will be developed.

The key contribution of this research is the discovery of the most important benefits of precision agriculture for the consumers and which of these benefits can motivate consumers to buy such products. The main achievement, including the contributions to the field can be to positively influence the adoption rate of precision agriculture by growers. The main advantage of the precision agriculture's value recognition by the growers will be to make the most out of it. Moreover, additional research can be conducted in the future so that growers will be able to make further use of the data produced through precision agriculture and make this information more valuable for consumers as well.

The main research question pertaining the above reasoning is the following:

- *What is the added value of precision agriculture for consumers that can lead to higher adoption rates by growers?*

The key research question is divided into three sub-questions:

- What are the advantages and the challenges of precision agriculture for growers?

- How do consumers perceive the benefits and the challenges of precision agriculture?

-Which of these advantages or challenges affect consumers' intention to buy precision agriculture products?

The remainder of the report is structured as follows: Chapter 2 cites theories on innovation adoption and a systematic literature review conducted to identify the precision agriculture advantages and the challenges and describes the conceptual framework and the methodology for the practical research related with consumers' perspectives; Chapter 3 describes the methodology used to answer the research questions; Chapter 4 reports the empirical results, while concluding remarks are stated in Chapter 5. Chapter 6 includes issues for further discussion.

Chapter 2: Literature background

2.1 Innovations' adoption theories

Technological innovations play a crucial role in the agricultural sector by facilitating growers to produce efficiently and sustainably (Cavallo et al., 2014). Previous research revealed growers' perspectives on precision agriculture and contributed to further understanding growers' behaviour. Recognizing which factors influence growers on their decision making, leads to drawing marketing strategies, which can enhance precision agriculture's adoption.

Roger (1983) suggests that **innovations' characteristics** have an impact on innovations' adoption rate. The innovations' characteristics are namely: *Relative advantage, compatibility, complexity, trialability, and observability.*

- The *relative advantage* describes how a new technology is superior to the one that intents to surpass. This can be realized by the adopters as higher financial returns, higher convenience and satisfaction or better reputation than without the use of these technologies (Roger, 1983).
- *Compatibility* describes how coherent a new technology is to the adopters' present activities or their beliefs. Innovations not consistent with the social norms or the adopters' and society's beliefs need more time to become accepted (Roger, 1983).
- *Complexity* explains how difficult an innovation is to be understood and utilized. An innovation is widely accepted when it is easier to be understood and does not require new knowledge and skills (Roger, 1983).
- *Trialability* describes how easily innovations can be tested by the adopters in advance. In growers' case, meaning that they are more willing to try an innovation when they can first make a trial in a small part of their production (Roger, 1983).
- Lastly, *observability* refers to the noticeableness of the innovations' results from the other potential adopters. For instance, when innovations are located in places that growers can easily observe then the adoption is broader (Roger, 1983).

The above attributes and how growers perceive them can clarify the different adoption rates. Prior research concerning precision agriculture adoption has shown that new technologies' complexity and compatibility are essential parameters influencing growers' decision making, given that they need to make high investments and they need to acquire new skills. The innovation adoption theory contributed in many studies about growers' decision making for the adoption of agricultural technologies involved in precision agriculture. Growers need to see the improvements an innovation can bring to their production, therefore determining the precision agriculture's advantages and challenges can provide useful information to investigate how taking advantage of them will contribute to increasing precision agriculture's adoption rate.

Another theory that supports the research of the technological innovations' adoption is the **Technology Acceptance Model (TAM)** (Davis, 1989). Research has shown that the information's usefulness and complexity are influencing adopters' decision-making. TAM is constructed from two elements. The "*Perceived ease of use*" which examines how easily an adopter can use an innovative technology and the "*Perceived usefulness*" which refers to the chance that adopters can improve their outcomes (Davis, 1989). Moreover, TAM theory discusses the relations of these two determinants with the beliefs, attitudes and the behaviour of the adopters. Studies based on TAM theories state that growers' intention to buy precision agriculture technologies is influenced by their attitudes and by their profits (Adrian et al., 2005). Therefore, it is assumed that consumers' perspectives can play an influential role to their decision-making since consumers determine their profitability by deciding whether they intent to buy the yielded products or not.

Another theory that investigates the technological adoption is the **Expected Utility Theory (EUT)**. This theory explains that a grower is willing to adopt an innovation when the expected added value surpasses the value attained by traditional technology (Batz et al., 1999). This can be explained by the benefits and the costs related to the innovation (Wejnert, 2002). The costs related to economic and non economic expenses or risks that adopters face when they should decide to adopt a new technology or not. Direct economic costs or financial uncertainty includes costs related to purchasing the new technologies while indirect can be monetary or not, such as purchasing new equipment on the side of adopting an innovation (Feder & Umali, 1993) or acquiring new skills to use the adopted innovation and train the labour force (Gerwin, 1988). Social challenges are related to societal perspectives and circumstances (Gerwin, 1988), for instance agricultural innovations can be easier adopted by richer growers than those that are in a weaker economic position (Feder & Umali 1993). This theory also confirms that precision agriculture's advantages and challenges should be investigated. An essential benefit for the growers is the high products' demand. Therefore, consumers' perspectives in relation to growers' perspective can motivate or not growers to adopt precision agriculture as well.

2.2 Systematic literature review

In this study a systematic literature review has been conducted to assess the available research related to the precision agriculture's advantages and challenges for the growers and the society overall. A systematic literature review is a procedure that aims to develop new insights and identify theoretical gaps in the literature so far (Tranfield et al. 2003). This study methodology was chosen to examine all the relevant research conducted in the past and synthesize studies in the agricultural marketing domain following a rigorous scientific procedure. Since the main objective of this research is to find out which of the benefits of the precision agriculture are important to the consumers, first a systematic literature review can contribute to defining and categorizing the values that are critical for the growers.

In this part of the research, the benefits are not directly related to the consumers' perspectives but are researched from a more general point of view so that to answer the first sub-research question namely ***"What are the advantages and the challenges of precision agriculture for growers?".*** This procedure is the first step before assessing consumers' perspectives through an empirical research.

2.2.1 Systematic literature review - procedure

A series of steps should be followed with the purpose of attaining accurate and objective results through this research. The study has been built upon a protocol after posing the research question and the three sub-questions to further clarify the objective of the research. For the systematic literature review the populations investigated are the growers and the society in general. The steps are explained in the paragraphs to follow.

Databases selection
To avoid any bias, the first crucial step was a strict selection of the most relevant papers from the most suitable data sources. Thus, the two databases selected were “Scopus” and “Web of Science” owing to their wide variety of articles related to the agricultural and marketing domains. The aim was to compile a comprehensive list of papers that could contribute to determining and categorizing the benefits and the challenges of precision agriculture.

Terms to be investigated
Three combinations of keywords (terms) were developed to research the available literature in the electronic databases. The keywords were selected by breaking down the research question into various components analysing the topic of the research. Specifically, the main components of the research question were “precision agriculture” and “added value”. Additionally, it was considered important to include synonyms of the keywords to create a wide list of papers related with the added value of precision agriculture. Therefore, the synonyms “advantages” OR “benefits” were included in the keyword combinations. Moreover, in the literature, precision agriculture and smart farming describe the same procedure of cultivation, therefore the second string included the keyword “smart farming”. The strings investigated are depicted in Table 1. The research was conducted between 9 December 2020 to 7 January 2021.

Table 1 Strings investigated in the electronic databases Scopus and Web of Science.

Strings to retrieve lists of papers	Scopus	Web of Science
1. (precision agriculture) AND (value) OR (benefits) OR (advantages)	3419	1009*
2. (smart farming) AND (value) OR (benefits) OR (advantages)	487	-

**The research in the Web of Science was limited only in the value variable and not the other synonyms, since the result from the full string was 1,718,090 papers*

While there is considerable literature from a technical sciences’ perspective on various precision technologies, social scientists have only recently started researching this topic (Klerkx et al.,2019). Given the gap in research on various aspects of precision agriculture and the digitalization of agriculture from a societal perspective, limitations to the lists produced by these strings were necessary. To minimize the number of unrelated articles and include the most suitable, more filters were added to the strings in each database. The following steps contributed to the selection of the most relevant papers.

Limitation and selection of the relevant papers

Stage 1 Limitations and initial criteria
The first criterion to identify the relevant papers for this research was to exclude non scientific papers. Book chapters or conference papers were also included to enrich the bibliography. Only papers in English were considered for the final list. A further limitation in the strings was to apply database filters excluding any papers not related to agriculture from the perspective of the scientific fields of Agriculture, Horticulture, Sociology, Decision Making, Management, Economics, Agricultural Economics and Policy Making. Scopus and Web of Science have different filter categories and the decision

making of the filters was made subjectively with the aim of representing similar results. The final strings of Keywords after applying the filters are depicted in Appendix 1. In this phase of the systematic literature review the duplicated papers from the two databases and strings were resolved and the final selection of the articles is described in Stage 2 and depicted in Flowchart 1.

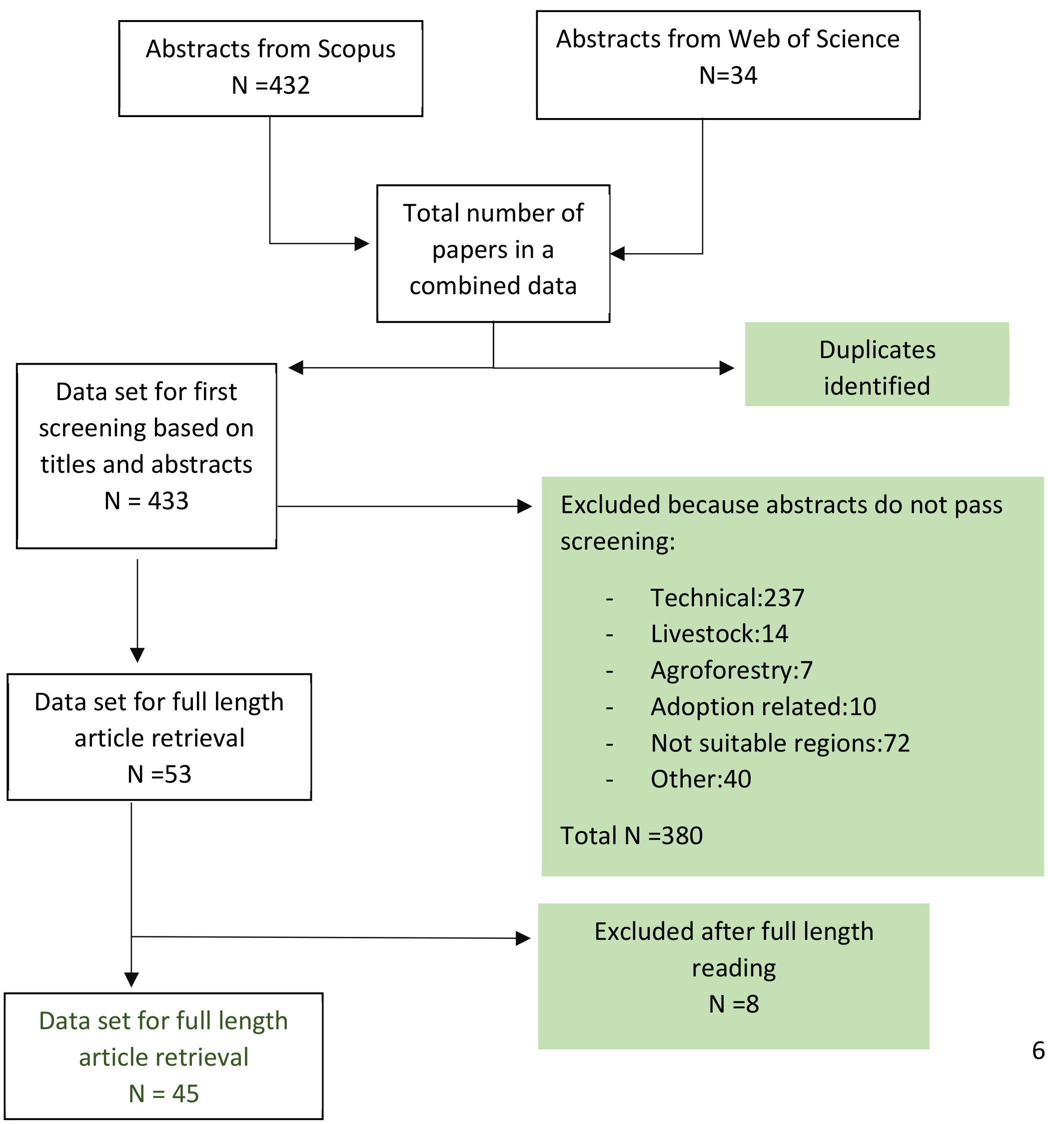
Stage 2 Title and abstract screening

Titles and abstracts were reviewed, and irrelevant articles were excluded based on the coding of abstracts. Finally, 380 papers were excluded as they did not meet the inclusion criteria. The inclusion criteria used for the list of papers are the following:

- The titles or the abstracts should refer to the added value or advantages or benefits of precision agriculture, smart farming, new technologies or Big Data in agriculture.
- Research should be conducted in Europe or developed countries.

The criterion for failing the screening phase was for an abstract to mention that the paper involves only technical research, livestock or the agroforestry sector. Papers addressing the adoption rate from a managerial perspective were included. Finally, papers with research not conducted in Europe or developed countries were excluded.

Flowchart 1: Systematic Literature Review procedure.



Stage 3 Analytical reading of the papers and final exclusion
This stage includes both the final selection of the literature review papers and data collection.

Data collection / extraction

The aim of the data collection procedure is to extract relevant information and results from studies that passed the screening and the abstract reading phase. The procedure followed aims to synthesize the results of studies related to the precision agriculture or smart farming and their values / benefits / advantages and finally link the collected data and answer the first SRQ *"What are the advantages and the challenges of precision agriculture for growers?"*.

All the articles collected for investigation were read and the pertinent data were collected. From each literature review paper related to precision agriculture's added values, information about the advantages or the challenges of precision agriculture has been identified and extracted manually following a review of each paper. An excel file (spreadsheet) was a tool to organise the advantages extracted, the challenges, the publication year and authors into tables.

In this stage, 8 more articles were excluded after being read. Appendix 2 illustrates the full list of the articles selected.

Data analysis of Systematic Literature review

The objective of the data analysis and synthesis is to summarize, combine and finally categorize the results of previous studies included in the systematic literature review, through a quantitative and qualitative analysis. Various advantages and challenges identified in the literature, and 9 categories were created to group the same or similar concepts The categories representing the grouped values were named by the researcher, and a brief description was provided. Quantitative results are presented as well.

In the next subchapter, the results and the categories are presented analytically.

2.2.2 Results of the Systematic Literature Review

Precision agriculture advantages

- **Resource efficiency and decision-making management**

The agricultural productivity, regarding quantity and quality, is usually connected with the efficiency of the production process. An efficient process occurs when the growers apply fewer inputs such as land, water, nutrients, energy, labour, or capital to reach their desired output result (Kumar et al., 2020). This can be achieved by understanding the crop demands in time and by applying management practices related to the site-specific measurements.

In the literature, it is stated that precision agriculture new technologies and the data produced by those assist the growers to understand the site-specific demands of the crops leading to growers' management practices improvement (Miao & Khanna, 2020). Data and innovative technologies allow the growers to make informed decisions about the planting time, the fertilization, and the safety of the crops (Sarker et al., 2020). This is owed to growers using the necessary inputs efficiently (Finger et al.,2019) and timely (Coble et al.,2018).

Examples of high – tech technologies are sensors, robots, and drones, which collect data from the fields and support the growers develop an insight into the production process of the crops. Growers can obtain essential information concerning the watering and fertilization needs (Loures et al.,2020). As a result, they can make incremental improvements in resource management, while optimizing the inputs and maximizing the yields. Moreover, IoT (Internet of Things) and data enable the growers to manage their production even remotely when needed, leading to timely decision-making (Miao & Khanna, 2020).

Other authors refer to the intelligent models technologies, which provide information and forecast the demands of the crops (Sharma et al.,2020). Such advanced assessments constitute a part of an enhanced decision-making process for the growers (Yu & Hendricks, 2020). Sarri et al. (2020) report that the use of such data contributed to the growers' decision-making and improved grape yield both in quantity and quality.

- **Low Production risk**

The production risk category has been drawn to describe the benefits that precision agriculture has on decreasing its production related risks. Production risk sources are associated with the inputs used, weather and machinery, and their impact on the estimated final yield (Crane et al., 2013).

New technologies can contribute to minimizing the production risk by providing growers with information about the necessary resources and the cultivation conditions. Thus, it is possible for the growers to eliminate the perceived risk, by making informed management decisions about the production procedure (Klerkx et al.,2019).

- **Economic benefits**

Profitability is among the major factors determining whether growers adopt a new technology or not. This category refers to the potential economic benefits that precision agriculture can bring to the growers and finally the consumers. The economic benefits identified in the literature review are not only related to the direct revenues but also to indirect benefits. Indirect benefits refer to the economic benefits that growers and society can claim by the access and use of the data produced in precision agriculture such as allowing them to have access to economically valuable statistics of the national product yields facilitating them to take the best decisions (Tack et al., 2019).

A number of authors have recognized the economic benefits that precision agriculture can bring. A recent study by Thompson et al. (2019) has concluded that 88% of the precision agriculture adopters have mentioned these technologies contributing to their financial gains. In particular, they reported an approximately 2% increase in their net returns and profits owing to higher yields after using new technologies (Finger et al., 2019).

Precision agriculture economic benefits result from the decision-making process and the efficient use of resources. For instance, some authors state that new technologies, such as in-field sensors, can be more economical and effective technologies to manage farms and allocate the resources efficiently (Odara et al.,2015). Currently, the number of new technologies used in agriculture is increasing, and the resource costs can decrease thanks to the effective decision-making process . This decrease in resource costs could predict a higher integration rate of precision agriculture, yet there are still concerns over whether all agricultural businesses could afford to integrate them (Finger et al.,2019).

