DESIGN AND PROPOSITION OF TECHNOLOGY POLICIES TO DIFFUSE GREENHOUSE TECHNOLOGIES IN TURKEY: A CASE FOR SPEAKING PLANT APPROACH

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

SERRA BAYKAL

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
THE DEPARTMENT OF SCIENCE AND TECHNOLOGY POLICY STUDIES

JUNE 2021

Approval of the thesis:

DESIGN AND PROPOSITION OF TECHNOLOGY POLICIES TO DIFFUSE GREENHOUSE TECHNOLOGIES IN TURKEY: A CASE FOR SPEAKING PLANT APPROACH

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ABSTRACT

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CASE FOR SPEAKING PLANT APPROACH

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June 2021, 230 pages

Main purpose of this thesis is to explore closed cultivation environment as greenhouses under protected cultivation in Turkey, emphasizing advanced production methods in use, challenges of improving current operations and ways of diffusing advanced tools and equipment through policies. In order to specify needs and solutions towards diffusing greenhouse technologies, solutions compatible to Speaking Plant Approach are centered. Protected cultivation technologies are not diffused at the potential level in Turkey, compared to countries known with their greenhouse operations and their scientific contribution in advancing Speaking Plant Approach, as Netherlands and Japan. Beside of financial investment concerns, key development areas need to be investigated with an interdisciplinary aspect to ensure policies have a holistic approach. Functional categories are designed and elaborated in accordance with Technological Innovation System approach to generate policy instruments and recommendations. The functional analysis underlines problems to be addressed, in parallel to prioritization made by actors taking part in public policies in agricultural concerns. Accordingly, greenhouse owners selected by different size of operations are included to this study to understand producer needs and expectations in the field. Bearing in mind the country-based resources and infrastructure on greenhouse operations and technologies, policy instruments are presented according to both greenhouse owner expectations and perspectives of public servants in Chambers of Agriculture.

Keywords: Speaking Plant Approach, Greenhouse, Greenhouse Technologies, Technological Innovation System, Policy

ÖZ

TÜRKİYE’DE SERA TEKNOLOJİLERİNİN YAYGINLAŞTIRILMASINDA GEREKLİ TEKNOLOJİ POLİTİKALARININ TASARLANMASI VE ÖNERİLER: KONUŞAN BİTKİ YAKLAŞIMI ÖRNEĞİ

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Haziran 2021, 230 sayfa

Bu tezin amacı, Türkiye'de korumalı tarım ve seracılıkta kullanılan gelişmiş üretim yöntemlerini araştırmak, mevcut operasyonları iyileştirmenin zorluklarını belirlemek ve üretimde kullanılabilecek teknolojik çözümlerin politika yolu ile yaymanın yollarını vurgulamaktır. Bu kapsamda seracılıkta kullanılabilecek teknolojileri belirlemek adına Konuşan Bitki Yaklaşımı temel alınmıştır. Hollanda ve Japonya gibi sera işletmeciliği ve Konuşan Bitki Yaklaşımının ilerletilmesinde bilimsel katkıları ile bilinen ülkelere kıyasla, korumalı tarım kapsamındaki sera teknolojilerinin Türkiye’deki yayılımı ülke potansiyelinin altında kalmaktadır. Temel iyileştirme alanlarının belirlenmesi için üç ülkenin farklı fonksiyon ve dinamiklerinin, disiplinler arası bir bakış açısıyla incelenmesi gereklidir. Fonksiyonel kategoriler, politika araçları ve öneriler, Teknolojik Yenilik Sistemi yaklaşımına göre tasarlanmış ve detaylandırılmıştır. Fonksiyonel analiz, tarımsal alanda kamu politikalarında yer alan aktörlerin yaptığı önceliklendirmelere paralel olarak ele alınması gereken ana sorunların altını çizmektedir. Ana problemler ise, farklı büyüklükteki operasyonlarda yer alan sera sahipleri, sahadaki üretici ihtiyaç ve beklentilerini kapsayıcı bir şekilde ortaya konmaktadır. Sera işletmeciliği ve teknolojilerine yönelik politikalar, ülke bazlı var olan kaynaklar ve altyapılar da göz önünde bulundurularak hem sera çalışanlarının ihtiyaçları hem de Ziraat Odası çalışanlarının bakış açılarına göre sunulmaktadır.

Anahtar Kelimeler: Konuşan Bitki Yaklaşımı, Sera, Sera Teknolojileri, Teknolojik Yenilik Sistemi, Politika

To my parents and my beloved grandmother

ACKNOWLEDGMENTS

I would like to express my deepest gratitude to Prof. Dr. Erkan Erdil and Assist. Prof. Dr. Arsev Umur Aydınoğlu for their encouragement, support and guidance throughout my years in METU. I have inspired by them not just for completing my master's degree but also for chasing my dream in pursuing an academic career.

In this long and exciting process, I had an amazing chance to meet greenhouse owners and representatives of the greenhouse sector. They shared the excitement of this research as I did and sincerely answered my questions to make this thesis complete. Thank you all for your patience and support.

In addition to my professors, I was part of an amazing network in TEKPOL. There are countless names that I am grateful for their support and belief. I thank all of you.

On top of the friends from TEKPOL, I am grateful for my closest friends who always supported me as I will always do for them. Ekin Erdolu, who has been by my side almost for a decade now; Elif Soysal, who always takes away my worries and encourages me to take another step further; Ogün Can Çetiner, who listened and guided me for anything; Öncü Morkoç and Yağızhan Yılmaz, who managed to be there for me anytime I need even though they are far away; Duygu Seyman, who carried my worries and made everything lighter to carry; and Kaancan Türkan, who listened and guided me for years. I couldn't do this without you guys, thank you for being there for me. Last but certainly not the least, I'm thankful to Anıl Aksu, for sharing the challenges and gains in life with me. Hopefully, there are still a lot to share and there are many adventures ahead us to begin.

Above all, I am deeply grateful to my family. I always felt their guideline and belief, no matter what I decide, and such strong support is actually made me who I am now. I'm dedicating this thesis to you.

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
BD	Business Development
CAP	Common Agricultural Policy
CO2	Carbon dioxide
COVID-19	Coronavirus Disease 2019
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAQ	Frequently Asked Question
FFTC	Food & Fertilizer Technology Center
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GFRAS	Global Forum for Rural Advisory Services
GHG	Greenhouse Gas
ICT	Information and Communication Technology
IPR	Intellectual Property Rights
IS	Innovation System
IT	Information Technology
KOSGEB	Small and Medium Enterprises Development Organization
KPI	Key Performance Indicator
NGO	Non-Governmental Organization
NIS	National Innovation System
OECD	Organization for Economic Co-operation and Development
PA	Precision Agriculture
PhD	Doctor of Philosophy
QDA	Quantitative Descriptive Analysis

R&D	Research and Development
RIS	Regional Innovation System
SERKONDER	Greenhouse Construction and Equipment Manufacturers and Exporters Association
SIS	Sectoral Innovation System
SME	Small and Medium Enterprise
SPA	Speaking Plant Approach
STI	Science, Technology and Innovation
TAGEM	General Directorate of Agricultural Research and Policies
TARSIM	Agricultural Insurance Pool
TIS	Technological Innovation System
TL	Turkish Lira
TUBITAK	Scientific and Technological Research Council of Turkey
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organization
USA	United States of America
USD	U.S. Dollar
VAT	Value Added Tax

CHAPTER 1

INTRODUCTION

For centuries, agriculture stood mainstay as a factor of growth and self-sufficiency. Many Latin American and Asian countries used agricultural development for their economic transformation (Diao et al., 2007). India, through its Green Revolution, stands as an important example. Green Revolution's objective was to adopt high-yield varieties, which eventually shifted India to be a key exporter of wheat (Freebairn, 1995; Sebby, 2010). Next to being a factor of economic development, agriculture is important for national recovery and self-sufficiency. Whilst being among most sensitive sectors against battles, civil wars, and large migration flows, national food stocks are compensated through agricultural reforms during post-war periods.

There are two perceptions on agriculture's role in today's world. At one side, agriculture is not considered a fundamental factor for economic development, but rather an element for poverty reduction (Christiaensen et al., 2011). On the other side, scholars motivated by Hirschman and Fields, define agriculture as a multiplier of economic development (Dzemydaite, 2017; Fields, 2004; Hirschman, 1958). Kalecki (1966) provides one of the arguments on that issue: "The point is that in an underdeveloped economy agricultural production is beset with a variety of limitations, which would prevent it from growing at a high rate even if all material resources were available" (López & Assous, 2010). Kalecki's study was on the nature of economic growth and food demand. Kuznets also agreed on agriculture's contribution through net output, production contribution per worker and agricultural labor force (Kuznets, 1961).

Agricultural activities in Turkey are serving more than self-sufficiency in terms of input supply to industrial sectors, agricultural export and employment opportunities (Yavuz, 2005). As per Maslow's hierarchy of needs, agricultural activities are in a wide spectrum starting from basic human needs to self-development.

Yet, due to insufficient awareness on organic and sustainable farming and tendency to avoid high price on products, good agricultural practices in Turkey serves for export (Eryılmaz et al., 2015). As result, agricultural production became one of the "Strategic Locomotive Sectors" in Vision 2023[1].

Either for economic development or for poverty reduction, agriculture is an inevitable part of life. Simply because, food production remains among basic needs of humanity (Berners-Lee et al., 2018; Harari, 2011; Pawlak & Kołodziejczak, 2020). Discussing agriculture apart from development – or vice versa – is not possible. Hayami and Ruttan (1970) emphasize the dependency of agricultural development to substantial investment on technical and institutional infrastructures Thereafter, "induced innovation model" is adopted, considering technical changes in agriculture as endogenous factors in economic systems (Diao et al., 2007). Even though this theory re-studied by other scholars (Grabowski, 1979), the idea of using interdisciplinary linkages for agricultural development remained still.