Since the economic profitability of precision agriculture is controversial in the literature review, there are some potentially open questions regarding the economic profitability of precision agriculture. For instance, Loures et al. (2020) claim that the performance costs of using aerial imagery technologies and the costs related to the consultants needed to interpret the data can exceed the potential economic gains. These concerns are related to the initial capital and the managerial skills needed to interpret the data (Stull et al.,2004). Profitability will be further discussed in the paragraphs about the challenging factors.

- **Environmental sustainability**

Prior literature has emphasized the positive impact of precision agriculture on the development of sustainable practices (Sharma et al., 2020), while it is often conventional production systems that have major environmental impacts. Recent theoretical developments have revealed that precision agriculture techniques and technologies have the potential to address environmental problems in the agricultural sector and finally lead to environmental sustainability. As defined by the United Nations (2020), *"Environmental sustainability is about acting in a way that ensures future generations have the natural resources available to live an equal, if not better, way of life as current generations.".*

Numerous existing studies in the broader literature have examined the application of new technologies in connection to precision agriculture contribution to environmental sustainability. Various data were collected emphasizing that the new technologies used in precision agriculture reduce the negative environmental impacts footprint of agricultural production by minimizing pesticides, fertilizers and or water used (Galioto et al.,2017). In this manner, precision agriculture can assist to monitoring pollution or resource depletion, thus leading to environmental sustainability. Indicatively, this has been discussed by numerous authors in literature and in this systematic literature review the positive impact of precision agriculture has been mentioned 31 times or in 58,5% of the total literature reviewed.

Several studies suggest that precision agriculture is a sustainable agricultural process (Sharma et al.,2020), environmentally friendly practice (Miles,2019), diminishing natural resources depletion (Lioutas et al.,2019). Miao & Khanna (2020) attribute this to using sensors and the evolution of IoT, which can precisely recognize the polluting sources during the production stages. Since precision agriculture process implementation can lead to proper management of such resources as water or nutrients (Loures et al., 2020), it results in energy savings and reduced greenhouse emissions (Finger et al.,2019). Moreover, these new agricultural technologies facilitate growers to minimize chemical treatments, while providing them with data to apply site – specific treatments and finally reduce resource usage (Lencsés et al.,2014).

An example identified in the literature is applying mechanical ways for weed control to prevent the negative impact of chemical herbicides. Lencsés et al. (2014) state that weeds can be controlled in a sustainable way either with mechanical management or by reducing or even eliminating the use of herbicides, controlled by a computer (Van Evert et al.,2017). However, the potential environmental benefits of these new technologies are questioned since the CO_2 emissions of mechanical systems for weed extraction (Van Evert et al.,2017) can be relatively high. Therefore, it remains unclear whether all the precision agriculture techniques and technologies can contribute to environmental sustainability.

- **Product quality**

The literature review illustrates another benefit from new technologies in precision agriculture, namely improving the quality of agricultural products (Beluhova-Uzunova & Dunchev, 2020). Quality is a critical factor both for growers and consumers despite their distinct perspectives. Product quality entails various product attributes, such as the taste, appearance, healthiness/nutritional value or sustainability (Brunsø et al., 2002).

Several authors have recognized these values. For example, Finger et al. (2019) report that precision agriculture management leads to high quality and thus higher prices for the growers, therefore they are more willing to adopt these technologies. Consumers that are highly aware of product quality and their quality requirements have transformed food production systems accordingly (Beluhova-Uzunova & Dunchev, 2020). Consequently, improved quality can lead to improved customer satisfaction, and thus improved profits for the growers.

Several examples are reported in the literature to address the issue of quality. Studies of new technologies and precision agriculture suggest that high product quality is achieved when growers follow proper and efficient cultivation techniques. For instance, high quality can be achieved by minimizing product damage and by efficient irrigation and disease control management.

Big data enable growers to observe a disease early and let them proceed to pest management measures timely and efficiently with the purpose of minimizing infection impact and produce high quality products (Sarker et al., 2020). Other research reveals that proper irrigation management, with an accurate irrigation schedule, affects product quality (Sharma et al.,2020). Such applications as machine learning algorithms, a field of artificial intelligence, can contribute to irrigation scheduling, by providing the growers with real-time accurate data about the crops' condition and forecasts about their water demands (Goap et al., 2018; Sharma et al., 2020). Literature on cereal production reports that yield monitoring technologies are associated with high – value products (Finger et al., 2019; Aggelopoulou et al. 2011). Another study by Ramundo et al. (2016) concluded that using quantitative measurements with new technologies used in vineyards to monitor grapes provided the growers with essential information for producing high quality grapes (Ramundo et al.,2016).

Overall, these results demonstrate a strong positive effect of precision agriculture on crops' quality. Precision agriculture can optimize production and yield innovative products of high quality (Kuch et al.,2020).

- **Product quantity or crop yield**

Increased yield is another asset important value of precision agriculture is increased yield productivity. The increased yield category has been created since several data collected refer to increased final product quantity through precision agriculture process (Grieve et al., 2019). A series of recent studies has indicated this an important effect of precision agriculture.

The use of precision agriculture can provide considerable assistance to the growers aiming to raise the yields produced. Increased yields can address social problems, such as malnutrition, in a sustainable way (Sarris et al., 2020). Increased productivity benefits growers as well. Growers will be satisfied if they can produce a higher crop output in the same land. Increased productivity can lead to lower costs for the growers and potentially lower prices for the consumers. It is notable that in 23/45 of the articles reviewed (see Table 2), precision agriculture technologies have enhanced productivity (Klerkx et al.,2019). Technologies and big data can help growers in the decision - making process and finally raise the quantity produced (Sarker et al., 2020).

- **Social sustainability**

Precision agriculture consists of practices with a positive impact on both environmental and social sustainability. The social sustainability category has been created so as to describe precision agriculture benefits to the food supply chain and the final consumers. It describes precision agriculture capacity to create an honest cooperation between the growers and society, by giving to the latter access to data on crop production. Regan's research (2019) has indicated that agricultural improvements can have a positive contribution to the relationship of the agriculture sector and the society (Regan, 2019).

Social sustainability's goal is to preserve and enhance social values, such as cohesion, reciprocity and honesty and the importance of relationships amongst people. Research has shown that social sustainability can be perceived positively by the society and the customers (Sarri et al., 2020) and this could potentially add value to the crops produced.

Finger et al., (2019) state that precision agriculture and new technologies may potentially provide customers with access to farming data on the whole production system. For instance, previous research showed that food production traceability can be achieved by precision agriculture's data (Miles, 2019). Moreover, IoT (Internet of Things) technologies can offer promising solutions to transparency issues by producing important information such as production and storage conditions (Bucci et al., 2018) that can inform and reassure consumers as to food safety (Regan, 2019).

Finally, Coble et al. (2018) report that Big Data can contribute to resolving social issues, such as identifying consumer needs by supplying additional data to financial and marketing agents. Further social benefits identified in the literature review and related to the growers are their improved work-life balance and well-being arising from efficient time management (Regan, 2019).

Precision agriculture challenges

- **Investment risk and uncertainty**

A major precision agriculture's challenge is that innovative technologies are often capital intensive, which may be restrictive, especially for small or medium-sized farms. This may account for the fact that the main adopters so far are growers with large agricultural businesses in developed countries (Miao & Khanna, 2020; Finger et al. 2019).

In research conducted in Bulgaria, the high investment costs involved were a major challenge for the growers wishing to adopt and take advantage of new technologies (Beluhova-Uzunova & Dunchev, 2020). Lencsés et al. (2014) and Loures et al. (2020) state in their research that adopting new technologies is negatively correlated with growers' financial situation. Growers' economic restrictions can lead to partial adoption of new technologies, as stated by Sarris at al. (2020) following research conducted in Italy. It is concluded that growers may wish to take advantage of precision agriculture, yet not take high economic risks. Uncertain investment returns have led to low adoption rates (Marra et al., 2003).

- **Knowledge and Skills**

Even though new technologies can readily collect data about precision agriculture, growers cannot easily analyse and interpret them due to the lack of necessary technical skills. New technologies and Big Data demand knowledge and skills such as *"technical experience, access to knowledge and technological education"* (Annosi et al.,2020).

Since most growers lack such skills, it is challenging for them to improve their decision-making processes (Wolfert et al. 2017; Weersink et al. 2018; Miao & Khanna, 2020). Sarker et al. (2020) state that unskilled growers need help from experts to use the data obtained and this equals to additional costs or more time for the growers to adjust to the digitalization era . When growers lack the skills to utilise precision agriculture, they need expert assistance. Yet, consultants may promote big companies' agenda rather than growers' benefits (Miao & Khanna, 2020; Wolfert et al. 2017; Weersink et al. 2018).

Another constraint identified in the literature is that both the grower and the workforce should have a positive attitude towards the new technologies. They should either already have the necessary skills or the willingness and background to acquire the skills to use the data produced and implement new techniques (Lencsés et al.,2014).

- **Ethical considerations**

Other crucial factors affecting precision agriculture adoption are the social and ethical issues arising from big data production and utilisation (Bronson, 2018; Eastwood et al., 2019; Carbonell, 2016). Data from the literature review conducted suggest that growers face some ethical considerations regarding the privacy of the data produced (Sharma et al., 2020).

Van der Burg et al. 's findings (2019) identify three main ethical challenges, namely *"(i) data ownership and access; (ii) distribution of power; and (iii) impacts on human life and society."*

As regards *"data ownership and access"*, the issues arising relate to who owns the data and which data should be open to the public or to private companies (Van der Burg et al., 2019). It is quite common for growers to work hard to produce field data, but have no ownership of them. A study on data ownership by Bronson and Knezevic (2016) mentions that growers are not responsible for or independent regarding the content, interpretation and use of the data collected (Lioutas et al.,2019). Nowadays, it is very common that growers to hire innovative agricultural machines, but cannot claim ownership of the data produced (Řezník et al., 2017), which accounts for their dissatisfaction. Sarker et al. (2020), Comi (2020) and Tack et al. (2019) mention in their research that many useful data are in the acquisition of big companies and that makes growers dissatisfied. Another implication of data ownership is whether growers can be autonomous to produce in the manner they believe could be efficient or they become 'data labourers' (Klerkx et al., 2019).

The second ethical challenge concerns *"distribution of power".* Power distribution is linked with data ownership and investigates issues such as "justice, equity, fairness and trust" (Van der Burg et al., 2019). This challenge involves the difficulties that growers face due to lacking the means or skills. When someone is empowered with all the necessary skills and capital, they will be able to utilise the new technologies, otherwise they are deprived of access to all this valuable information. Finally, inequality between growers and big companies can lead to power imbalances (Van der Burg et al., 2019). Other research describes that a wrong distribution of power can lead to big companies' acquiring data control and access raising concerns about the manner that this information will be used (Sykuta, 2016). These power imbalances can impact environmental, economic, and societal sustainability and bring major positive outcomes only to private companies and not the society.

It is observed that the three ethical challenges are related with each other. The challenge *"impacts on human life and society"* represents the concerns about precision agriculture influences on humans and the society and how it can have an impact on the original sustainability goals. The main questions raised by this challenge are whether the implication of precision agriculture can influence employment, safety, economic activities and biodiversity in an area as well as issues concerning the farming skills requirements and, ultimately, the growers' freedom to determine the cultivation process (Carolan, 2018; Van der Burg et al., 2019).

Table 2: Quantitative representation of literature review

Category	Numerical frequency	Percentage
Values / Advantages		
Resource efficiency & decision-making management	43 / 45	95.5 %
Environmental sustainability	31 / 45	69 %
Low Production risk	29 / 45	64.5 %
Economic benefits	28 / 45	62 %
Product quantity or crop yield	23 / 45	51 %
Product quality	19 / 45	42 %
Environmental sustainability	31 / 45	69 %
Social sustainability	9 / 45	2 %
Disadvantages / Challenges		
Investment risk and uncertainty	16 / 45	35.5 %
Knowledge / Skills	11 / 45	24.5 %
Ethical considerations	13 / 45	29 %

Quantitative analysis

The quantitative results of the systematic literature review (see Table 2) indicate that the advantage which was the most frequently observed in the literature review is the *"Resource efficiency and decision-making management"*. The next categories with a relatively high frequency in the literature were *"Environmental sustainability", "Low production risk" and "Economic benefits"*, with a score of 31/45, 29/45 and 28/45 respectively. The categories *"Product quantity or crop yields"* and *"Product quality"* were identified in half of the papers and *"Social sustainability"* in 9 papers. It is observed that the disadvantages of precision agriculture have low rates of presence in the articles since the percentage of their scores are lower than 50%, yet it is interesting to research their influence.

2.3 Conceptual framework

Prior research confirms that there are both advantages and challenges for the growers adopting precision agriculture. In the literature it is also mentioned that precision agriculture's adoption rate is low. While research has been conducted to record growers' opinions regarding precision agriculture, little research has investigated consumers' perspectives of

precision agriculture. Growers' decision-making is influenced by the expected market rewards. If growers are informed about consumers' perspectives, they may adopt production processes that they consider as rewarding in terms of higher prices.
Consumers are key figures in the food supply chain and their choices can have a crucial impact on the success or failure of the suppliers' decision-making (Asp, 1999; Senauer et al., 1991; Sloan, 1994a). Therefore, this research aims to investigate consumers' perceived benefits from products produced by precision agriculture and their intention to buy such products.

A number of authors have studied the factors affecting consumers' motives in their food decision making and their intentions to purchase food products. This section outlines how consumers perceive the benefits of food in general, and a theoretical framework is drawn. The theoretical framework (see Diagram 1) is divided in two parts. The left part depicts *"Consumers' perception of precision agriculture benefits"* and the right part represents "*Consumers' intention to buy products produced by precision agriculture*". In the middle of the diagram "*Consumers' perception of precision agriculture benefits*" is a linkage to clarify consumers' decision-making.
Consumers' perception of food is illustrated based on the products' price, quality and appearance (Grunert et al., 1996). Grunert et al. (1996) state that quality has more than one features and is described based on the following aattributes: **taste, healthiness, process and convenience**. Brunsø et al. (2002) suggest that this categorization of the quality concept can be applied in the developed countries.

2.3.1 Consumers' perception of precision agriculture benefits

The aim of the left side of the conceptual framework (see Diagram 1) is to assess how consumers perceive growers' advantages and challenges when they choose precision agriculture as a cultivation process. The objective of this research is to investigate the gap in the literature regarding consumers' perspectives about precision agriculture. The link between "Precision agriculture vs traditional agriculture" and "Consumers' perception of precision agriculture benefits" will be researched.

Assumptions regarding the potential links between growers' and consumers' advantages were derived from the data derived from the systematic literature review.

First, it is assumed that growers' perceived advantages can either positively affect consumers' benefits or do not affect them at all. Examples from the literature are the following:

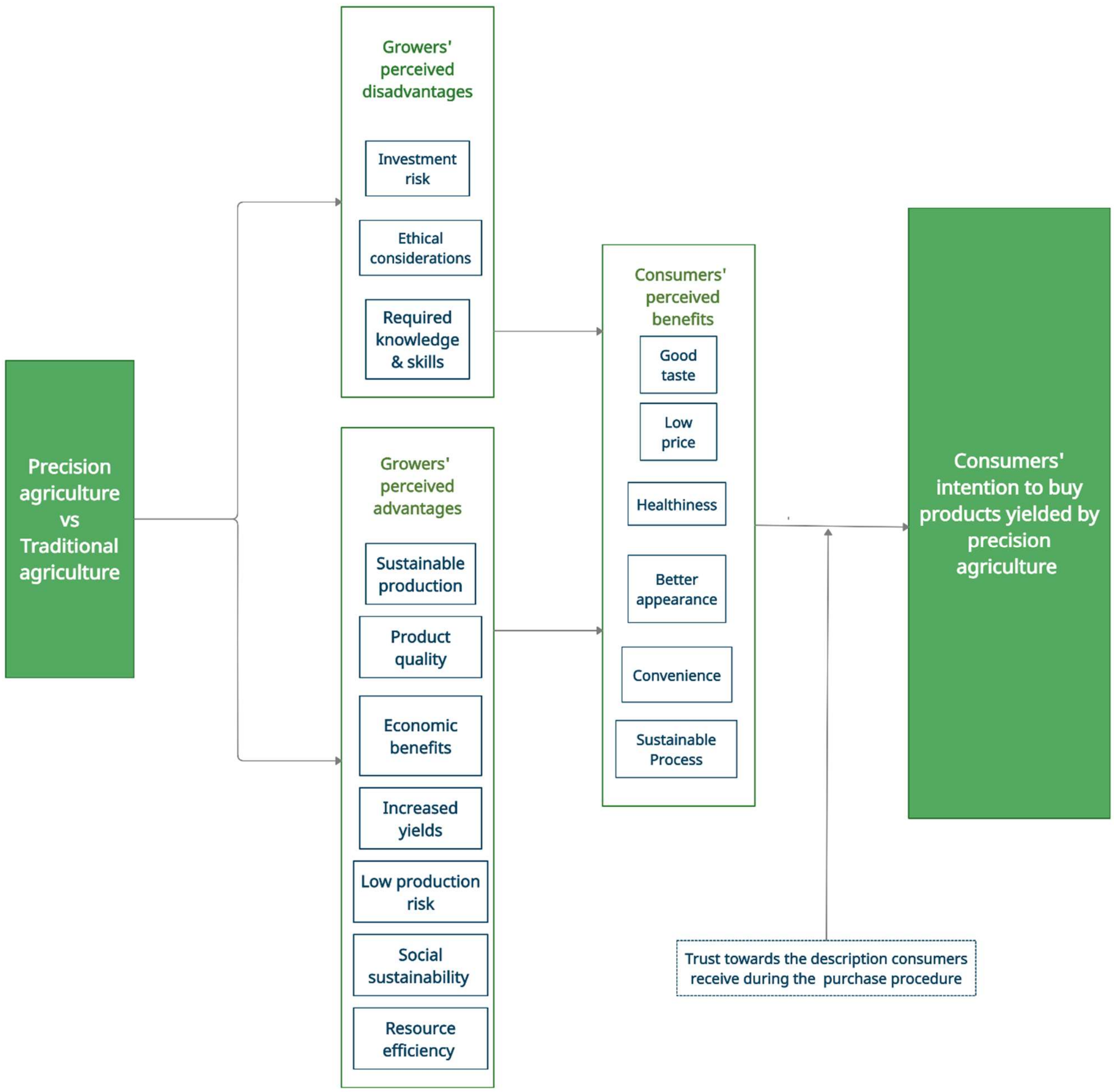
- "**Resource efficiency and decision-making management**" can be positively related with the product quantity and quality or the environmentally friendly processes.
- **"Increased yields"** can be positively related with lower prices for the consumers.
- **"Sustainable production"** can be positively related with healthiness and environmentally friendly processes.
- **"Lower production risks"** results in high quality products, therefore to a nice appearance and healthy products.
- **"Product quality"** can be positively related to all consumers' benefits.
- **"Other economic benefits"** can positively affect the products' prices.
- **"Social sustainability"** can be positively related to the environmentally friendly processes.