This thesis is an interdisciplinary study combining agricultural technologies and technology policies. There are numerous research areas in agricultural studies. Since agriculture is an immense field of study, focuses are given to different issues as location, production method, product or technology. This thesis takes greenhouse cultivation under protected cultivation as the main agricultural field and questions the current and potential usage of advanced technologies in production. Protected cultivation eliminates external factors arising from geographical and climate factors, thanks to its closed and laboratory-similar environment. Therefore, it creates a great potential for scientific and interdisciplinary studies.

Studies of protected cultivation involve different concepts as horticulture, agronomy, plant sciences, agricultural engineering, food science technology, entomology, soil science, microbiology and so on (Figure 1).

[1] http://www.tsv2023.org/index.php/stratejik-lokomotif-sektorler/41-uncategorised/143-tarim-gida-ve-hayvancilik.html

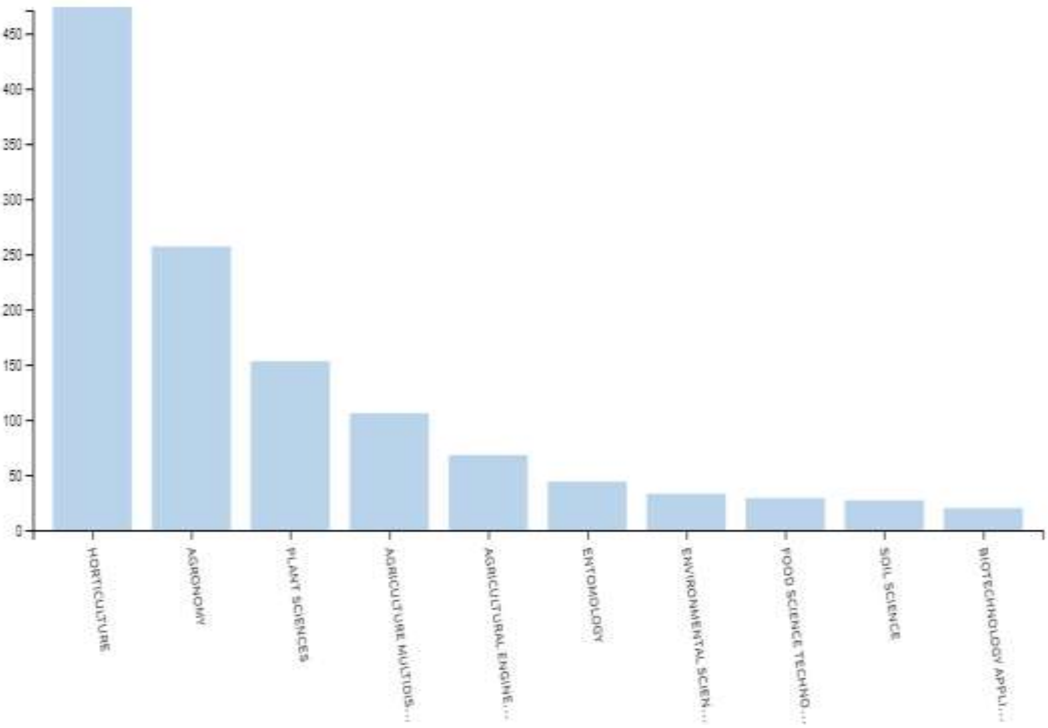


Figure 1: Top 5 Research Areas in Protected Cultivation

Source: Web of science, filtered with "protected cultivation"

Under protected cultivation, there are 103 results on multidisciplinary studies (Figure 1). Among those studies, majority of the concept involves investigation and assessment of technological applications and scientific methods on productivity and cultivation process of different products. Yet, studies on policies to bring current grower knowledge and ways to diffuse necessary technologies are limited. There are several studies involving the dynamics of Turkey. Main focus is given to product-based requirements, trade potential, competition power and climate affects in different greenhouse types.

Protected cultivation in Turkey goes back to 1940s (Sevgican, 1999). Since then, businesses are located in the south regions where favorable climate and geothermal sources exist. Along with the developments in production techniques, high-tech greenhouses also take part in agricultural production with climate control systems, advanced growing technologies and integrated production and production techniques (Tuzel & Oztekin, 2016).

Under protected cultivation, businesses operate mainly in greenhouses and tunnels. Also, it is possible to grow in soil and soilless environments. Today, modern greenhouses have usually soilless production and control techniques of production inputs. Controlled techniques are usually adopted in closed greenhouses, semi-closed greenhouses and classical modern greenhouses (Silleli et al., 2020). Different types of greenhouses and tunnels of Turkey are detailed in Table 1, in terms of area of land.