Growers' perceived challenges can negatively influence consumers' advantages.

- **"Investment risk"** may negatively affect the low price of the products yielded.

- **"Ethical considerations"** the environmentally friendly processes.
- **"Required knowledge and skills"** can negatively affect the products' prices and positively the rest of the consumers' advantages.

Diagram 1. Conceptual framework



2.3.1 Consumers' perceived advantages and their intention to buy products yielded with precision agriculture

Consumers' intention to buy is described as a decision regarding an exchange of the *"perceived quality and perceived costs"* (Brunsø et al., 2002) and as an assessment of the consumers' motives to buy a certain product (Shah et al., 2012). Often it is connected with the *"behaviour, perceptions and attitudes of consumers"* (Mirabi, 2015). Purchase intention may be positively or negatively affected by the price or the perceived quality (Mirabi, 2015). Furthermore, consumers' intentions can be influenced by either personal motivation or by the market environment while purchasing a product (Gogoi, 2013).

Price
A very important element for consumers' food choice is what they are willing to give to acquire a product (Brunsø et al., 2002). Research states that price plays a crucial role in food consumption behaviour (Steenhuis et al., 2011). Price is defined as the monetary value that consumers pay for a product or the value that they get (Kotler and Armstrong, 2010). Price influences consumers' intention to buy food since it affects their attitude either directly by the objective price value or indirectly by its fairness (Hermann et al., 2007). Moreover, Shugan (1984) states that price can be a quality indicator for consumers not having much information about the products. Consumers perceive expensive products as products of higher quality (Shugan, 1984).

As regards precision agriculture products, their prices can be positively influenced by the use of innovative production processes. Research reveals that precision agriculture implementation can decrease production costs and increase efficiency, leading to more competitive prices. At the same time, high investment costs can initially raise prices, which may give rise to consumers' mixed perspectives.

Price is a motivational factor for consumers' intention to buy horticultural products, therefore it can be hypothesized that lower prices can positively affect consumers' intentions to buy products produced by precision agriculture.

H1: The lower the expected price, the higher the consumers' purchasing intention.

The next factors being studied are related to product quality. Compared to the price factor these factors describe consumers' perceived benefits from the purchased products and not what are they willing to offer to acquire them (Brunsø et al., 2002; Zeithaml, 1988). Prior research suggests that quality can be divided in two dimensions. The first one refers to the products' physical characteristics, which can be objectively described. The subjective dimension refers to what each consumer perceives as beneficial for them. When growers offer the quality wanted to the consumers, then quality plays a beneficial role both for the growers and the consumers (Paustian & Theuvsen, 2017). This is demonstrated by a number of authors, as for example Chi et al. (2008) and Tsiotsou (2005 and 2006), who suggest that the better the food quality, the higher the consumers' intention to buy it. Brunsø et al. (2002) define quality in terms of four main dimensions: taste, health, process characteristics and convenience. These dimensions will be analysed in this research.

Taste

For most people, food is highly associated with satisfaction. Taste is a hedonic food characteristic that represents a leading quality measurement for consumers. Taste is an experiential characteristic that can be assessed only after food consumption (Brunsø et al., 2002). Consumers demand a nice taste in their food, thus taste is considered a crucial factor in consumers' food decision-making (Brunsø et al., 2002; Verbeke, 2006).

Research into precision agriculture reveals that its technologies and techniques enhance food taste, Hence, it may be hypothesised that taste can positively affect consumers' intentions to buy products yielded by precision agriculture.

H2: The better the expected taste, the higher the consumers' purchasing intention.

Healthiness

Healthiness is viewed by two aspects, "*Eating healthily"* and "*Avoiding unhealthy foods*". "Eating healthily" includes factors related to health and nutrition meaning that healthy food provides consumers with the necessary nutrients and helps them maintain a balanced nutrition. "Avoiding unhealthy foods" is related with food safety that consumers demand (Brunsø et al., 2002). Food safety can be defined as the possibility of staying healthy without being affected by a disease due to food consumption (Grunert, 2005). Consumers' expectations for a long and superior life enhances their healthy lifestyle attitudes and is a crucial parameter in their decision-making (Roininen et al., 2001). Food healthiness can have a positive effect on consumers' intentions to buy products yielded by precision agriculture, leading to the following hypothesis.

H3: The higher the food healthiness, the higher the consumers' purchasing intention.

Both "eating healthily" and "avoiding unhealthy food" are parameters that consumers cannot assess in a short term, thus they are based on the consumers' trust in the information that they receive during the purchasing procedure (Brunsø et al., 2002). This leads to the second assumption that the higher the trust in the description that consumers receive at the purchasing procedure, the higher their intention to buy food produced with precision agriculture techniques.

H4: The trust towards the description that consumers receive for the production process during the purchasing procedure has a moderating effect between healthiness and intention to buy.

Process

Another parameter that consumers have become more aware of and influences their decision-making is the process with which food is produced. Consumers' concerns include the usage of GMOs (Genetically modified organisms) and chemical compounds in food production (Brunsø et al., 2002). In precision agriculture, resource efficiency achievement and sustainable production lead to high quality products with lower chemical use. Precision agriculture, though, is a new process that raises ethical concerns, thus consumers perceive it as an unnatural process (Brunsø et al., 2002).

The confirmation that a process is sustainable is a characteristic influenced by consumers' trust during the purchasing procedure, since consumers rely on the growers' reassurance about the production procedure (Brunsø et al., 2002). The two hypotheses emerging are the following:

H5: The higher the perceived sustainability of the production, the higher the consumers' purchasing intention.

H6: The trust towards the description that consumers receive for the production process during the purchasing procedure has a moderating effect between sustainability and intention to buy.

Convenience

Convenience is the next factor that influences consumers' intention to buy food. Consumers define convenience in terms of food purchasing accessibility, the time-needed to use or cook the products, the effort needed for food preparation before cooking and finally cleaning the kitchen up (Grunert, 2005).

Precision agriculture cultivates products with lower quantities of fertilizers and in many cases in greenhouses under controlled conditions. This means that the products are less dirty compared to those produced in a real field and with numerous chemical applications. Therefore, it is assumed that producing by using all the resources efficiently and sustainably, there is less need for the final consumers to hard wash the vegetables . This is convenient for them and can positively affect their intention to buy precision agriculture products.

H7: The higher the perceived convenience when using a product, the higher the consumers' purchasing intention.

Other factors than price and quality.

Appearance

Pleasure or hedonism is an experiential consequence of food consumption. Thus, consumers' intention to buy food products is associated with the expectations created by such food characteristics as food appearance during purchase (Olson & Jacoby, 1972; Steenkamp, 1990). Precision agriculture products are similar in appearance. It is expected that diseases and infections can be avoided and products can be clean without any damage signs when produced by precision agriculture. The next hypothesis is formulated on the basis that a good appearance can positively influence consumers' intention to buy products yielded by precision agriculture.

H8: The better the appearance of the products, the higher the consumers' purchasing.

Chapter 3: Research Methodology

3.1 Introduction

A survey was conducted online in Qualtrics, between 14/4 and 29/4, in English and in Dutch. A pilot survey was conducted with nine respondents to check the questions' clarity and the time needed for them to fill it in. The respondents proposed suggestions regarding the questions which were not clearly stated and there should be more explicit description. After implementing the feedback received, the survey was conducted in the real population.

3.2 Participants

The participants were people living in the Netherlands and consuming vegetables. The survey was sent to the researcher's social and professional network via email or in WhatsApp groups and it was published in Online groups in social media. Finally, 100 respondents were eligible for the research. Table 6 depicts the demographic characteristics of the respondents in comparison to the characteristics of the Dutch population.

3.3 Measurements

The dependent variable *Consumers' intention to buy* was measured after respondents were exposed to the manipulation of the experimental design with product pictures. Respondents' intention to buy was measured by asking them to grade the following three items that had been reported by Baker and Churchill (1977) in previous research. "Would you like to try this product?", "Would you buy this product if you happened to see it in a store?" and "Would you actively seek out this product in a store in order to purchase it?" (See Appendix 3). Respondents should grade them in a 7-Likert scale, with (1) representing "*definitely no*" and (7) "*Definitely yes*".

Consumers' perceived benefits from precision *agriculture* was measured by asking respondents' perception about the products' low price, healthiness, sustainability, convenience, appearance and taste. The questionnaire's items (see Appendix X) were inspired by the multi–item Food Choice questionnaire (FCQ) developed by Steptoe (1995), and for each factor three items were created. Therefore, the respondents were asked "How would you rate the following factors about this tomato/paprika? I expect that this tomato/ paprika…", and rate 18 items, in a seven-point Likert scale. Respondents should choose from 1 to 7 in a range from "Strongly disagree" to "Strongly agree".

Respondents' ***trust to the description of the production procedure*** was measured with three items, based on Chaudhuri and Holbrook's (2001) scale about *Trust in a brand*. Respondents were asked to indicate how much they agree with the following statement "Looking at the description about the production of this paprika/tomato, I feel that…" and rate three items. The items used to measure the trust to the description were the following. "I trust this description", "This is an honest description", "I can rely on this description" (see Appendix 3). Respondents should rate these three items in a seven-point Likert scale, from (1) "Strongly disagree" to (7) "Strongly agree".

The connection of the ***growers' perceived advantages and challenges*** **variables** with the ***consumers' perceived benefits and their correlations*** were measured by 10 questions (See Appendix 3). Respondents should evaluate on a scale from -2 to +2, where 0 represents no connection, items regarding their perceived benefits. The +2 represents a positive connection while -2 a negative connection. An example of the questions and the items is depicted in Table 3. The rest of the questions can be found in Appendix 3.

Table 3: Example question about the connection of consumers' perceived benefits and growers' perceived advantages and challenges.

I believe that when growers use less fertilizers, then the products will:						
	-2	-1	0	+1	+2	
Taste worse	○	○	○	○	○	Taste better
Have higher prices	○	○	○	○	○	Have lower prices
Be less healthy	○	○	○	○	○	Be more healthy
Be produced less environmentally friendly	○	○	○	○	○	Be produced more environmentally friendly
Look less attractive	○	○	○	○	○	Look more attractive
Require more time to prepare	○	○	○	○	○	Require less time to prepare

3.4 Procedure

3.4.1 Introduction and eligibility screening

Before the survey, the respondents were given a description of the content and the aim of this research , its academic objectives, the researcher and an assurance of anonymity and confidentiality (See Appendix 3). Moreover, respondents were asked two yes/no questions to check their eligibility for the research (see Appendix 3). The respondents that passed the eligibility procedure could continue to the next two main stages of the survey, otherwise the survey would end automatically.

3.4.2 Experimental survey

In the first part of the survey, an experimental design was conducted. The respondents were randomly allocated to one of four different groups.

The participants of the first group were exposed to two pictures and a description of the production system of a paprika produced with precision agriculture and in two pictures and a description of the production system of a tomato produced with traditional agriculture.

The participants of the second group were exposed to two pictures and a description of the production system of a tomato produced with precision agriculture and to two pictures and a description of the production system of a paprika produced with traditional agriculture.

The participants of the third group were exposed to two pictures and a description of the production system of a paprika produced with traditional agriculture and to two pictures and a description of the production system of a tomato produced with precision agriculture.

The participants of the fourth group were exposed to two pictures and a description of the production system of a tomato produced with traditional agriculture and to two pictures and a description of the production system of a paprika produced with precision agriculture.

The manipulations for the four groups were drawn to test the effect of precision agriculture and traditional agriculture to consumers' perception and intention to buy products yielded by precision agriculture. Moreover, pictures and descriptions were used to enhance realism and make respondents familiar with precision and traditional agriculture (Table 4, Table 5).

Participants of all groups were asked for each manipulation (precision and traditional agriculture) to answer the question about their intention to buy the product, the questions of assessing their perceived benefits from the product and the last ones of assessing their trust level to the description that they received (See Appendix 3).

The manipulation (pictures and description) of products yielded by precision agriculture is displayed on Table 4. The aim of using the pictures of a paprika or tomato was for the respondents to picture the products prior to indicating intention to buy them or not. The second picture illustrated a paprika or a tomato greenhouse, with a robot collecting the products and taking measurements of the proper collection time, thereby depicting precision agriculture procedures

Table 4: Precision agriculture manipulation




"This paprika / tomato was produced using precision agriculture techniques. Growers collect large amounts of data about individual plants with sensors, such as cameras to monitor and optimize the growth of their crops."

The pictures for the products yielded by traditional agriculture are displayed on Table 5. Following the same reasoning as with precision agriculture, the respondents were to picture the products and indicate intention to buy. The other picture depicted a tomato or paprika greenhouse, with a farmer collecting the products by hand. The pictures from traditional agriculture represented a cultivation process where a farmer was more physically involved in the production procedure.

Table 5: Traditional agriculture manipulation




"This paprika/ tomato was produced using traditional agriculture techniques. Growers walk around their greenhouses to visually inspect their crops and use their knowledge and experience to optimize the growth of their crops."

3.4.3 Consumers' perception of precision agriculture advantages and challenges

In this part of the survey respondents were asked to grade items (see Appendix 3) exploring their perception of whether or the degree to which consumers' benefits were connected to the growers' benefits and challenges.

3.4.4 Demographic characteristics and conclusion

Finally, sociodemographic questions (see Appendix 3) were asked, to reach conclusions about consumers' beliefs in relation to their age, their educational level, where did they grow up, and where they usually buy vegetables from.

Most of the respondents were young belonging in the age group 18-34 (N=95). Most of them have at least a Bachelor degree (N=88), indicating that they are highly educated. Most respondents grew up in a city (N=66). N=27 of them grew up in a village and the minority of the respondents (N=7) in the countryside. Finally, most of the respondents do their groceries in a supermarket (N=68), a few in the market (N=22) and N=9 of them in specialty shops (see Table 6).

This results indicate that the respondents are young people, highly educated, that grew up in a city and they prefer doing their groceries in the supermarket. This indicates that the results can not be generalized to the general Dutch population, since only 8.3% of the Dutch population belong to the age group 18-24 and 12.7% to the age group 25-34 compared to the sample's age group deviation. It is observed the Dutch population is more equally distributed in the age groups compared to the respondents' distribution. As regards the respondents' educational level in comparison to the Dutch population educational level, it is observed that only approximately 27% attended the higher education compared to the respondents that most of them (88%) have a bachelor or master degree. Therefore, the sample is considered as biased and the generalisability to the Dutch population is not possible.

Table 6: Demographic characteristics frequencies

	N=100	Dutch population (N=17.282.163)
Age	**Frequencies (%)**	**Frequencies (%)**
18-24	35	8.3
25-34	60	12.7
35-44	1	12
45-54	1	13
55-64	3	13.5
Level of education		
Secondary school	5	30.75
"MBO"	1	30.75
"HBO"	6	-
University, Bachelor	37	17.15*
University, master	51	10*
Place they grew up		
City	66	-
Village	27	-
Countryside	7	-
Place they do their groceries		
Supermarket	69	-
Specialty shops	9	-
Market place	22	-

**These results include HBO & university bachelor or master*

In the end of the survey, the respondents were provided by a "Thank you message " and a clarification about the aim of this research.

3.5 Analysis

Data were analysed by using the Statistical Package IBM SPSS Statistics software.

3.5.1 Reliability and validity test

First, validity tests of the questionnaire's measurements were applied to assess their accuracy. Factor analyses were used to identify whether the items represented the underlying construct well and to identify whether the items correlated with those that they should.

Then, reliability tests were performed to assess the quality of the measurement scales and their consistency. Reliability analyses were conducted for all the subscales by calculating the Cronbach's alpha (α). Results are depicted on Table 7.

Buying intention

The properties of the measurements used for the *Buying intention* variable are evaluated to be good. The results of the factor analysis indicate that the eigen value of the second component is 0.567, (lower than 1.0) and the % of variance explained by the first component is 73.317% (higher than 60%). All the items' loadings are higher than 0.6 on the first unrotated component, with the lowest loading being 0.768. The reliability analysis presented a Cronbach's alpha coefficient of 0.782, which is a good result.

Expected characteristics

First, a principle component analysis was conducted to identify the components of the products' "*expected characteristics*", whether those products were yielded by precision or traditional agriculture. This analysis identified which variables measured the same concept. Based on the literature review, the expected components were 6. After conducting a principle components analysis, though, the 18 items used in the survey were reduced to 7 components. The *Total variance explained* table (Appendix 4) indicated that the 7th component's Eigenvalue was .772. Those 7 components explained 79.267% of the variation. This components' number was chosen after examining the Structure Matrix Table (see Appendix 4). It is observed that the 7 components can better identify the variables that explain same concepts, since the item measuring the sweetness of the products scores high in a component itself therefore it was necessary to split it from the component that it was expected to score high. Consequently, 7 components instead of 6 were chosen.