Table 1: Areas for Land under Protective Cover by Type

	GLASS GREENHOUSES	**PLASTIC GREENHOUSES**	**HIGH TUNNEL**	**LOW TUNNEL**
2010	80 772	230 543	81 521	170 969
2011	78 878	247 962	108 910	175 701
2012	80 728	278 730	95 095	163 207
2013	80 739	278 661	97 986	157 737
2014	80 976	298 651	107 095	156 720
2015	79 977	306 074	112 674	161 541
2016	80 137	328 745	112 974	169 867
2017	85 749	355 121	119 899	191 399
2018	78 110	368 527	114 232	211 222
2019	75 495	378 670	111 038	224 400
2020	80 779	401 795	104 258	218 326

Source: Ministry of Agriculture and Forestry, Land under protective data have been compiled since 1995

Along with increasing area of lands, good agricultural practices and organic farming also improved in Turkey. Today, greenhouse cultivation addresses more than consumption. With trade-oriented objectives, shift to food health and environmental impact concerns came to stage (Yılmaz, 2014). Coupling this shift with changing indoor and outdoor climate conditions, technological improvements become an inevitable part of greenhouse cultivation for quality and yield (Cemek et al., 2015).

Even though such shift contributes on production development; integrated control and monitoring for diseases, pets, fertilization and irrigation remain limited (Kurtaslan, 2021). Studies also suggest that grower decisions are applied rather than automated scheduling and plant-specific need examination, except from few high-technology greenhouses (Kacira et al., 2004). This creates a large gap between small and large firms in terms of network, financial capabilities and technology. Hence, prioritization of the government bodies and policy makers towards advanced greenhouse cultivation remains limited. To that end, industrial prioritization mainly depends on institution-based objectives and capabilities.

This thesis elaborates one of the advanced greenhouse production method for protected cultivation, namely Speaking Plant Approach (SPA). While investigating current status of Turkish greenhouses, technology diffusion approaches lessons learnt from two selected innovation systems are taken into consideration as guidance. Japan and the Netherlands are selected as best-practice countries to follow their steps in adopting SPA related technologies.

Japanese agriculture involves different scales of farming with advanced plant management systems. For that reason, precision agriculture and SPA are quite appealing for a variety of actors in Japan. They include but not limited to farmers, government officials, private sector members and academic institutions (Sasao & Shibusawa, 2000). Hence, Japanese policies are designed to integrate advanced technologies to different business areas (Deguchi et al., 2020). Greenhouse cultivation, as part of agricultural operations, also takes part in these policies. Thanks to numerous actor involvement and comprehensive policy designs, Japan represents one of the best examples to understand SPA applications and relevant steps for technology adoption strategies.

The Netherlands, on the other hand, is known by being one of the giants in greenhouse cultivation. 80% of cultivated land in Southern region is under glass greenhouse (*Could High-Tech Netherlands-Style Farming Feed the World?*, 2019a). Modern greenhouse cultivation, especially among European countries, is far most represented by Dutch businesses (Tataraki et al., 2020). Apart from scientific and technological diffusion, Dutch greenhouses are examined in terms of their part in national economy and trade. In that sense, commercialization and successful business applications are catching aspects to choose the Netherlands as the second best-practice example.

To contribute to the potential of greenhouse cultivation in Turkey, this thesis primarily aims to (1) understand greenhouse cultivation in Turkey and advanced production methods, (2) challenges of improving current greenhouse operations, and

(3) identify ways of diffusing advanced tools and equipment through policy recommendations. To achieve these three aims, following research question is asked: in comparison to Japan and the Netherlands, how should early technology policies be designed to adopt SPA in greenhouse operations?

1.1 Organization of the Thesis

In the Second Chapter, a detailed literature review is provided. Literature review starts with introducing agricultural innovation path throughout the history. Afterwards, precision agriculture and SPA are further detailed to understand the potential contribution of this method to traditional practices. Examples from empirical studies and historical evolution of SPA applications are also emphasized. Hence, interdisciplinary studies having similar context are also presented. Finally, the research question is asked and theoretical framework is detailed. Constructing the theoretical framework from Technological Innovation Systems (TIS), functional analysis for policy development is elaborated. After examining literature on policy development under innovation system approach, the need for having a tailor-made framework is explained.

In the Third Chapter, tailor-made theoretical framework and methodology are presented. First, functions involved in the analysis are detailed. Second, methodology is explained including the reasoning of selected data, methods of analysis and the degree on answering the research question with existing sources.

In the Fourth Chapter, findings are discussed under each selected function. Findings are descriptive in two ways. First, they are describing current status of greenhouse cultivation in Turkey. It is necessary to see strengths and weaknesses of the sector, so that needs of producers are better identified. Second, problematic issues against effective technology diffusion policies are presented. These issues are pointing out key areas to focus in designing policy instruments. Each function and problem are important to ensure a long term and sustainable technology diffusion objective, so that producer needs are better addressed.

In the Fifth Chapter, concluding remarks are given. Re-emphasizing everything elaborated throughout the analysis, limitations of this study is detailed. Thus, discussions and future research topis are given.

1.2 Significance of the Thesis

This thesis contributes to existing literature in four aspects. First, the design of technology diffusion policies is centered, instead of studying a particular cultivation method. Majority of agricultural studies are addressing a product or production method. While new techniques and scientific contribution are seen in those studies, interdisciplinary approach from social sciences are not quite adopted. This thesis differs from those by focusing on a technology policy approach.

Second, this thesis attempts to re-structure existing policies in favor of advanced greenhouse cultivation in Turkey. Turkish government policies on greenhouse cultivation are found limited with energy saving priorities or financial incentives through bank credits. The context of policy instruments given in this thesis goes one step further. Issues beyond heating and energy concerns are explained and prioritized.

Third, this thesis plays an introductory role in designing technology policies favoring SPA in Turkish greenhouses. While being the first academic study on SPA application and relevant policy instruments in Turkey, advantages of systematic policy design method are highly emphasized. Meaning that, same research and analysis structure are applicable to different technologies in agricultural practices. Agricultural Technology and Innovation studies aiming to apply the same theoretical framework are highly encouraged.

Fourth, functional analysis given in literature is re-designed by adding an additional function. Methodological contribution involves F7: Public Awareness and Information Network as an added-value to existing literature. While existing studies emphasize similar context through investigating the relationship between actors, this thesis separates the sources of communication, networking and awareness raising.

CHAPTER 2

LITERATURE REVIEW

2.1 Agriculture, Science, Technology and Innovation

Farming has the same scope as scientific experiments (Hoffmann et al., 2007). In that sense, farmers are acting as scientists, rather than industrial workers. They are not solely subject to provide inputs for food and textile, but also to take cautions against soil erosion, nutrient loss, water flows and floods (Oliver et al., 2013). Accordingly, DeWalt suggests agricultural innovation to be combined with indigenous knowledge of farmers for ecologically sustainable solutions (Dewalt, 1994). Nevertheless, Scientific Revolution prioritized artisans and mechanics more than agricultural workers (Deborah Fitzgerald et al., 2018). For that reason, agricultural development attributes did not show considerable success until 1960s (Ruttan & Hayami, 1973). Albert Moseman puts his concern as: *"Perhaps the most certain feature about building national systems for agricultural research is that neither significance nor their processes are well understood"* (Busch & Lacy, 1983).

Rosenberg (1971) outlines the earlier interaction between science, technology, society, and agriculture through "agricultural experiment stations". Similar to today's Research and Development Centers, these stations concerned with both technological development and societal impacts of agriculture (Danbom, 1986). They were important in designing alliances and policies with the aim of agricultural technology development. Yet, they were still focused to have chemical inputs to have a technological change (Danbom, 1986; Marcus, 1985). As of 1970s, agricultural development broadened its concept from chemical interests and entered to a transition path from resource-based to technology-based practices (Kristensen, 1997). This transition brough different aspects into agricultural practices.

First, new methods influenced rate of return and productivity levels. In that framework, mechanization also played an important role (Anderson, 2005). Second, social roles and relationship between farmers-scientists came to stage (Byerlee et al., 2009; Fitzgerald, 1991). Consequently, subjects like system of production, women employment in agriculture, and actor-network theories became important study areas in agricultural development (Deborah Fitzgerald et al., 2018).

Hughes explains the relationship among institutions, individuals, theories, and machineries by: "technology is both a shaper of, and is shaped by values" (Blake, 1990). Transferring his approach into agricultural technology development, two types of knowledge are essential: (1) basic knowledge to overcome exogenous factors against production and (2) knowledge on institutional structures for technology adoption strategies (Smithers & Blay-Palmer, 2001).

As per the first type of knowledge, modern agricultural technologies focused on eliminating exogenous factors in value chain. This means, in hypothetical sense, humans communicating with nature and addressing its needs for productivity. Second type of knowledge, on the other hand, deals with the technological trajectories in agricultural value chain and innovation systems. While these trajectories are not exceptional for agricultural operations, they target greater concepts as adaptation to climate changes, strengthening food security, biodiversity, natural resource management and public and private partnership (Possas et al., 1996; Touzard et al., 2015).

Bearing in mind Hughes's statement, this thesis deals with the second type of knowledge and functional framework to adopt necessary technologies. Selected production method (SPA under Precision Agriculture) and method of analyzing relevant innovation system (TIS as part of Innovation System Approach) are detailed in the next two sections.

2.2 Precision Agriculture

There are several taxonomies to define precision agriculture. Some scholars use the methodological aspects to understand precision agriculture. These include process of collection, interpretation, and usage of crop data (Buick, 1997; Gebbers &

Adamchuk, 2010). Some scholars, on the other hand, matches the conceptual framework to tools (Mcbratney et al., 2005; Mulla, 2013). Meaning that, precision agriculture is considered as a combination of guidance systems, recording technologies, and reacting technologies (Balafoutis et al., 2017). Among all, most generic and comprehensive definition for precision agriculture is: "the right treatment in the right place at the right time" (Gebbers & Adamchuk, 2010, p. 828).

Initial reference of precision agriculture goes back to 1980s (Baylou, 1987; Cowan, 2000; Krutz, 1983; Lowenberg-DeBoer & Boehlje, 1996; Pitts et al., 1986; Schueller, 2009). At that time, main objective of was to understand and manage means of drainage, landscape, soil features, texture, nutrition, and pH level through soil survey (Oliver et al., 2013). Together with the adaptation of microcomputers, agriculture is exploited through advanced tools and methods. This was the beginning of "Farming by Soil Types" concept, so as called Precision Agriculture (Robert, 1999).