Table 7: Results of principles components analysis and reliability analysis

Concepts	Number of items	Eigenvalue second component	Total variance explained(%)	Lowest item loading	Cronbach's alpha
Buying intention	3	.567	73.317	.768	.782
Price	3	.733	67.848	.658	.760
Healthiness	3	.394	78.474	.858	.861
Convenience	3	.390	77.880	.857	.851
Sustainability	3	.436	74.147	.845	.826
Appearance	3	.449	71.619	.837	.797
Taste	2	.317	84.169	-.917	.808
Sweetness	1	-			
Trust	3	.426	77.313	.845	.851

For each component created, further PCAs and reliability analyses were conducted, to investigate the validity and reliability of the components' measurements.

- ***Price.*** It is noted that the second component of "Price" is below 1.0 (.733) and the % of variance of the first component is 67.848 (higher than 60%). All the items' loadings are higher than 0.60 on the first component. The item "will be good value for money" has the lowest item loading (.658). The Cronbach's alpha is 0.760, which is higher than 0.6, suggesting a reliable measurement.
- ***Healthiness.*** It is observed that the second component of "Healthiness" is below 1.0 (.394) and the % of variance of the first component is 78.474 . All the items' loadings are higher than 0.60 on the first component, having the lowest item loading (.858). The reliability of the measurements was tested, resulting in a Cronbach's alpha coefficient (α) of .861, suggesting a reliable component.
- ***Convenience.*** It is observed that the second component of "Convenience" is below 1.0 (.390) and the % of the first components' variance is 77.880. Checking the lowest item loadings, it is verified that all the items' loadings are higher than 0.6, with the lowest scoring 0.857. Cronbach's alpha (.8551) confirms the component's reliability as well.
- ***Sustainability.*** The results demonstrate that the Eigenvalue score in the second component is .390 and the first component's variance is 74.147 %. All the item

loadings are higher than 0.6, with the lowest scoring 0.845. Checking the Cronbach's alpha (.826) result, it is concluded that the measurements' reliability is good.

- ***Appearance.*** The results confirm the component's validity and reliability. The Eigenvalue of the second component is 0.449, the % variance of the first component is 71.619. and the lowest item loading is .837. The Cronbach's alpha is 0.797, representing reliable measurements.
- ***Taste.*** The component "Taste" includes two items. It is observed that the Eigenvalue of the second component is below 1.0 (.317) and the % of variance of the first component is 84.169. All the items' loadings are higher than 0.60 on the first component, having the lowest item loading (-.917). The measurements' reliability is verified by the Cronbach's alpha score, 0.797.

The factor analysis, separated the variable ***Sweetness*** to a separate component, while it was expected to be included in the component Taste.

Moderator - Trust

The results indicate that the Eigenvalue of the second component scores 0.426 and the % of variance explained by the first component is 77.313%. All the items' loadings are higher than 0.6 with the lowest loading being 0.845. The reliability analysis reported a Cronbach's alpha coefficient of 0.851, which is a good result.

3.5.2 Analysing how respondents connect growers' perceived benefits to consumers' benefits

To analyse how respondents connect growers' perceived advantages and challenges to consumers' benefits descriptive statistics were used. The mean scores of all the questions have been compared to the mean score (M=3), which represents the answer *"It does not affect consumers' benefits"*. The differences were tested for significance by conducting one-sample t-test analyses. By further examining the descriptive statistics results, the positive, negative or no influence of the growers' advantages and disadvantages on the consumers' advantages can be detected. In this manner, consumers' perception of precision agriculture can be identified, and the second research sub-question, namely ***"How do consumers perceive the benefits and challenges of precision agriculture?"*** can be answered.

Furthermore, a cluster analysis was conducted to identify groups of consumers with similar perspectives about the influence of precision agriculture's advantages and disadvantages on consumers' food choice characteristics. Then, an ANOVA test was used to check whether there was any variation between those groups.

3.5.3 Respondents' intention to buy

Multiple linear regression analyses were conducted to assess the main factors related to consumers' intention to buy products yielded by precision agriculture. The dependent variable in this analysis was "respondents' intention to buy" and the variables "Low price", "Taste", "Healthiness", "Appearance", "Convenience", "Sustainable process", "Trust" and "Sweetness" were included as independent variables in the regression model. Moreover, the interactions of "Trust" with "Healthiness" and of "Trust" with "Sustainable process" were tested.

Chapter 4: Results

4.1 Consumers' perception of precision agriculture

For the identification and interpretation of the relationship between the advantages and disadvantages of precision agriculture and consumers' perceived benefits, descriptive statistics have been applied. For every question regarding growers' perceived advantages or disadvantages and consumers' benefits (e.g. *I believe that when growers use less fertilizers, then the products will: Taste worse till Taste better*) a mean score (M) was calculated (see Table 8).

Table 8: Means and significances of the means of the connection between growers' and consumers' advantages

Advantages	Taste	Lower Price	Healthiness	Sustainability	Appearance	Convenience
Increased yields	2.42 (.000)*	3.93 (.000)*	2.73(0.002)*	2.42 (.000)*	3.02(.832)	3.04 (.519)
Resource efficiency/ Decision making	3.41(.000)*	2.86 (.279)	3.45(.000)*	3.69 (.000)*	2.91 (.427)	2.95(.487)
Low production risk	3.65 (.000)*	3.16 (.219)	3.69 (.000)*	3.61 (.000)*	3.68 (.000)*	3.09 (.129)
Product quality	3.97 (.000)*	2.09 (.000)*	3.69 (.000)*	3.60 (.000)*	4.07 (.000)*	3.10 (.175)
Sustainable production	3.76 (.000)*	2.29 (.000)*	3.96 (.000)*	4.56 (.000)*	2.92 (.385)	2.89 (.160)
Social sustainability	3.24 (.002)*	2.51 (.000)*	3.26 (.000)*	3.63 (.000)*	3.27 (.002)*	3.03 (.615)
Economic benefits	4.22 (.000)*	3.01 (.937)	3.83 (.000)*	3.74 (.000)*	4.13 (.000)*	3.66 (.000)*
Challenges						
Required knowledge and skills	3.78 (.000)*	2.80 (.030)*	3.79 (.000)*	3.99 (.000)*	3.65 (.000)*	3.28 (.000)*
Ethical consideration	3.04 (.685)	3.03 (.805)	2.88 (.192)	2.77 (.044)*	3.56 (.000)*	3.17 (.046)*
Investment risk	3.71 (.000)*	2.4 (.000)*	3.52 (.000)*	3.59 (.000)*	3.79 (.000)*	3.28 (.000)*

**Significantly different than the Mean score=3, p>.05. a) The relationship between the variables in the first column (growers' advantages and disadvantages) with the variables on the columns (consumers' advantages) have been tested with questions mentioned in the methodology chapter (eg I believe that when growers use less fertilizers, then the products will: Taste worse (-2) till Taste better (+2)). b) The results in a green colour indicate a positive influence and in the red colour a negative influence.*

The results indicate that the respondents think that *"Increased yields"* result in worse taste (M= 2.42, p=.000), less healthy products (M= 2.73, p=.002), less sustainable (M=2.42, p=.000) and lower prices (M= 3.93, p=.000). Increased yields do not influence the appearance (M=3.02, p=.832) and the convenience (M=3.04, p=.519) of the products.

Results indicate that respondents think that when growers have a better understanding of the demands of the crop production and apply better management practices ("*Resource efficiency / Decision making*"), the final products will taste better (M=3.41, p=.000), will be healthier (M=3.45, p=.000) and more sustainable (M=3.69, p=.000). Yet, they think that these management practices do not influence the price (M=2.86, p=.279), the appearance (M=2.91, p=.427) or the convenience (M=2.95, p=.487) of the products.

The data from Table 8 demonstrate the respondents' perception that when growers have sufficient information to eliminate risks, such as crop diseases during the production procedure *("Low production risk"),* then the taste (M= 3.65, p=.000), healthiness (M= 3.69, p=.000), sustainability (M= 3.61, p=.002) and appearance (M=3.68, p=.000) of the precision agriculture products will be better. Yet, they think that there is no influence on the products' price (M=3.16, p=.219) or convenience (M=3.09, p=.129).

Moreover, the respondents confirm that when growers can produce high "*Quality*" products, meaning with a good taste, nice appearance, increased healthiness and sustainability, this can lead to products with a better taste (M=3.97, p=.000), better appearance (M=4.07, p=.000), increased healthiness (M=3.69,p=.000) and increased sustainability (M= 3.60, p=.000). Results also reveal that respondents think that high quality products have higher prices (M=2.09, p=.000), while their convenience (M=3.10, p=.175) is not influenced.

The results demonstrate that respondents think that when growers use cultivating practices having no negative environmental impacts ("*Sustainable production"),* the products yielded have a better taste (M=3.76, p=.002), are healthy (M=3.96, p=.000) and sustainable (M= 4.56, p=.000). Nonetheless, they have higher prices (M=2.29, p=.000). Respondents think that there is no influence on the products' appearance (M=2.92, p=.385) or convenience (M=2.89, p=.160) when they are produced in a sustainable way.

Respondents were asked to express their perspective on the products yielded in a way that enhances the social values, such as honesty and information availability ("Social sustainability"). They were asked to score answers to the question "*I believe that when growers provide more information about the production process, through a description or a label, the products will:…".* Their mean scores indicated that they thought that when information of the production process was available, then the products had a better taste (M=3.24, p=.002), higher prices (M=2.51, p=.000), were healthier (M=3.26, p=.000), more sustainable (M= 3.63, p=.000) and had better appearance (M=3.27, p=.002). They thought that there was no effect on the products' convenience (M=3.03, p=.615).

Finally, results indicate that the respondents think that when growers have high profits ("*Economic benefits*") the products have better taste (M=4.22, p=.000), are more sustainable (M= 3.74, p=.000), have better appearance (M=4.13, p=.000) and are more convenient (M=3.66, p=.000). Nonetheless, they believe that there is no influence on the products' price (M=3.01, p=.937) or healthiness (M=3.83, p=.000).

As regards the data on precision agriculture's disadvantages, respondents are shown to think that highly-educated, skilled growers (*Required knowledge and skills*) yield products of better taste (M=3.78, p=.000), healthier (M=3.79, p= .000) and more sustainable (M=3.99, p=.000). Moreover, products will have better appearance (M=3.65, p=.000) and will be more convenient (M=3.28, p= .000), yet having higher prices (M=2.80, p= .030).

As for the *Ethical considerations* raised by precision agriculture, such as data ownership, the results demonstrate that respondents think that when big companies own the data produced by precision agriculture, the products will have better appearance (M=3.56, p=.000) and higher convenience (M=3.17, p=.046). Yet, they think that the ethical considerations lead to less sustainable products (M=2.77, p= .044). Respondents think that there is no influence on the products' taste (M=3.04, p=.685), prices (M=3.03, p=.805) or healthiness (M=2.88, p=.192).

Finally, this research concludes with the consumers' perceptions that when growers invest heavily (*Investment risk*) in the production procedure, such as for buying new technologies, the products will have better taste (M=3.71, p=.000), will be healthier(M=3.52, p=.000) and be more sustainable(M=3.59, p=.000). Moreover, they will have better appearance (M=3.79, p=.000) and be more convenient (M=3.28, p=.000), yet having higher prices (M=2.4, p=.000).

Consumers' perspectives about precision agriculture are not considered as fixed results, and the findings cannot fully represent the respondents, while it is assumed that respondents' perspectives may differ. For a more thorough analysis of the findings produced, it was researched whether there were groups of respondents with the same perspectives and whether there were differences between those groups. Therefore, a cluster analysis was conducted.

Cluster analysis

The first step of the cluster analysis was to conduct a **factor analysis** to reduce the data on consumers' expectations in fewer factors. A PCA was conducted, including all the questions from the research's second part (see Appendix 5), to create uncorrelated factors to be used in the cluster analysis.

In the PCA's results, the Kaiser-Meyer-Olkin (KMO) test scored .575, indicating that the factor analysis could help minimize the variables. Moreover, all the factor communalities were higher than 0.5, with the lowest value being .589, meaning that all the variables were well represented by the 19 factors chosen. Examining the *Total Variance Explained Table in the SPSS output* (Appendix 5), the first 19 components explained a variance of 75.907 %, all of them having an Eigenvalue higher than 1.0, with the next component having an Eigenvalue of .913. For this research, 19 components were chosen since the explained variance was quite high, 75.907 %, and it was the final factor before the Eigenvalue became less than 1. In the scree plots results, 19 components were accepted, since the plot's line (see Appendix 5) appeared to become stable after that.

Then, a **hierarchical cluster analysis** followed with the aim of defining the clusters' number for the final non-hierarchical cluster analysis. In the hierarchical cluster analysis, the clusters' number was decided based on the Ward's method and using the agglomeration schedule table. The agglomeration table depicts the progress of the clusters' creation. The final clusters' number was chosen based on the "elbow rule", which describes that when the biggest jump of the coefficients between two stages is observed, then the clustering procedure should stop. This jump was observed between the 3rd and the 2nd cluster, resulting in 3 clusters.

The next step of the clustering procedure was a **non-hierarchical cluster analysis,** conducted by using the defined cluster number (3) from the hierarchical cluster analysis. For this analysis, the centroids (means) of the hierarchical cluster analysis were used as a start. These three clusters created were composed by 12, 41 and 47 respondents in each cluster respectively. The choice of the clusters was a procedure involving many repetitions of the clustering analysis.

Finally, to check whether there were statistically significant differences between the clusters an **ANOVA analysis was conducted.** Moreover, Student-Newman-Keuls posthoc tests were conducted to define the characteristics of the different cluster. In these analyses, all the variables were included. Table 9 depicts the mean scores per cluster and provides an insight into consumers' perspectives on precision agriculture, by revealing whether consumers have different opinions about precision agriculture. Table 9 depicts all the variables and highlights those that are significantly different between the clusters. The results are presented below.

Table 9: Consumers mean scores for all the variables, in the three clusters

	Cluster Number			
	1	2	3	Total
Frequencies (N)	12	41	47	
Increased yield - Taste	2.50	2.45	2.38	2.42
Increased yield - Low prices*	3.25	4.35	3.75	3.93
Increased yield - Healthiness	2.58	2.68	2.81	2.73
Increased yield - Sustainability	2.58	2.30	2.48	2.42
Increased yield - Appearance	2.92	2.95	3.10	3.02
Increased yield - Convenience	2.92	3.10	3.02	3.04
Resource efficiency - Taste	3.83	3.28	3.42	3.41
Resource efficiency - Lower price	2.58	2.63	3.13	2.86
Resource efficiency - Healthiness	3.58	3.73	3.19	3.45
Resource efficiency – Sustainability*	3.83	4.28	3.17	3.69
Resource efficiency – Appearance*	2.75	2.43	3.35	2.91
Resource efficiency – Convenience*	3.42	2.80	2.96	2.95
Low production risk – Taste	3.83	3.73	3.54	3.65
Low production risk - Low price*	2.00	3.63	3.06	3.16
Low production risk – Healthiness	3.33	3.83	3.67	3.69
Low production risk - Sustainability	3.67	3.90	3.35	3.61
Low production risk – Appearance	3.42	3.88	3.58	3.68
Low production risk - Convenience	2.83	3.10	3.15	3.09
High quality – Taste	4.50	3.95	3.85	3.97
High quality - Low price*	1.17	1.93	2.46	2.09
High quality – Healthiness*	4.42	3.58	3.60	3.69
High quality – Sustainability*	4.58	3.48	3.46	3.60
High quality – Appearance*	4.75	4.38	3.65	4.07
High quality – Convenience*	3.58	2.90	3.15	3.10
Sustainability - Taste	4.17	3.80	3.63	3.76
Sustainability - Low price	1.92	2.03	2.60	2.29
Sustainability – Healthiness	4.50	3.88	3.90	3.96
Sustainability – Sustainability*	4.75	4.88	4.25	4.56

Sustainability - Appearance	3.00	2.78	3.02	2.92
Sustainability – Convenience*	3.17	2.58	3.08	2.89
Social sustainability – Taste	3.50	3.10	3.29	3.24
Social sustainability - Low price	2.17	2.38	2.71	2.51
Social sustainability - Healthiness	3.33	3.15	3.33	3.26
Social sustainability - Sustainability	3.83	3.78	3.46	3.63
Social sustainability - Appearance	2.83	3.40	3.27	3.27
Social sustainability – Convenience*	3.33	2.88	3.08	3.03
Economic benefits – Taste*	4.83	4.35	3.96	4.22
Economic benefits - Low price*	2.33	3.25	2.98	3.01
Economic benefits – Healthiness*	4.50	3.70	3.77	3.83
Other economic benefits – Sustainability*	4.67	3.63	3.60	3.74
Economic benefits – Appearance*	4.75	4.18	3.94	4.13
Economic benefits – Convenience*	4.33	3.68	3.48	3.66
Required knowledge and skills – Taste*	4.17	3.40	4.00	3.78
Required knowledge and skills - Low price*	1.92	2.83	3.00	2.80
Required knowledge and skills – Healthiness*	4.50	3.38	3.96	3.79
Required knowledge and skills – Sustainability*	4.58	3.75	4.04	3.99
Required knowledge and skills – Appearance*	4.08	3.33	3.81	3.65
Required knowledge and skills – Convenience*	4.08	3.00	3.31	3.28
Ethical consideration – Taste	3.42	2.95	3.02	3.04
Ethical consideration - Low price*	2.25	3.03	3.23	3.03
Ethical consideration – Healthiness	3.00	2.75	2.96	2.88
Ethical consideration - Sustainability	2.75	2.83	2.73	2.77
Ethical consideration – Appearance	3.75	3.33	3.71	3.56
Ethical consideration - Convenience	3.17	3.10	3.23	3.17
Investment risk – Taste	3.92	3.60	3.75	3.71
Investment risk - Low price	2.50	2.45	2.33	2.40
Investment risk – Healthiness*	4.17	3.48	3.40	3.52
Investment risk – Sustainability	3.50	3.85	3.40	3.59
Investment risk – Appearance*	4.67	3.70	3.65	3.79
Investment risk – Convenience*	4.00	3.18	3.19	3.28

**Significantly different between the clusters, $p < .05$*

a) The cells that are underlined with red colour are the those with the highest scores for each connection, while those with the blue with the lowest. b) The cells that are underlined with yellow depict the different perspectives between two cluster, while with grey the differences in the intensity of consumers opinions.