Together with challenges faced throughout the history, agricultural engineers integrated multidisciplinary concepts to solve sustainability problems in agriculture (Maohua, 2001). Having numerous spotlights within the value chain, sustainable agriculture could be defined by following:

> *Sustainable Agriculture as the one that, over the long term, enhances environmental quality and the resource base in which agriculture depends; provides for basic human food and fiber needs; is economically viable; and enhances the quality of life for farmers and the society as a whole*. (Bongiovanni & Lowenberg-Deboer, 2004, p. 360).

Correspondingly, means of sustainability of precision agriculture are explained under profitability, productivity, safety and quality, decision-making process, and environmental friendliness (Table 2).

Table 2: Concerns of Agricultural Sustainability and Link to Precision Agriculture

Profitability	Agricultural profit is challenging to measure due to its nature of mixed results (Lowenberg-DeBoer & Swinton, 1997). Still, there are several suggestions implicating risk assessment to be based on variability of crop yield (Olson, 1998; Zhang et al., 2002), risk reduction hypotheses (C. Oriade & Popp, 2000) and bio economic model on control systems (C. A. Oriade et al., 1996). Among all profitability analyses, precision agriculture practices showed positive results by optimizing inputs and reducing any type of overusing (Lambert & Lowenberg-DeBoer, 2000).
Productivity	Agricultural productivity is achievable through diminished input costs and time saving (Soto et al., 2019). Once farmers and agronomists.

Table 2 (continued)

	understand the characteristics of plants and exogenous environment, decision support systems could define biophysical attributes of crop and how to react towards them (Liaghat & Balasundram, 2010)**.** By meaning, productivity is the core concept of precision agriculture because it deals with effective use of existing natural resources.
Food Safety and Quality	Beside the monetary impacts, a controlled and guided system is strongly correlated with quality and safety measures. Not only the productivity, but also the quality improvement of yield is altered by the soil and fertility (Tardaguila et al., 2011). Relatedly, technology-driven solutions prioritize taking necessary precautions against extreme weather conditions, pests, insects and fungal infestations (Dryancour, 2017). Keeping and sharing the real-time plant data during the cultivation not only guide farmers how to react against any unforeseen circumstances but also track plant status to make sure the cultivation and storage processes are in accordance with health and safety standards.
Management Support	Decision support systems have high impact on farm management for both cultivation and storage processes (Erickson & Widmar, 2015). Decisions on hybrid selection, arable land rentals, fertilizer applications, chemicals, and fuel intakes are depending on the crop or soil characteristics (Mulla, 2013). Therefore, decision making processes involve well-established communication networks between the producer and the land or greenhouse environmental control system (Ehret et al., 2001). Precision agriculture promotes a strong communication with the soil and crop, so that farmers can obtain more data to make better decisions to reach all-round objectives (Olson, 1998).
Environmental Impacts	Water pollution, floods, erosion, crop damages, GHG emissions, and destruction in biodiversity are among potential environmental impacts of farm operations. Hence, Olivier describes consequences of over application of fertilizers and pesticides as part of environmental degradation (Oliver et al., 2013). Technological solutions are studied as mitigating measures against any potential environmental damage of farm operations (Balafoutis et al., 2017; Fuglie & Bosch, 1995; Hudson & Hite, 2003; Oliver et al., 2013; C. A. Oriade et al., 1996). These studies involve irrigation control systems (Goumopoulos et al., 2014), application of optimal level of nitrate contamination for yield productivity (Biermacher et al., 2009), controlled pest and pesticide treatment (Oliver et al., 2013). These concepts are highly interlinked with precision agriculture practices in terms of how much, when or exactly where to use these production inputs to have minimum environmental damage.

While precision agriculture comes with numerous assets, there are still challenging issues. In sum, there are two problematic categories: finance and perception.

Precision agriculture requires technologically advanced equipment and tools, which brings a high cost of investment (Long et al., 2016; Ondoua & Walsh, 2017;

Wiebold et al., 2015). Hence, inability to access financial resources also impacts agri-businesses, which is a frequently seen problematic (Long et al., 2016). As for almost all businesses, investment costs are first-in-mind before taking a step towards automation and technological improvement. In order to get the maximum return on investment, producers should be aware of their needs and be clear on their long-term objectives.

Thus, perception-related factors (as psychological, demographic, and sociological factors) are affecting how agricultural businesses grow. In that sense, age and background greatly matter in technology adoption (Tey & Brindal, 2012). Younger farmers have better potential to adopt technology driven solutions since they might be less reluctant to change. Thus, they might better understand the technological value-add (Mahant et al., 2012). Yet, there is always a risk of positive illusions for this target group (Vishwanath, 2009). Therefore, agricultural technologies should compromise new methods of doing the traditional activities, rather than suggesting a bottom-up changes.

There are numerous production methods under precision agriculture. These methods are differing by product needs, existing natural resources and technological infrastructure. Methods and technologies related to precision agriculture are not examined: however, one of the production method for greenhouse cultivation is selected. Next section details historical development and exemplary details from academic literature on SPA.

2.3 Speaking Plant Approach

Growth path of each plant differs from other, not only based on external factors such as light, water and humidity, but also their own characteristics. To achieve an understanding and external control on behavioral status of plants, SPA is proposed (Udink ten Cate et al., 1978). Optimization of calculation and techniques to monitor and control plant reactions with real-time measurement are the core concepts (Tetsuo Morimoto & Hashimoto, 1998). In that sense, SPA simply deals with qualitative understanding of plant behavior through data collection and analysis.

First proposed in 1978 as a system theory of greenhouse cultivation, SPA has been studied in the manner of behavioral control modelling. Coming up to 21st century, SPA studies faced several changes in academic studies due to advancing technologies and increasing usage by greenhouse businesses. To understand the academic study concentration for SPA, abstracts published between 1978-2020 in Web of Science, Google Scholar, Science Direct, Academia, Springer, Semantic Scholar and Sage Journals are examined. Figure 2 shows number of studies since 1978 with more detail.

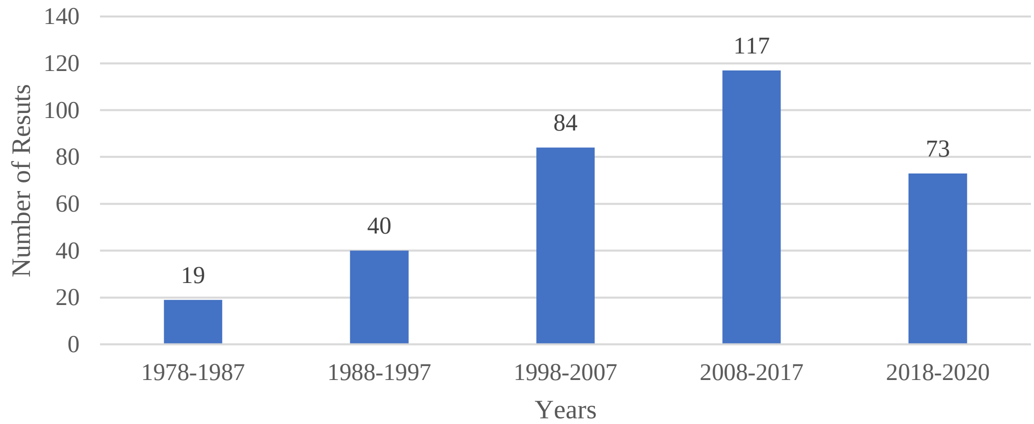


Figure 2: Number of academic results for "Speaking Plant Approach" between 1978-2020

Source: Web of Science, Google Scholar, Science Direct, Academia, Springer, Semantic Scholar and Sage Journals, filtered with “Speaking Plant Approach”

By eliminating overlapping publications, 294 studies are selected and analyzed by their title, author keywords and abstracts. In this analysis, a categorization is made by following titles: review, model development, testing, system development, interdisciplinary study, method development, AI applications, hardware system introduction, policy and technology development.

After the theoretical studies presented at the end of 1970s; technical testing, control algorithms, computer processing systems, and different modelling approaches are started to be investigated. By 1985, pilot studies and artificial intelligence applications are introduced to be applied in modern greenhouses.

Between 1978 and 1987, academic studies were mainly involving reviews and testing of proposed approach including recent developments at that time, features of a controlled and modern greenhouse, latest practices, system concepts, modelling techniques, controlling mechanisms, examination of changes for a certain crop or condition and so on. In a way, studies showed how to approach this method in greenhouses and why.

Once testing and pilot studies come in front, number of studies almost doubled in each decade. Relatedly, method development studies increased considerably as of 1988. Meaning that, studies started to consider SPA from wider understanding and to go one step further from the preliminary works.

Excluding some engineering aspects identified on 1990s, interdisciplinary works accelerated as of 2000s, mainly on education and training, policy implications, and location based best practices. There are studies on intelligent agriculture and its policy implications (Shi et al., 2018), modern greenhouse design characteristics (Von Elsner et al., 2000), and smart irrigation methods (Karaşahin et al., 2018).

Today’s advanced sensing systems use SPA to apply computer-based and automated solutions for controlled environments. Figure 3 provides a generic visualization of the described control and measurement system.