Increased yields

The respondents of all the clusters think that the products produced with precision agriculture do not taste better, are less sustainable and are slightly less healthy when growers yield high amounts of products. Additionally, the respondents in all three clusters think that there is no influence on the products' appearance or convenience (see Table 9).

Differences are observed between clusters 1 and 2 regarding the products' prices when growers produce high yields. Respondents in the second cluster think that increased yields can lead to much lower prices compared to those in the first one who think that the prices will be slightly lower.

Resource efficiency

Table 9 results indicate that the respondents in all three clusters think that when growers have much information to use their resources efficiently, the products will have a better taste and will be healthier. The respondents think that the products are slightly more expensive as well.

Differences are observed between clusters 2 and 3. Respondents in cluster 2 think that the products are highly sustainable, while those in cluster 3 view the products as only slightly sustainable. Moreover, respondents in cluster 2 tend to think that when growers manage their resources efficiently, the products will have slightly worse appearance than respondents in Cluster 3 who think that the products will have a slightly better appearance. Finally, there are differences between the respondents in clusters 1 and 2 on their perception of the products' convenience. Respondents in cluster 1 think that the products are more convenient and respondents in cluster 2 less convenient.

Low production risk

The results suggest that all the respondents think that when growers are able to manage situations involving some risk, such as crop diseases, the products will taste better, be healthier, more sustainable, have a better appearance and will be more convenient.

Differences are observed between the first and the second clusters. The respondents in the first cluster think that when growers do not face many risks during the production procedure, the products will be more expensive, while the respondents belonging to the second cluster think that the prices will be lower.

High quality

The results demonstrate that the respondents, irrespective of the cluster to which they belong, think that when growers yield high quality products their taste will be better.

Respondents of cluster 1 think that products of high quality are much more expensive, while the respondents in cluster 3 think that their prices are only slightly higher. Other differences observed between cluster 1 and cluster 3 are related to the products' sustainability and appearance. Respondents in cluster 1 think that when growers produce high quality products, these products will have a better appearance and will be more sustainable compared to those in cluster 3 that expect a quite good appearance. Differences are also observed between Clusters 1 and 2 for the products' convenience. Respondents in cluster 1 think that when growers produce high quality products, the products will be more convenient, compared to respondents in cluster 2 that tend to think that the products are slightly less convenient.

Sustainability

The results indicate that all the clusters' respondents think that when growers use sustainable techniques to produce their crops, the products will taste better, be healthier, yet will have slightly higher prices and a worse appearance.

Slight differences have been observed between the respondents in cluster 2 and 3 regarding the products' sustainability, though both groups think that the products will be more sustainable. Differences can be identified between Cluster 1 and 2, since respondents in Cluster 1 think that products yielded by a sustainable procedure are slightly more convenient than the respondents of Cluster 2, who think that the products are slightly less convenient.

Social sustainability

The results in Table 9 suggest that when growers can provide consumers with information about the production procedure (e.g. through a label), respondents think that the products will taste better, have higher prices, be healthier, be more sustainable and will have a better appearance.

There is a difference between the respondents in cluster 1 and cluster 2 regarding the influence of the available information on the products' convenience. Respondents in cluster 1 think that when there is available information for the products, then the products are more convenient. Respondents in cluster 2 think that the products are slightly less convenient.

Economic benefits

The results state that there are differences between the respondents of the three clusters regarding their perspectives of the growers' profitability influence on the products' characteristics.

Specifically, respondents in cluster 1 think that when growers have high economic benefits, the products are very tasty, while those in cluster 3 think that they are only quite tasty. Respondents in cluster 1 also think that when growers have high profits, then the products are more sustainable, have a much better appearance and are much more convenient compared to the respondents in cluster 3 that think that the products' characteristics are only slightly improved. Moreover, data reveal that respondents in cluster 1 think that when growers have high profits, the products will have higher prices, while those in cluster 2 think that the products will have lower prices. Another difference between cluster 1 and cluster 2 is that the respondents belonging to cluster 1 think that the products are healthier compared to cluster 2 respondents who support the opposite.

Required knowledge and skills

The results on Table 9 demonstrate that the respondents' perspectives regarding the influence of the growers' educational level on the products' characteristics vary between the three clusters. It can be noticed that the differences between the clusters are mainly between the first and the second ones.

Cluster 1 respondents think that when growers are highly educated, then the products have a much better taste, are much more healthier, much more sustainable, have a much better appearance and are much more convenient compared to cluster 2 respondents. An interesting difference is observed between the first and the third cluster. The respondents in the first cluster think that the prices are higher when the growers are highly educated, while the respondents in the third cluster think that there is no influence on the prices.

Ethical considerations

The data on Table 9 reveal that all the respondents, irrespective of their cluster, think that when big companies own the data produced by precision agriculture, the products will have a slightly better taste, be slightly more convenient and they will have a better appearance. The respondents also think that the products will be less healthy and less sustainable.

A difference is observed between cluster 1 and cluster 3. Respondents in cluster 1 think that when big companies own the data produced by precision agriculture, the products will be more expensive. The respondents in cluster 3 think that they will be slightly cheaper.

Investment risk

Finally, the results suggest that the respondents of all clusters think that when growers make considerable investments in the production procedure, then the products will have a better taste, higher prices and will be more sustainable.

Differences are observed between Cluster 1 and Cluster 3, regarding the products' healthiness and appearance. Respondents in cluster 1 think that high investments lead to healthier products of a better appearance. Respondents in cluster 3 expect quite healthy products of a quite good appearance. Differences are also observed between Cluster 1 and Cluster 2, with respondents in Cluster 1 thinking that the products are much more convenient, while the respondents in Cluster 2 think that the products' convenience is only a little influenced by the growers' investments.

This clustering procedure provided extra insight into consumers' perspectives on precision agriculture. As depicted on Table 9 and described above, differences between clusters can be observed. Some of these differences, coloured in grey, indicate that the differences between the clusters are mainly due to the differences in the intensity of consumers' viewpoints. For example, most of the consumers think that when growers have high yields, then the products' prices will be lower. Nonetheless, there are differences between Cluster 1 and Cluster 2, since respondents in Cluster 1 think that there is a slight decrease in prices when growers have higher yields, compared to respondents in Cluster 2 thinking that the prices will have a bigger decrease. Such differences are observed between other clusters as well as depicted on Table 9.

The interesting finding is that there are groups of respondents with different viewpoints, and they are highlighted with yellow on Table 9. Respondents seem to have differing perspectives regarding the influence of the resource efficiency on product appearance and convenience. Consumers in Cluster 2 think that the products will have a worse appearance, while consumers in Cluster 3 think that the products will have a better appearance. In terms of convenience, consumers in cluster 1 expect the products to be more convenient in comparison to consumers in Cluster 2 that expect the opposite.

Cluster 1 consumers think that when growers can control the production risks, the prices will be high, while Cluster 2 consumers think that they will be low.

Consumers have different viewpoints as for the influence of high quality products on products' convenience. Cluster 1 consumers think that the products will be more convenient, while Cluster 2 consumers think that they will be less convenient.

Other differences are observed between Cluster 1 and Cluster 2 consumers regarding the products yielded in a sustainable way. Consumers in Cluster 1 think that they are more convenient while those in Cluster 2 think that they are less convenient.

Cluster 1 consumers think that when growers are able to share their information with them, then the products will be more convenient compared to the consumers in cluster 2 who think that the products will be less convenient.

Moreover, clusters 1 and 2 differ as for the influence of the growers' economic advantages when using precision agriculture on the products' prices. Cluster 1 consumers expect the prices to be higher, while cluster 2 consumers expect prices to be lower.

Cluster 1 consumers think that when growers are highly educated, the products' prices are high. Consumers in Cluster 3 think that the prices can become lower.

Finally, clusters 1 and 2 differ in their opinions about the influence of precision agriculture's ethical considerations on products' prices. Cluster 1 consumers think that the prices will be higher while those in Cluster 2 think that prices will be lower.

4.2 Consumers' intention to buy

In this part of the analysis, a multiple regression analysis was conducted to examine how and which product characteristics influence consumers' intention to buy products yielded with precision agriculture.

4.2.1 General Linear Model (GLM) analyses

Before concluding on the final regression model, various tests were conducted to research whether there are aspects with a significant effect on the results of the experimental design. Various general linear model (GLM) analyses were conducted.

Table 10 shows the results of the Multivariate tests, considering the effects of:

- the **product** that the respondents saw first (tomato or paprika/pepper),
- the **method** that they saw first (either precision or traditional agriculture),
- the **order** that they saw the manipulation (first or second manipulation) and
- the **cluster** to which respondents belong on the consumers' intention to buy a product and on the product perceived characteristics.

In the first GLM (GLM 1) analysis, the parameters product, method, order, cluster and their double interaction were taken into account. This analysis aimed to assess whether respondents' answers in the experimental part of the survey were influenced by the cluster to which they belonged. The results indicated no significant influence either of the parameter cluster or the cluster interaction with the other parameters of the experiment (see Table 10). This means that all the influences of the experiment were similar across the clusters.

The next GLM analysis (GLM 2) investigated whether the product (tomato or paprika), the method (traditional or precision) or the order of manipulation (first or second) influenced respondents' answers. In the analysis, the parameters product, method, order and their double and triple interaction were considered. The results (see Table 10) indicate that there is not a significant effect of the triple interaction of these parameters ($p=.211$).

Given that there was no triple interaction between the parameters, the next GLM analysis (GLM3) was run only considering the double interactions of the parameters. The results on Table 10 indicate that the parameters method ($p=.031$), order ($p=.038$), and their interaction, method*order ($p=.037$) are significant and influence the respondents' answers.

The next GLM analysis (GLM 4) conducted included the parameters product, method, order and the interaction method*order. The results indicate that method ($p=.030$), order ($p=0.038$) and their interaction ($p=.030$) are still significant and influence the results of the experiment. Since the experimental design included randomization in the order that the respondents saw the manipulations the parameter order and the interaction order*method were excluded in the final GLM analysis.

The final GLM analysis contained only the parameter method. The results indicate that the method that the products were yielded influenced respondents' answers. Specifically, the results state that the method parameter influenced the respondents' perspective for the factors taste (.049) and health (.005). Therefore, the parameter method was included in the final regression analysis.

Specifically, the results suggest that the parameter method influenced the respondents' perspective for the factors price (p=0.005) and appearance(p=0.049). The results of the mean scores indicate that respondents think that precision agriculture products have higher prices (mean score = -.1995) compared to traditional agriculture products (mean score=.1995). Respondents consider precision agriculture products (mean score=.1392) to have a better appearance compared to those of traditional agriculture (mean score=-.1392).

Table 10: GLM analyses' significances

Aspects	Significances
GLM 1	
Cluster	.327
Product	.419
Method	.294
Order	.031*
Method*Order	.075
Product*Method	.143
Cluster*Method	.825
Product*Order	.115
Cluster*Order	.954
Cluster*Product	.863
GLM 2	
Product	.742
Method	.037*
Order	.052*
Product*Method	.124
Product*Order	.166
Method*Order	.035*
Product*Method*Order	.211
GLM 3	
Product	.767
Method	.031*
Order	.038*
Product*Method	.128
Product*Order	.167
Method*Order	.037
GLM 4	
Product	.771
Method	.030*
Order	.038*
Method*Order	.030*
GLM 5	
Method	.025*

**These significances indicate that p<.05 and these aspects are significantly different than "there is no influence".*

4.2.2 Regression analysis

The next paragraphs present the results indicating which product characteristics or experimental factors affect consumers' intention to buy precision agriculture products. Two regression analyses were conducted.

Table 11: Regression analysis results (coefficients and significances) indicating which factors influence consumers' intention to buy products

	Unstandardized β coefficient	
Independent variable	Regression analysis 1	Regression analysis 2
Lower price	.031 (.624)	.024 (.713)
Healthiness	.211 (.026)*	.241 (.015)*
Convenience	-.012 (.868)	-.012 (.861)
Sustainability	.101 (.172)	.097 (.193)
Appearance	.253 (.000)*	.231 (.002)*
Taste	.143 (.049)*	.157 (.034)*
Sweet	.032 (.561)	.041 (.461)
Trust	.020 (.770)	.029 (.675)
Method	-.219 (.079)*	-.212 (.090)
Healthiness*Trust	--------------	.068 (.371)
Sustainability*Trust	--------------	-.002 (.975)

**These significances indicate that p<.05 and these aspects are significantly different than "there is no influence".*

The first regression analysis had as independent variables the lower price, healthiness, convenience, sustainability, taste, sweetness, trust and method and as dependent variable the consumers' intention to buy them. The role of trust as a moderator in the relationship of healthiness or sustainability and consumers' intention to buy was finally excluded, since it was proven that the interaction of Healthiness*Trust (p=.371) and Sustainability*Trust (p=.975) do not influence respondents' intention to buy (see Table 11). These findings demonstrate that Hypotheses 4 and 6 are not confirmed, and trust does not enhance the relationship between consumers' intention to buy precision agriculture products and consumers' perception of the products' healthiness and sustainability.

A second regression analysis was conducted using as independent variables only the price, health, convenience, sustainability, appearance, taste, sweetness, trust and method. The results presented in Table 11 indicate that the variables that can significantly predict consumers' intention to buy are Healthiness (p=.026), Appearance (p=.000) and Taste(p=.049). Moreover, it is observed that the method's significance (p=.079) is slightly higher than p=.05. This result indicates that the method (precision or traditional agriculture) influences consumers' intention to buy products. Specifically, precision agriculture (compared to traditional agriculture) has a negative influence on consumers' intention to buy.

Healthiness has a positive influence on consumers' intention to buy precision agriculture products (β = 0.211, p = .026), which confirms Hypothesis 3 stating that the healthier the products are perceived to be, the higher the consumers' intention to buy them.

The results show that Appearance also has a positive influence on consumers' intention to buy products (β = 0.253, p = .000), which confirms Hypothesis 8. Hypothesis 8 states that the more attractive the products are, the higher the consumers' intention to buy them.

Last, Taste has a positive influence on consumers' intention to buy products (β = 0.143, $p = .049$), which confirms Hypothesis 2, stating that the better the expected taste of the products, the higher the consumers' intention to buy them.

The rest of the hypotheses (H1, H5, H7) are not confirmed, due to the lack of significant results (see Table 11).

Chapter 5: Conclusion

The aim of this research was to provide an insight into the challenges of precision agriculture low adoption rates by answering three research questions.

The systematic literature review revealed that the growers adopting precision agriculture process can increase their yields, use their resources efficiently, manage their production risks better and yield high quality products in a sustainable way. Moreover, they can provide information about their production methods and procedures and have economic benefits. The challenges that growers face when using innovative techniques are being highly educated or skilled and making considerable investments in the new technologies involved. Another challenge is that big companies often exploit the data produced by them.

The research questionnaire respondents provided information about the advantages of precision agriculture in relation to the characteristics of precision agriculture products. The respondents think that most of the precision agriculture's advantages and challenges have a positive influence on the products' characteristics indicating that the products will have a better taste and a better appearance, be healthier and more sustainable. Yet, the respondents tend to think that most advantages and challenges of precision agriculture result in higher prices and do not influence the products' convenience. The exception to their positive perspectives is the increased yield resulting from precision agriculture, which has the opposite effect on product characteristics: a worse taste, being less healthy or less sustainable, yet having lower prices.

Owing to the sample's heterogeneity, differences have been observed between the different groups of respondents. Three groups have been identified, two of them with a comparable number of respondents (41 and 47) and one with fewer respondents (12). The differences noted between the groups concern precision agriculture benefits' and challenges' influences on product price and convenience. Consumers in Cluster 1 (consisting of 12 respondents) think that precision agriculture yields products of higher prices, while respondents in Cluster 2 (41 respondents) think that the prices are lower, while those in Cluster 3 have similar perspectives to Cluster 2. Another difference observed between clusters 1 and 2 concerns precision agriculture's influence on product convenience. Respondents in Cluster 1 consider the products to be more convenient, while Cluster 2 respondents consider them to be less convenient, much as Cluster 3 respondents .

Last, data were collected to answer the last question regarding consumers' intention to buy precision agriculture products. Although not all the hypotheses drawn were confirmed by the research results, it was concluded that the respondents' intention to buy was positively influenced by products with a nice appearance, good taste or perceived to be healthy.

Moreover, the study results indicate that even though the respondents are separated in three clusters, their distinct perspectives do not influence their intention to buy. The production method seen by the respondents in the experimental part of the survey had a marginal influence on their intention to buy, which suggests some differences between precision and traditional agriculture that were not examined in this survey and can have an influence on consumers' intention to buy.

Examining the factors influencing consumers' intention to buy (i.e. taste, appearance, healthiness and method), it is concluded that growers could increase consumers' intention to buy precision agriculture products if they communicate precision agriculture benefits and challenges to the consumers. Yet, they should not refer to increased productivity as a precision agriculture benefit because this is considered to have a negative influence on the product. Consumers are proven to be positive towards precision agriculture's influence on product characteristics, which finally influences their intention to buy. Further implications of these results are discussed in the next chapter.

Chapter 6: Discussion

Theoretical implications

This study in line with previous studies confirms the societal demands regarding food and the efficiency demands in the agricultural sector (Ofori et al., 2020). The literature review confirms that despite technological evolution, precision agriculture technologies' adoption rate is still low (Bucci et al., 2018). Moreover, technological acceptance theories (Technology Acceptance Model, Roger's theory of products' characteristics and Expected Utility characteristics) identifying the technological characteristics' influence on this adoption rate, contributed to structuring this research. One of the aims of this research is to close the gap in the literature between precision agriculture's advantages and challenges and the products' characteristics which finally influence their intention to buy. The results indicate that consumers think that the precision agriculture's advantages and challenges mostly positively influence the products' characteristics. Therefore, after this research evidence for the consumers' perspectives have been added.

Previous research aimed to identify growers' characteristics determining precision agriculture adoption (Diederen et al., 2003). This study introduces data on consumers' perspectives on precision agriculture in order for its low adoption rate to be increased. Relevant literature could broaden its scope by examining how consumers' opinions about product characteristics and consumers' intention to buy these products can influence growers' decision-making.

Findings from the systematic literature review regarding precision agriculture's advantages and challenges for the growers were used in this research to investigate consumers' opinions. This study connects technical to marketing research, and proves that consumers consider precision agriculture's advantages and challenges as positive influential parameters in the food characteristics (taste, appearance, price, healthiness, sustainability and convenience). These results are in line with research found in the literature review suggesting that precision agriculture can benefit the agricultural sector (Leonello et al., 2019; Miao & Khanna, 2020). It is worth mentioning that literature on precision agriculture's economic benefits for the growers is controversial, suggesting that the investment costs are high, yet their economic prospects for the growers are promising. This research suggests that consumers think that precision agriculture products are more expensive, which is also in line with the economic concerns regarding its adoption (Marra et al., 2003).

Consumers' intention to buy food was researched in the past by many authors (Brunsø et al., 2002). Those studies indicated that food characteristics (taste, appearance, price, healthiness, sustainability and convenience) influence consumers' decision making. In this research, though, only three of those parameters, taste, appearance and healthiness, proved to influence consumers' intention to buy.

Managerial implications

In an age that consumers' awareness is rising and feeding the ever-growing population in a sustainable way is crucial, food production optimization can become a valuable tool for stakeholders such as policy makers, companies, cooperatives and growers.

Policy makers who are responsible for taking decisions on agricultural issues and sustainability can take advantage of this research results and use them to promote a sustainable and efficient agricultural future. Policy makers can communicate to the consumers and the growers how precision agriculture can positively influence the products' characteristics (i.e. quality, sustainability) which can finally positively influence precision agriculture's acceptance and enforce laws to protect both growers and consumers from big companies' exploitation which is a challenge for growers and society. Laws that will reassure that any precision agriculture's ethical and legal challenges related to the products' healthiness and safety or issues regarding agricultural sustainability will be overcome.

Moreover, there are practical implications for the new technologies' suppliers, whose main problem is precision agriculture's low adoption rate. Therefore, the suppliers can benefit from this research results and create marketing strategies not only based on the technical advances of the technologies they offer but also by promoting precision agriculture's effects on product characteristics.

Cooperatives, retailers and growers may potentially draw marketing strategies assuring their clients that precision agriculture products have extra value and surpass their competitors' products. For example, cooperatives can use the data regarding consumers' opinions to motivate growers to adopt precision agriculture and emphasize its marketing prospects. Independent growers can strengthen their communication strategies to reach clients, as well. While consumers tend to see technologies as unnatural, growers can promote precision agriculture's sustainability as well as products with better taste, healthiness and appearance in order to raise consumers' acceptance and intention to buy these products.

Limitations

This research has some limitations, though.

- The sample size is small compared to the Netherlands' population and mainly composed of highly-educated young people. Most respondents in this research live in Wageningen, where agricultural issues awareness is high. These limitations make generalizability of the results to the Dutch population difficult.
- Another limitation of the study is the lack of previous studies in the area of consumers' perceptions on precision agriculture, so previous research could not be used as a foundation to build upon. Therefore, it is not possible to confirm or not hypotheses, but only describe the results collected and describe them as a current depiction.
- Another limitation in the experimental design is the repetition of the same questions to the respondents asking about their intention to buy products either yielded by precision or traditional agriculture. Respondents may not have distinguished the difference in the production procedure until the second manipulation, that is after having already the questions of the first manipulation. This weakness of the experimental design to inform the respondents before the manipulations may account for the similar results between precision and traditional agriculture.

Further research

- Future research can focus on a larger sample and a broader Dutch population regarding age and socio-demographic characteristics. The replication of the same or an improved study in a bigger sample may yield evidence that confirms these results or find different ones, since it may include people from different backgrounds.
- Further research may identify additional parameters influencing consumers' perspectives when buying vegetables such as their social classes, cultural backgrounds

or their origin i.e. other European countries regarding their food needs or preferences. This type of research can contribute to identifying more differences among consumers and creating other clusters of people with different perspectives. Research can also identify how the cultural values of the consumers may contradict with their needs and their perspectives and finally influencing their intention to buy. Additionally, companies can acquire useful data in order to promote their products to new countries; policy-makers promoting precision agriculture can introduce its advantages to countries with different perspectives towards precision agriculture than the Netherlands.

- The current research included theories (TAM, Roger's, EUT) emphasizing the products' characteristics as parameters likely to influence growers' decision making. Future research may include consumers' attitudinal characteristics. Consumers' perspective is influenced, yet their perception of the products but at the same time their attitudes can be ambivalent (Sipilä et al., 2018). Theories based on consumers' attitudes and consumers' behaviour such as "the Motivation-Need Theory" or "the Theory of planned behaviour" to identify whether consumers' perspectives of precision agriculture are ambivalent.

References

Adrian AM, Norwood SH, Mask PL (2005). Producers' perceptions and attitudes toward precision agriculture technologies. Comput. ElectronicsAgric. 48(3): 256-271.

Aggelopoulou AD, Bochtis D, Fountas S, Swain KC, Gemtos TA,Nanos GD. 2011. Yield prediction in apple orchards based on image processing. *Precis. Agric.* 12(3):448–56

Annosi, M. C., Brunetta, F., Capo, F., & Heideveld, L. (2020). Digitalization in the agri-food industry: the relationship between technology and sustainable development. Management Decision.

Antonopoulos, K., Panagiotou, C., Antonopoulos, C. P., & Voros, N. S. (2019, July). A-FARM Precision Farming CPS Platform. In 2019 10th International Conference on Information, Intelligence, Systems and Applications (IISA) (pp. 1-3). IEEE.

Asp, E. H. (1999). Factors affecting food decisions made by individual consumers. *Food policy*, *24*(2-3), 287-294.

Batz FJ, Peters K, Janssen W (1999). The influence of technology characteristics on the rate and speed of adoption. Agric. Econ. 21:121-130.

Beluhova-Uzunova, R., & Dunchev, D. (2020). Precision Technologies in soft fruit production. Scientific Papers Series-Management, Economic Engineering in Agriculture and Rural Development, 20(3), 131-137.

Blackmore, S., Godwin, R., and Fountas, S. (2003). The analysis of spatial and temporal trends in yield map data over six years. Biosystems Engineering 84, 455–466. http://dx.doi.org/10.1016/S1537-5110(03)00038-2

Bronson, K., 2018. Smart farming: including rights holders for responsible agricultural innovation. Technol. Innov. Manag. Rev. 8, 7–14. https://doi.org/10.22215/timreview/1135.

Bronson, K., Knezevic, I., 2016. Big data in food and agriculture. Big Data Soc. 3, 1–5. https://doi.org/10.1177/2053951716648174.

Brunsø, K., Grunert, K. G., & Fjord, T. A. (2002). *Consumers' food choice and quality perception* (Vol. 77). MAPP, Center for markedsovervågning,-vurdering og-bearbejdning til fødevaresektoren.

Bucci, G., Bentivoglio, D., & Finco, A. (2018). Precision agriculture as a driver for sustainable farming systems: State of art in literature and research. Calitatea, 19(S1), 114-121.

Cavallo, E., Ferrari, E., Bollani, L., & Coccia, M. (2014). Attitudes and behaviour of adopters of technological innovations in agricultural tractors: A case study in Italian agricultural system. *Agricultural Systems*, *130*, 44-54.

Carbonell, I. (2016). The ethics of big data in big agriculture. *Internet Policy Review*, *5*(1).

Carolan, M. (2018). 'Smart'farming techniques as political ontology: Access, sovereignty and the performance of neoliberal and not-so-neoliberal worlds. Sociologia Ruralis, 58(4), 745-764.

Chi, H, K., Yeh, H, R., Huang, M, W., (2008). The Influences of Advertising Endorser, Brand Image, Brand Equity, Price Promotion, on Purchase Intention. The Mediating Effect of Advertising Endorser, Retrieved December 5, 2011

Coble, K. H., Mishra, A. K., Ferrell, S., & Griffin, T. (2018). Big data in agriculture: A challenge for the future. Applied Economic Perspectives and Policy, 40(1), 79-96.

Comi, M. (2020). The distributed farmer: rethinking US Midwestern precision agriculture techniques. Environmental Sociology, 6(4), 403-415.

Crane, L., Gantz, G., & Isaacs, S. I. (2013). *Introduction to risk management*.

Davis, F. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 319-340. doi:10.2307/249008

De Bernardi, P., & Azucar, D. (2020). Innovative and Sustainable Food Business Models. In Innovation in Food Ecosystems (pp. 189-221). Springer, Cham.

Diederen, P., Van Meijl, H., Wolters, A., & Bijak, K. (2003). Innovation adoption in agriculture: innovators, early adopters and laggards. *Cahiers d'Economie et de Sociologie Rurales*, *67*, 29-50.

Eastwood, C., Klerkx, L., & Nettle, R. (2017). Dynamics and distribution of public and private research and extension roles for technological innovation and diffusion: Case studies of the implementation and adaptation of precision farming technologies. *Journal of Rural Studies*, *49*, 1-12.

Eastwood, C., Klerkx, L., Ayre, M., Rue, B.D., 2019. Managing socio-ethical challenges in the development of smart farming: from a fragmented to a comprehensive approach for responsible research and innovation. J. Agric. Environ. ETH. https://doi.org/10.1007/s10806-017-9704-5. In press.

Feder, G., & Umali, D. L. (1993). The adoption of agricultural innovations: a review. *Technological forecasting and social change*, *43*(3-4), 215-239.

Finger, R., Swinton, S. M., El Benni, N., & Walter, A. (2019). Precision farming at the nexus of agricultural production and the environment.

Galioto, F., Raggi, M., & Viaggi, D. (2017). Assessing the potential economic viability of precision irrigation: a theoretical analysis and pilot empirical evaluation. Water, 9(12), 990.

Gallardo, R. K., Grant, K., Brown, D. J., McFerson, J. R., Lewis, K. M., Einhorn, T., & Sazo, M. M. (2019). Perceptions of precision agriculture technologies in the US fresh apple industry. HortTechnology, 29(2), 151-162.

Gerwin, D. (1988). A theory of innovation processes for computer-aided manufacturing technology. IEEE Transactions on Engineering Management, 35(2), 90-100.

Giua, C., Materia, V. C., & Camanzi, L. (2020). Management information system adoption at the farm level: evidence from the literature. British Food Journal.

Gogoi, b. (2013), Study of antecedents of purchase intention and its effect on brand loyalty of private label brand of apparel, International Journal of Sales & Marketing, Vol. 3, Issue 2, Jun 2013, 73-86

Grebitus, C., Printezis, I., & Printezis, A. (2017). Relationship between consumer behavior and success of urban agriculture. *Ecological Economics*, *136*, 189-200.

Grieve, B. D., Duckett, T., Collison, M., Boyd, L., West, J., Yin, H., ... & Pearson, S. (2019). The challenges posed by global broadacre crops in delivering smart agri-robotic solutions: A fundamental rethink is required. Global Food Security, 23, 116-124.

Griffin, T.W. and Yeager, E.A. (2018), "Adoption of precision agriculture technology: a duration analysis", in Proceedings of 14th International Conference on Precision Agriculture, Monticello, IL, International Society of Precision Agriculture.

Grunert, K. G., Larsen, H. H., Madsen, T. K. and Baadsgaard, A. (1996). Market Orientation in Food and Agriculture. Boston, MA: Kluwer.

Grunert, Klaus G. (2005). Food Quality and Safety: Consumer Perception and Demand. European Review of Agricultural Economics. 32. 369-391. 10.1093/eurrag/jbi011.)

Herrmann, A., Xia,L., Monroe, K. B. & Huber, F. (2007). The influence of price fairness on customer satisfaction: an empirical test in the context of automobile purchases. Journal of Product & Brand Management, 16, 49-58.

Higgins, V., Bryant, M., Howell, A., & Battersby, J. (2017). Ordering adoption: Materiality, knowledge and farmer engagement with precision agriculture technologies. Journal of Rural Studies, 55, 193-202.

Hunt, A. R. (2007). Consumer interactions and influences on farmers' market vendors. *Renewable agriculture and food systems*, *22*(1), 54-66.

Iaksch, J., Fernandes, E., & Borsato, M. (2020, October). Digitalization and Big Data in Smart Farming–Bibliometric and Systemic Analysis. In Transdisciplinary Engineering for Complex Socio-technical Systems–Real-life Applications: Proceedings of the 27th ISTE International Conference on Transdisciplinary Engineering, July 1–July 10, 2020 (Vol. 12, p. 115). IOS Press.

Jiber, Y., Harroud, H., & Karmouch, A. (2011, July). Precision agriculture monitoring framework based on WSN. In 2011 7th International Wireless Communications and Mobile Computing Conference (pp. 2015-2020). IEEE.

Kaine, G. (2004). Consumer behaviour as a theory of innovation adoption in agriculture. *Social research working paper*, *1*(04).

Kamilaris, A., Kartakoullis, A., & Prenafeta-Bold, F. X. (2017). A review on the practice of big data analysis in agriculture. Computers and Electronics in 1095 Agriculture, 143 , 23 – 37. doi:10.1016/j.compag.2017.09.037

Kapoor, K. K., Dwivedi, Y. K., & Williams, M. D. (2014). Rogers' innovation adoption attributes: A systematic review and synthesis of existing research. *Information Systems Management*, *31*(1), 74-91.

Klerkx, L., Jakku, E., & Labarthe, P. (2019). A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. NJAS-Wageningen Journal of Life Sciences, 90, 100315.

Kopishynska, O., Utkin, Y., Galych, O., Marenych, M., & Sliusar, I. (2020, May). Main Aspects of the Creation of Managing Information System at the Implementation of Precision Farming. In 2020 IEEE 11th International Conference on Dependable Systems, Services and Technologies (DESSERT) (pp. 404-410). IEEE.

Kotler P. & Armstrong G. (2010), "Principles of Marketing", New Jersey: Pearson Prentice Hall.

Kuch, D., Kearnes, M., & Gulson, K. (2020). The promise of precision: datafication in medicine, agriculture and education. Policy Studies, 1-20.

Kutter, T., Tiemann, S., Siebert, R., Fountas, S., 2011. The role of communication andco-operation in the adoption of precision farming. Precis. Agric. 12 (1), 2e17. http://dx.doi.org/10.1007/s11119-009-9150-0.

Lencsés, E., Takács, I., & Takács-György, K. (2014). Farmers' perception of precision farming technology among Hungarian farmers. Sustainability, 6(12), 8452-8465.

Leonello, T., Andrea, A., Filippo, C., Rana, R. L., Gualtiero, F., & Angela, T. (2019). From Precision Agriculture to Industry 4.0: unveiling technological connections in the agricultural sector.

Lioutas, E. D., & Charatsari, C. (2020). Smart farming and short food supply chains: Are they compatible?. Land Use Policy, 94, 104541.

Lioutas, E. D., Charatsari, C., La Rocca, G., & De Rosa, M. (2019). Key questions on the use of big data in farming: An activity theory approach. NJAS-Wageningen Journal of Life Sciences, 90, 100297.

Loures, L., Chamizo, A., Ferreira, P., Loures, A., Castanho, R., & Panagopoulos, T. (2020). Assessing the Effectiveness of Precision Agriculture Management Systems in Mediterranean Small Farms. Sustainability, 12(9), 3765.

Marra, M., Pannell, D. J., & Ghadim, A. A. (2003). The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: where are we on the learning curve?. *Agricultural systems*, *75*(2-3), 215-234.

McCrindle Research, 2007. Socially Conscious or Selfish and Materialistic? http://www. mccrindle.com.au/ResearchSummaries/Socially-Conscious-or-selfish-andmaterialistic.pdf, accessed 1/8/2017

Mekonnen, Y., Burton, L., Sarwat, A., & Bhansali, S. (2018, October). Iot sensor network approach for smart farming: An application in food, energy and water system. In 2018 IEEE Global Humanitarian Technology Conference (GHTC) (pp. 1-5). IEEE.

Miao, R., & Khanna, M. (2020). Harnessing Advances in Agricultural Technologies to Optimize Resource Utilization in the Food-Energy-Water Nexus. Annual Review of Resource Economics, 12, 65-85.

Miles, C. (2019). The combine will tell the truth: On precision agriculture and algorithmic rationality. Big Data & Society, 6(1), 2053951719849444.

Mirabi, D. (2015). A Study of Factors Affecting on Customers Purchase Intention Case Study : the Agencies of Bono Brand Tile in Tehran.

Odara, S., Khan, Z., & Ustun, T. S. (2015, July). Integration of precision agriculture and smart grid technologies for sustainable development. In 2015 IEEE Technological Innovation in ICT for Agriculture and Rural Development (TIAR) (pp. 84-89). IEEE.

Ofori, E., Griffin, T. and Yeager, E. (2020), "Duration analyses of precision agriculture technology adoption: what's influencing farmers' time-to-adoption decisions?", Agricultural Finance Review, Vol. 80 No. 5, pp. 647-664. https://doi.org/10.1108/AFR-11-2019-0121

Olson, J. C., & Jacoby, J. (1972). Cue utilization in the quality perception process. *ACR Special Volumes*.

Pannell, D.J., Marshall, G.R., Barr, N., Gurtis, A., Vanclay, F., Wilkinson, R., 2006. Understanding and promoting adoption of conservation practices by rural landholders. Aust. J. Exp. Agric. 46, 1407–1424.

Paustian, M., & Theuvsen, L. (2017). Adoption of precision agriculture technologies by German crop farmers. *Precision agriculture*, *18*(5), 701-716)

Pedersen, S. M., Pedersen, M. F., Ørum, J. E., Fountas, S., Balafoutis, A. T., van Evert, F. K., van Egmond, F., Knierim, A., Kernecker, M., & Mouazen, A. M. (2020). Economic, environmental and social impacts. In A. Castrignanò, G. Buttafuoco, R. Khosla, A. M. Mouazen, D. Moshou, & O. Naud (Eds.), Agricultural Internet of Things and Decision Support for Precision Smart Farming(pp.279-330).Elsevier.https://doi.org/10.1016/B978-0-12-818373-1.00006-8

Phillips, P. W., Relf-Eckstein, J. A., Jobe, G., & Wixted, B. (2019). Configuring the new digital landscape in western Canadian agriculture. NJAS-Wageningen Journal of Life Sciences, 90, 100295.

Pierpaoli, E., Carli, G., Pignatti, E. and Canavari, M. (2013), "Drivers of precision agriculture technologies adoption: a literature review", Procedia Technology, Vol. 8, pp. 61-69.

Rajkumar, S. & Arun, M. & Hirwani, J. & Sanjeev, S.S.. (2019). Predictive analysis of crops cultivation for a smart green environment using azure services. International Journal of Recent Technology and Engineering.7.295-298.

Ramundo, L., Taisch, M., & Terzi, S. (2016, September). State of the art of technology in the food sector value chain towards the IoT. In 2016 IEEE 2nd International Forum on Research and Technologies for Society and Industry Leveraging a better tomorrow (RTSI) (pp. 1-6). IEEE.

Regan, Á. (2019). 'Smart farming in Ireland: A risk perception study with key governance actors. NJAS-Wageningen Journal of Life Sciences, 90, 100292.

Řezník, T., Charvát, K., Lukas, V., Junior, K. C., Kepka, M., Horáková, Š., ... & Řezníková, H. (2017, May). Open farm management information system supporting ecological and economical tasks. In International Symposium on Environmental Software Systems (pp. 221-233). Springer, Cham.

Robert, P.C. (2002), "Precision agriculture: a challenge for crop nutrition management", Plant and Soil, Vol. 247, pp. 143-149.

Rogers, E. M. (1983). Diffusion of innovations (3rd ed.). New York: The Free Press.

Rogers, E. M. (2003). Diffusion of innovations (5th ed.). New York: The Free Press.

Roininen, K., Tuorila, H., Zandstra, E. H., de Graaf, C., Vehkalahti, K., Stubenitsky, K., & Mela, D. J. (2001). Differences in health and taste attitudes and reported behaviour among Finnish, Dutch and British consumers: a cross-national validation of the Health and Taste Attitude Scales (HTAS). *Appetite*, *37*(1), 33–45. https://doi.org/10.1006/appe.2001.0414

Sarker, M. N. I., Islam, M. S., Murmu, H., & Rozario, E. (2020). Role Of Big Data On Digital Farming.

Sarri, D., Lombardo, S., Pagliai, A., Perna, C., Lisci, R., De Pascale, V., ... & Vieri, M. (2020). Smart Farming Introduction in Wine Farms: A Systematic Review and a New Proposal. Sustainability, 12(17), 7191.

Schimmelpfennig, D. (2018). Crop production costs, profits, and ecosystem stewardship with precision agriculture. Journal of Agricultural and Applied Economics, 50(1), 81-103.

Senauer, B., Asp, E., Kinsey, J., 1991. Food Trends and the Changing Consumer. Eagan Press, St. Paul, MN.

Shah, H., Aziz, A., Jaffari, A. R., Waris, S., Ejaz, W., Fatima, M. and Sherazi., K.(2012), The Impact of Brands on Consumer Purchase Intentions, Asian Journal of Business Management 4(2): 105-110

Sharma, R., Kamble, S. S., Gunasekaran, A., Kumar, V., & Kumar, A. (2020). A systematic literature review on machine learning applications for sustainable agriculture supply chain performance. Computers & Operations Research, 104926.

Shibusawa, S., 1998. Precision Farming and Terra-mechanics. Fifth ISTVS Asia-Pacific Regional Conference in Korea, October 20–22.

Shugan, M.S. (1984). "Price-Quality Relationships", in *NA - Advances in Consumer Research* Vol. 11, eds. Thomas C. Kinnear, Provo, UT : Association for Consumer Research, Pages: 627-632.

Sipilä, J., Tarkiainen, A., & Sundqvist, S. (2018). Toward an improved conceptual understanding of consumer ambivalence. AMS Review, 8(3), 147-162.

Sloan, A. E. (1994). Top ten trends: to watch and work on. *Food technology (Chicago)*, *48*(7), 89-100.

Steenhuis, I. H., Waterlander, W. E., & De Mul, A. (2011). Consumer food choices: the role of price and pricing strategies. *Public health nutrition*, *14*(12), 2220-2226.

Steenkamp, J. B. E. (1990). Conceptual model of the quality perception process. *Journal of Business research*, *21*(4), 309-333.

Stull, J., Dillon, C., Shearer, S., & Isaacs, S. (2004). Using precision agriculture technology for economically optimal strategic decisions: The case of CRP filter strip enrollment. Journal of Sustainable Agriculture, 24(4), 79-96.

Surry, D. 1997. Diffusion theory and instructional technology. Paper presented at the Association for Educational Communications and Technology: Albuquerque, NM

Sykuta, Michael. (2016). Big Data in Agriculture: Property Rights, Privacy and Competition in Ag Data Services. The International Food and Agribusiness Management Review. 19.

Tack, J., Coble, K. H., Johansson, R., Harri, A., & Barnett, B. J. (2019). The Potential Implications of "Big Ag Data" for USDA Forecasts. Applied Economic Perspectives and Policy, 41(4), 668-683.

Tantalaki, N., Souravlas, S., & Roumeliotis, M. (2019). Data-Driven Decision Making in Precision Agriculture: The Rise of Big Data in Agricultural Systems. *Journal of Agricultural & Food Information*, *20*(4), 344-380.

Thompson, N. M., Bir, C., Widmar, D. A., & Mintert, J. R. (2019). Farmer perceptions of precision agriculture technology benefits. Journal of Agricultural and Applied Economics, 51(1), 142-163.

Tranfield, D., Denyer, D. and Smart, P. (2003), "Towards a Methodology for Developing EvidenceInformed Management Knowledge by Means of Systematic Review", British Journal of Management, Vol.14 No. 3, 207-222.

Tsiotsou, R., (2005). Perceived quality levels and their relation to involvement, satisfaction, and purchase intention, marketing bulletin, 16(4), 1-10.

Van Evert, F. K., Gaitán-Cremaschi, D., Fountas, S., & Kempenaar, C. (2017). Can precision agriculture increase the profitability and sustainability of the production of potatoes and olives?. Sustainability, 9(10), 1863.

Venter, C. (2020). Driving efficiencies with precision agriculture: technology. *FarmBiz*, *6*(9), 35-37.

Verbeke, W. (2005). Consumer acceptance of functional foods: socio-demographic, cognitive and attitudinal determinants. Food quality and preference, 16(1), 45-57.

Wejnert, Barbara. (2002). Integrating Models of Diffusion of Innovations: A Conceptual Framework. Annual Review of Sociology - ANNU REV SOCIOL. 28. 297-326. 10.1146/annurev.soc.28.110601.141051.

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. J. (2017). Big data in smart farming–a review. *Agricultural Systems*, *153*, 69-80.

Yigezu, Y. A., Mugera, A., El-Shater, T., Aw-Hassan, A., Piggin, C., Haddad, A., ... & Loss, S. (2018). Enhancing adoption of agricultural technologies requiring high initial investment among smallholders. *Technological Forecasting and Social Change*, *134*, 199-206.

Yu, J., & Hendricks, N. P. (2020). Input Use Decisions with Greater Information on Crop Conditions: Implications for Insurance Moral Hazard and the Environment. American Journal of Agricultural Economics, 102(3), 826-845.

Zeithaml, V. A. (1988). Consumer perceptions of price, quality, and value: A means-end model and synthesis of evidence. Journal of Marketing, 52(3), 2-22.

Appendix

Appendix 1

String 1:

- Scopus
(TITLE-ABS-KEY (precision AND agriculture) AND TITLE-ABS-KEY (value) OR TITLE-ABS-KEY (benefits) OR TITLE-ABS-KEY (advantages))
AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "DECI") OR LIMIT-TO (SUBJAREA , "ECON"))

- Web of Science
TOPIC: (precision agriculture) AND TOPIC: (value)
Refined by: WEB OF SCIENCE CATEGORIES: (MANAGEMENT OR ECONOMICS OR BUSINESS OR AGRICULTURAL ECONOMICS POLICY OR HORTICULTURE)

String 2:

- Scopus
(TITLE-ABS-KEY (smart AND farming) AND TITLE-ABS-KEY (value) OR TITLE-ABS-KEY (benefits) OR TITLE-ABS-KEY (advantages)) AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "DECI") OR LIMIT-TO (SUBJAREA , "ECON")

Appendix 2

Title	**Author**	**Year**	**Database**
Precision agriculture as a driver for sustainable farming systems: State of art in literature and research	Bucci et al.	2018	Web of Science
‘Smart farming’ in Ireland: A risk perception study with key governance actors	Regan	2019	Scopus
‘Smart’ Farming Techniques as Political Ontology: Access, Sovereignty and the Performance of Neoliberal and Not-So-Neoliberal Worlds	Carolan	2018	Scopus
A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda	Klerlx et al.	2019	Scopus
A systematic literature review on machine learning applications for sustainable agriculture supply chain performance	Sharma et al.	2020	Scopus
A-FARM Precision Farming CPS Platform	Antonopoulos et al.	2019	Scopus
Assessing the Effectiveness of Precision Agriculture Management Systems in Mediterranean Small Farms	Loures et al.	2020	Scopus
Assessing the Potential Economic Viability of Precision Irrigation: A Theoretical Analysis and Pilot Empirical Evaluation	Galioto et al.	2017	Scopus
Big Data in Agriculture: A Challenge for the Future	Coble et al.	2018	Scopus
Can Precision Agriculture Increase the Profitability and Sustainability of the Production of Potatoes and Olives?	Van Evert et al.	2017	Scopus
Configuring the new digital landscape in western Canadian agriculture	Phillips et al.	2019	Scopus
Crop production costs, profits, and ecosystem stewardship with precision agriculture	Schimmelpfennig	2018	Scopus
Digitalization and Big Data in Smart Farming – Bibliometric and Systemic Analysis	Iaksch et al.	2020	Scopus
Digitalization in the agri-food industry: the relationship between technology and sustainable development	Annosi et al.	2020	Web of Science
Duration analyses of precision agriculture technology adoption: what’s influencing farmers’ time-to-adoption decisions?	Ofori et al.	2020	Scopus
Economic, environmental and social impacts	Pederson et al.	2020	Scopus
Farmer perceptions of precision agriculture technology benefits	Thompson et al.	2019	Scopus
Farmers’ Perception of Precision Farming Technology among Hungarian Farmers	Lencséset al.	2014	Scopus

From precision agriculture to Industry 4.0 Unveiling technological connections in the agrifood sector	Leonello et al.	2019	Web of Science
Harnessing Advances in Agricultural Technologies to Optimize Resource Utilization in the Food-Energy-Water Nexus	Miao & Khanna	2020	Scopus
Innovative and Sustainable Food Business Models	De Bernardi & Azucar	2020	Scopus
Input Use Decisions with Greater Information on Crop Conditions: Implications for Insurance Moral Hazard and the Environment	Yu & Hendricks	2020	Scopus
Input Use Decisions with Greater Information on Crop Conditions: Implications for Insurance Moral Hazard and the Environment	Yu & Hendricks	2020	Web of Science
Integration of Precision Agriculture and SmartGrid technologies for Sustainable Development	Odara et al.	2015	Scopus
IoT Sensor Network Approach for Smart Farming: An Application in Food, Energy and Water System	Mekonnen et al.	2018	Scopus
Key questions on the use of big data in farming: An activity theory approach	Lioutas et al.	2019	Scopus
Main Aspects of the Creation of Managing Information System at the Implementation of Precise Farming	Koposhynska et al.	2020	Scopus
Management information system adoption at the farm level: evidence from the literature	Giua et al.	2020	Scopus
Open Farm Management Information System Supporting Ecological and Economical Tasks	Řezník et al.	2017	Scopus
Ordering adoption: Materiality, knowledge and farmer engagement with precision agriculture technologies	Higgins et al.	2017	Scopus
Perceptions of Precision Agriculture Technologies in the US Fresh Apple Industry	Gallardo et al.	2019	Web of Science
Precision Agriculture Monitoring Framework Based on WSN	Jiber et al.	2011	Scopus
Precision Farming at the Nexus of Agricultural Production and the Environment	Finger et al.	2019	Scopus
Precision Technologies in soft fruit production	Beluhova-Uzunova &Dunchev	2020	Web of Science
Predictive Analysis of Crops Cultivation for a Smart Green Environment Using Azure Services	Rajkumar et al.	2019	Scopus
Role of Big Data On Digital Farming	Sarker et al.	2020	Scopus
Smart farming and short food supply chains: Are they compatible?	Lioutas & Charatsari	2020	Scopus
Smart Farming Introduction in Wine Farms:A Systematic Review and a New Proposal	Sarri et al.	2020	Scopus
State of the art of technology in the Food sector value chain towards the IoT	Ramundo et al.	2016	Scopus

The challenges posed by global broadacre crops in delivering smart agrirobotic solutions: A fundamental rethink is required	Grieve et al.	2019	Scopus
The combine will tell the truth: On precision agriculture and algorithmic rationality (maybe)	Miles	2019	Scopus
The distributed farmer: rethinking US Midwestern precision agriculture techniques	Comi	2020	Scopus
The Potential Implications of “Big Ag Data” for USDA Forecasts	Tack et al.	2019	Scopus
The promise of precision: datafication in medicine,agriculture and education	Kuch et al.	2020	Scopus
Using Precision Agriculture Technology for Economically Optimal Strategic Decisions: The Case of CRP Filter Strip Enrollment	Stull et al.	2004	Scopus

Appendix 3

Questionnaire:

1) Introduction:

Hello!

My name is Emmanouela Alexopoulou. I would like to welcome you to this survey, which is part of my Master's thesis at Wageningen University. In this survey, you will see pictures of vegetables and a description about how they were produced. Afterwards I ask you to evaluate these vegetables by indicating to what extent you agree with a list of statements. I also ask you to indicate whether you would buy the vegetables when shopping for groceries.

At the end of the survey, I will give you more detailed information about the purpose of this research. I cannot give you more information upfront, because that might influence your answers. In any case feel free to send me an e-mail at: emmanouela.alexopoulou@wur.nl.

The survey consists of two sections, and it will take you about 10 minutes to finish it. Your answers will be registered anonymously and this research will only be used for academic purposes.

Please press the "Next" button to proceed to the survey.

Thank you!

2) Eligibility questions:

Q1: Do you live in the Netherlands?

- o Yes
- o No

Q2: Do you consume vegetables?

- o Yes
- o No

Part 1

Below, you see pictures and a description of a paprika. Read the description and take a look at the pictures. Then answer the questions.

Group 1:

Group 2:

Group 3:

Group 4:

"This paprika / tomato was produced using precision agriculture techniques. Growers collect large amounts of data about individual plants with sensors, such as cameras to monitor and optimize the growth of their crops."

OR

"This paprika/ tomato was produced using traditional agriculture techniques. Growers walk around their greenhouses to visually inspect their crops and use their knowledge and experience to optimize the growth of their crops."

Q1: Please answer the following questions about this paprika / tomato:

	Definitely Not 1	2	3	4	5	6	Definitely Yes 7
Would you like to try this product?	○	○	○	○	○	○	○
Would you buy this product if you happened to see it in a store?	○	○	○	○	○	○	○
Would you actively seek out this product in a store in order to purchase it?	○	○	○	○	○	○	○

Q2: How would you rate the following factors about this paprika/tomato?

I expect that this tomato/ paprika…

	Strongly disagree (1)	Moderately Disagree (2)	Slightly disagree (3)	Neither agree nor disagree (4)	Slightly agree (5)	Moderately Agree (6)	Strongly agree (7)
will not be expensive	○	○	○	○	○	○	○
will not be cheap	○	○	○	○	○	○	○
will be good value for money	○	○	○	○	○	○	○
keeps me healthy	○	○	○	○	○	○	○
is nutritious	○	○	○	○	○	○	○
contains a lot of vitamins and minerals	○	○	○	○	○	○	○
is easy to prepare (clean and cook it)	○	○	○	○	○	○	○

can be prepared (such as cook it) very simple	○	○	○	○	○	○	○
takes little time (such as clean it) before the consumption	○	○	○	○	○	○	○
has been produced ethically	○	○	○	○	○	○	○
is not harmful to the environment	○	○	○	○	○	○	○
has been produced in an environmentally friendly way	○	○	○	○	○	○	○
looks attractive	○	○	○	○	○	○	○
has a nice shape	○	○	○	○	○	○	○
has a nice color	○	○	○	○	○	○	○
is tasty	○	○	○	○	○	○	○
is sweet	○	○	○	○	○	○	○
has a poor taste	○	○	○	○	○	○	○

Q3 : Please indicate how much you agree with the following statements.

Looking at the description about the production of this paprika/tomato, …

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
I trust this description	○	○	○	○	○	○	○
I think this is an honest description	○	○	○	○	○	○	○
I rely on this description	○	○	○	○	○	○	○

(Next page of the survey)

Group 1

Group 2

Group 3

Group 4

"This paprika/ tomato was produced using traditional agriculture techniques. Growers walk around their greenhouses to visually inspect their crops and use their knowledge and experience to optimize the growth of their crops."

OR

"This paprika / tomato was produced using precision agriculture techniques. Growers collect large amounts of data about individual plants with sensors, such as cameras to monitor and optimize the growth of their crops."

Q4: Please answer the following questions about this paprika / tomato:

	Definitely Not 1	2	3	4	5	6	Definitely Yes 7
Would you like to try this product?	○	○	○	○	○	○	○
Would you buy this product if you happened to see it in a store?	○	○	○	○	○	○	○
Would you actively seek out this product in a store in order to purchase it?	○	○	○	○	○	○	○

Q5: How would you rate the following factors about this product?

I expect that this tomato/ paprika…

	Strongly disagree (1)	Moderately Disagree (2)	Slightly disagree (3)	Neither agree nor disagree (4)	Slightly agree (5)	Moderately Agree (6)	Strongly agree (7)
will not be expensive	○	○	○	○	○	○	○
will not be cheap	○	○	○	○	○	○	○
will be good value for money	○	○	○	○	○	○	○
keeps me healthy	○	○	○	○	○	○	○
is nutritious	○	○	○	○	○	○	○
contains a lot of vitamins and minerals	○	○	○	○	○	○	○
is easy to prepare (clean and cook it)	○	○	○	○	○	○	○
can be prepared (such as cook it) very simple	○	○	○	○	○	○	○

takes little time (such as clean it) before the consumption	○	○	○	○	○	○	○
has been produced ethically	○	○	○	○	○	○	○
is not harmful to the environment	○	○	○	○	○	○	○
has been produced in an environmentally friendly way	○	○	○	○	○	○	○
looks attractive	○	○	○	○	○	○	○
has a nice shape	○	○	○	○	○	○	○
has a nice color	○	○	○	○	○	○	○
is tasty	○	○	○	○	○	○	○
is sweet	○	○	○	○	○	○	○
has a poor taste	○	○	○	○	○	○	○

Q6 : Please indicate how much you agree with the following statements.

Looking at the description about the production of this paprika/tomato, I feel that…

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
I trust this description	○	○	○	○	○	○	○
I think this is an honest description	○	○	○	○	○	○	○
I rely on this description	○	○	○	○	○	○	○

(Next page)

3) Part 2

Evaluate the following questions about vegetables. Score +2 if you believe that there is a positive effect, -2 if you believe that there is a negative effect. Zero (0) represents no effect.

Q7: I believe that when growers increase their production, their products will:

	-2	-1	0	+1	+2	
Taste worse	○	○	○	○	○	Taste better
Have higher prices	○	○	○	○	○	Have lower prices
Be less healthy	○	○	○	○	○	Be more healthy
Be produced less environmentally friendly	○	○	○	○	○	Be produced more environmentally friendly
Look less attractive	○	○	○	○	○	Look more attractive
Require more time to prepare	○	○	○	○	○	Require less time to prepare

Q8: I believe that when growers use less fertilizers, then the products will:

	-2	-1	0	+1	+2	
Taste worse	○	○	○	○	○	Taste better
Have higher prices	○	○	○	○	○	Have lower prices
Be less healthy	○	○	○	○	○	Be more healthy
Be produced less environmentally friendly	○	○	○	○	○	Be produced more environmentally friendly
Look less attractive	○	○	○	○	○	Look more attractive
Require more time to prepare	○	○	○	○	○	Require less time to prepare

Q9: I believe that when growers can predict crop diseases better, then the products will:

	-2	-1	0	+1	+2	
Taste worse	○	○	○	○	○	Taste better
Have higher prices	○	○	○	○	○	Have lower prices
Be less healthy	○	○	○	○	○	Be more healthy
Be produced less environmental friendly	○	○	○	○	○	Be produced more environmental friendly
Look less attractive	○	○	○	○	○	Look more attractive
Require more time to prepare	○	○	○	○	○	Require less time to prepare

Q10: Compared to lower grades, I believe that "grade I" (higher quality) products will:

	-2	-1	0	+1	+2	
Taste worse	○	○	○	○	○	Taste better
Have higher prices	○	○	○	○	○	Have lower prices
Be less healthy	○	○	○	○	○	Be more healthy
Be produced less environmental friendly	○	○	○	○	○	Be produced more environmental friendly
Look less attractive	○	○	○	○	○	Look more attractive
Require more time to prepare	○	○	○	○	○	Require less time to prepare

Q11: I believe that environmentally friendly techniques result in products that :

	-2	-1	0	+1	+2	
Taste worse	○	○	○	○	○	Taste better
Have higher prices	○	○	○	○	○	Have lower prices
Be less healthy	○	○	○	○	○	Be more healthy
Be produced less environmental friendly	○	○	○	○	○	Be produced more environmental friendly
Look less attractive	○	○	○	○	○	Look more attractive
Require more time to prepare	○	○	○	○	○	Require less time to prepare

Q12: I believe that when growers provide more information about the production process, through a description or a label, the products will:

	-2	-1	0	+1	+2	
Taste worse	○	○	○	○	○	Taste better
Have higher prices	○	○	○	○	○	Have lower prices
Be less healthy	○	○	○	○	○	Be more healthy
Be produced less environmental friendly	○	○	○	○	○	Be produced more environmental friendly
Look less attractive	○	○	○	○	○	Look more attractive
Require more time to prepare	○	○	○	○	○	Require less time to prepare

Q13: For growers to obtain higher profits, the products should:

	-2	-1	0	+1	+2	
Taste worse	○	○	○	○	○	Taste better
Have higher prices	○	○	○	○	○	Have lower prices
Be less healthy	○	○	○	○	○	Be more healthy
Be produced less environmental friendly	○	○	○	○	○	Be produced more environmental friendly
Look less attractive	○	○	○	○	○	Look more attractive
Require more time to prepare	○	○	○	○	○	Require less time to prepare

Q14: I believe that when a grower is highly educated , the products will:

	-2	-1	0	+1	+2	
Taste worse	○	○	○	○	○	Taste better
Have higher prices	○	○	○	○	○	Have lower prices
Be less healthy	○	○	○	○	○	Be more healthy
Be produced less environmental friendly	○	○	○	○	○	Be produced more environmental friendly
Look less attractive	○	○	○	○	○	Look more attractive
Require more time to prepare	○	○	○	○	○	Require less time to prepare

Q15: I believe that when big companies own the data about how products are produced, the products will:

	-2	-1	0	+1	+2	
Taste worse	○	○	○	○	○	Taste better
Have higher prices	○	○	○	○	○	Have lower prices
Be less healthy	○	○	○	○	○	Be more healthy
Be produced less environmental friendly	○	○	○	○	○	Be produced more environmental friendly
Look less attractive	○	○	○	○	○	Look more attractive
Require more time to prepare	○	○	○	○	○	Require less time to prepare

Q16: I believe that when a grower invests a lot to buy new technologies, the products will:

	-2	-1	0	+1	+2	
Taste worse	○	○	○	○	○	Taste better
Have higher prices	○	○	○	○	○	Have lower prices
Be less healthy	○	○	○	○	○	Be more healthy
Be produced less environmental friendly	○	○	○	○	○	Be produced more environmental friendly
Look less attractive	○	○	○	○	○	Look more attractive
Require more time to prepare	○	○	○	○	○	Require less time to prepare

3) Part 3 - Demographic questions

Q17: What is your age? Please Choose in which age group you belong.

- ○ Under 18
- ○ 18-24
- ○ 25-24
- ○ 35-44

- 45-54
- 55-64
- 65-74
- 75-84
- 85 or older
- I don’t want to tell

Q18: What is your highest level of education you have completed?

- No education
- Primary school
- Secondary school
- "MBO"
- "HBO"
- University, bachelor
- University, master

Q19: Between the age of 4 to 18 I used to live in …

- a City
- a Village
- the Countryside

Q20: Where do you usually buy vegetables?

- In the supermarket
- Online
- Directly from the farmer
- At specialty shops (like vegetable shops)
- Market place
- Other, namely:

4) Conclusion

“Thank you for your time and effort!

This research took place in order to find out how consumers perceive the benefits of precision agriculture and whether they intent to buy such products.”

END OF THE SURVEY

Appendix 4

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	5.857	32.538	32.538	5.857	32.538	32.538	3.645
2	2.378	13.210	45.748	2.378	13.210	45.748	2.176
3	1.930	10.725	56.472	1.930	10.725	56.472	3.320
4	1.261	7.006	63.479	1.261	7.006	63.479	3.242
5	1.180	6.553	70.032	1.180	6.553	70.032	2.880
6	.890	4.944	74.976	.890	4.944	74.976	1.303
7	.772	4.291	79.267	.772	4.291	79.267	3.612
8	.526	2.920	82.187				
9	.464	2.577	84.764				
10	.438	2.433	87.197				
11	.402	2.234	89.431				
12	.387	2.148	91.580				
13	.350	1.944	93.524				
14	.320	1.779	95.303				
15	.246	1.364	96.667				
16	.235	1.306	97.973				
17	.185	1.030	99.003				
18	.179	.997	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Structure Matrix

	Component						
	1	2	3	4	5	6	7
How would you rate the following factors about this paprika? I expect that this paprika... - will not be expensive	.054	.927	.209	.040	.007	-.019	.129
How would you rate the following factors about this paprika? I expect that this paprika... - will not be cheap	.002	-.912	-.120	-.113	-.025	.088	.045
How would you rate the following factors about this paprika? I expect that this paprika... - will be good value for money	.154	.555	.425	-.135	-.397	-.071	.584
How would you rate the following factors about this paprika? I expect that this paprika... - keeps me healthy	.768	.128	.504	-.423	-.386	.134	.456
How would you rate the following factors about this paprika? I expect that this paprika... - is nutritious	.877	.109	.343	-.372	-.445	.190	.525
How would you rate the following factors about this paprika? I expect that this paprika... - contains a lot of vitamins and minerals	.889	.082	.332	-.412	-.400	.200	.427
How would you rate the following factors about this paprika? I expect that this paprika... - is easy to prepare (clean and cook it)	.392	.165	.876	-.334	-.087	.063	.168
How would you rate the following factors about this paprika? I expect that this paprika... - can be prepared (such as cook it) very simple	.229	.110	.891	-.296	-.134	.067	.196
How would you rate the following factors about this paprika? I expect that this paprika... - takes little time to prepare (such as clean it) before the consumption	.341	.250	.847	-.180	-.154	.021	.090
How would you rate the following factors about this paprika? I expect that this paprika... - has been produced ethically	.412	.100	.183	-.259	-.279	.198	.808
How would you rate the following factors about this paprika? I expect that this paprika... - is not harmful to the environment	.380	-.024	.099	-.243	-.252	.084	.852
How would you rate the following factors about this paprika? I expect that this paprika... - has been produced in an environmentally friendly way	.395	.036	.109	-.202	-.355	.171	.866
How would you rate the following factors about this paprika? I expect that this paprika... - looks attractive	.294	.029	.352	-.847	-.370	.025	.216
How would you rate the following factors about this paprika? I expect that this paprika... - has a nice shape	.340	-.032	.290	-.846	-.089	.077	.174
How would you rate the following factors about this paprika? I expect that this paprika... - has a nice color	.381	-.134	.084	-.840	-.303	.221	.278
How would you rate the following factors about this paprika? I expect that this paprika... - is tasty	.395	.034	.197	-.335	-.907	.193	.345
How would you rate the following factors about this paprika? I expect that this paprika... - is sweet	.204	-.003	.098	-.130	-.223	.983	.169
How would you rate the following factors about this paprika? I expect that this paprika... - has a poor taste	-.361	.075	-.034	.238	.888	-.228	-.287

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Appendix 5

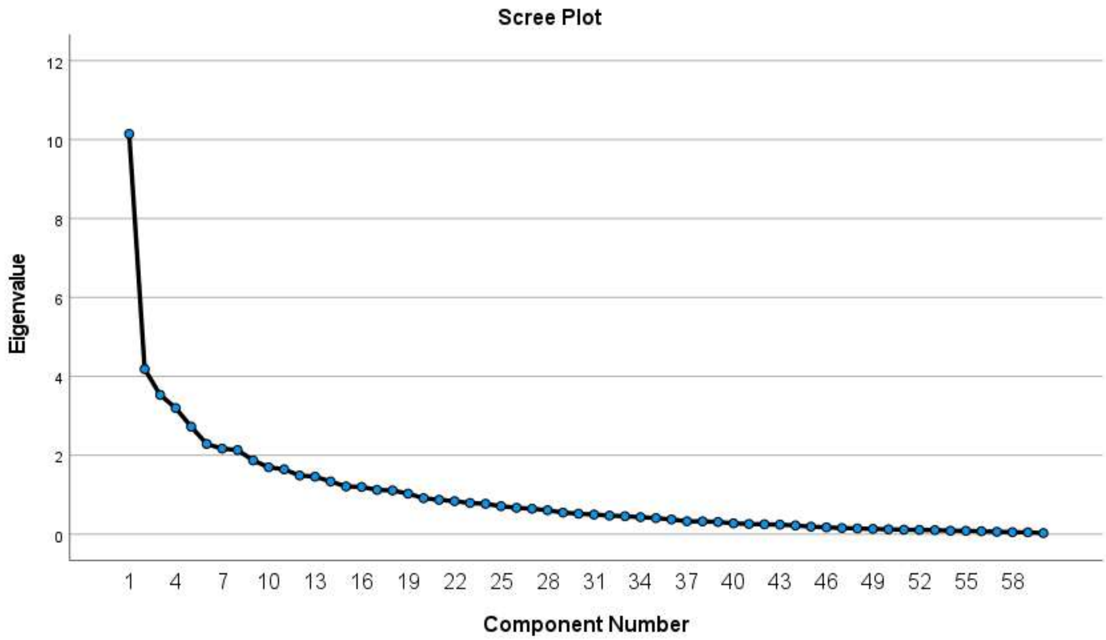
1)Factor analysis output – Total Variance Explained

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.145	16.909	16.909	10.145	16.909	16.909	3.404	5.673	5.673
2	4.185	6.975	23.884	4.185	6.975	23.884	3.217	5.362	11.034
3	3.530	5.884	29.768	3.530	5.884	29.768	3.091	5.151	16.186
4	3.198	5.330	35.098	3.198	5.330	35.098	3.027	5.045	21.231
5	2.726	4.544	39.641	2.726	4.544	39.641	2.848	4.746	25.977
6	2.289	3.815	43.456	2.289	3.815	43.456	2.788	4.647	30.624
7	2.170	3.617	47.073	2.170	3.617	47.073	2.727	4.545	35.169
8	2.133	3.555	50.628	2.133	3.555	50.628	2.599	4.332	39.501
9	1.870	3.117	53.745	1.870	3.117	53.745	2.433	4.056	43.557
10	1.698	2.829	56.575	1.698	2.829	56.575	2.394	3.990	47.547
11	1.645	2.741	59.316	1.645	2.741	59.316	2.337	3.895	51.442
12	1.488	2.481	61.797	1.488	2.481	61.797	2.334	3.890	55.332
13	1.459	2.432	64.229	1.459	2.432	64.229	2.221	3.702	59.034
14	1.336	2.227	66.456	1.336	2.227	66.456	1.919	3.199	62.233
15	1.211	2.018	68.474	1.211	2.018	68.474	1.787	2.978	65.211
16	1.198	1.997	70.471	1.198	1.997	70.471	1.740	2.900	68.111
17	1.124	1.873	72.344	1.124	1.873	72.344	1.708	2.847	70.958
18	1.110	1.850	74.193	1.110	1.850	74.193	1.562	2.603	73.561
19	1.028	1.714	75.907	1.028	1.714	75.907	1.408	2.346	75.907
20	.913	1.522	77.430						
21	.872	1.453	78.883						
22	.838	1.397	80.280						
23	.792	1.319	81.599						
24	.772	1.286	82.886						
25	.711	1.185	84.071						
26	.670	1.117	85.188						
27	.646	1.077	86.264						
28	.608	1.014	87.278						
29	.549	.914	88.193						
30	.520	.867	89.060						
31	.499	.831	89.891						
32	.472	.786	90.677						
33	.456	.760	91.437						
34	.433	.722	92.159						
35	.409	.682	92.840						
36	.375	.624	93.465						
37	.328	.547	94.012						
38	.326	.543	94.555						
39	.311	.518	95.073						
40	.277	.461	95.534						
41	.260	.433	95.967						
42	.251	.419	96.385						
43	.244	.407	96.792						
44	.222	.370	97.162						
45	.192	.320	97.482						
46	.174	.291	97.773						
47	.157	.262	98.035						
48	.146	.244	98.279						
49	.135	.225	98.504						
50	.124	.207	98.711						
51	.115	.192	98.903						
52	.110	.184	99.087						
53	.105	.176	99.262						
54	.089	.148	99.410						
55	.086	.144	99.554						
56	.077	.128	99.682						
57	.062	.103	99.784						
58	.052	.086	99.871						
59	.048	.081	99.951						
60	.029	.049	100.000						

Extraction Method: Principal Component Analysis.

2) Scree Plot


Scree Plot
Eigenvalue
12
10
8
6
4
2
0
1
4
7
10
13
16
19
22
25
28
31
34
37
40
43
46
49
52
55
58
Component Number