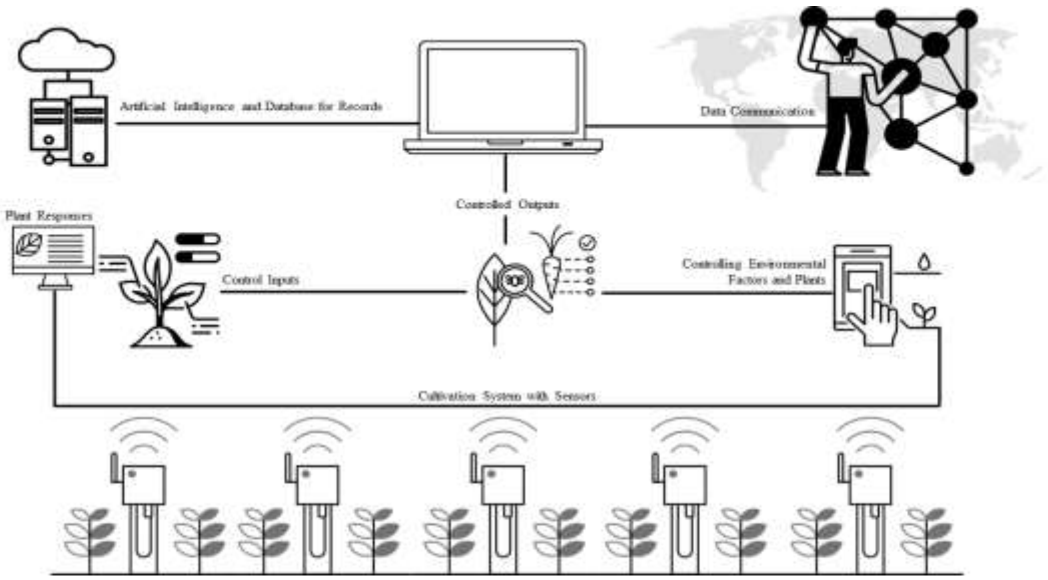


Figure 3: Logic of Speaking Plant Approach in a Cultivation System
Source: Hashimoto and Morimoto (2009) (Redesigned)

Such advanced and interconnected cultivation system acquires a variety of sensor technologies to make accurate estimations for the psychological status of plant. That being said, SPA is applicable for intelligent greenhouses, rather than conventional greenhouses to control exogenous factors and plant status (Arima, 2011). Some of the examples from literature are described below:

- Setting temperature level as control input and color change as output to examine heat treatment to delay the fruit ripening for tomatoes (T. Morimoto et al., 1997). Research suggests that optimal temperature level should be searched for effective ripening delay via a simulation using genetic algorithms.
- Applying chlorophyll fluorescence induction imaging system to examine plant health for tomatoes (Takayama et al., 2011). Imaging system aims to detect drought stress level to understand plant health status.
- Testing an environmental control system, using mushroom's bioelectric potential as biosensor to operate four lighting conditions (Tetsuo Morimoto & Hashimoto, 2009). Study argues that mushroom as biosensor could maximize factory productivity while minimize energy usage and production costs.

Regardless of the complexity and variety of tools, precision agriculture was found profitable with an average of 68% success rate (Gebbers & Adamchuk, 2010). Bearing in mind of method, system, and technology development studies, SPA also plays a part in interdisciplinary studies. Studies having similar methodological approach and agricultural development purpose are presented in Table 3.

Table 3: Similar Studies from Literature

Authors	Details of Studies
Lamprinopoulou et al., 2014	Objective of this study is comparing Scotland and the Netherlands on the basis of their systemic structures, functions, failures, and merits of agricultural innovation systems. Both methodological work and preliminary results showed that proposed strategies are useful in impacting on direction and rate of innovation in agricultural operations.
Turner et al., 2016	This study concerns with the systemic problems in New Zealand for agricultural innovation system capacity. Main importance of this paper is to show systemic functions and problems in an integrated analysis for New Zealand along with considering their interconnections. Thus, historical background and persistent structural and institutional factors are also examined.
Kebebe et al., 2015	The investigation of dairy innovation system has been made in Ethiopia to identify technical, economic, and institutional barriers for further development. Seven innovation functions are included in this study and problems with structural elements are identified.

Table 3 (continued)

Hermans et al., 2019	This article looks into the impact of public-private partnership within agricultural innovation systems and how to set feedback loops. The scope of study consists of four cases from the history of innovation.
Davies et al., 2018	Innovation platforms, which is considered a part of participatory practices in innovation system, are observed within Africa region. For that purpose, nine platforms in agricultural sector are selected and analyzed in terms of complex nature of innovation system.
Kruger, 2017a	Objective of this study is to analyze a technology-specific application (Queensland Fruit Fly) in terms of pest management approach in innovation system. Area-wide management is centered to ensure an enabling environment.
Kruger, 2017b	This study highlights applications to strengthen complex agricultural practices as biosecurity. Taking area-wide management approach to apply a systemic approach, a functional-structural analysis is presented.
Minh, 2019	Regional and structural dimensions on systemic problems under structural-functional analysis have been provided in this article. Regional functions in innovation systems are said to be neglected. Structural components are defined as infrastructures, actors and institutions along with how they might create blocking mechanisms.
Borremans et al., 2018	This paper observes agroforestry systems in Europe. Through observing actor involvement and gap implementations, a comprehensive agricultural innovation system is examined.
Menary et al., 2019	This article investigates socio-economic barriers of agricultural innovation system in UK fresh production. As methodological approach, this paper applies functional-structural analysis.
Schiller et al., 2020	Agroecology, especially in terms of diffusion relevant problems in agroecology, has been analyzed in this study. Such technological innovation system is concentrated to Latin America region, Nicaragua.
Maghabl et al., 2018	Main objective of this paper is to map nanotechnological innovation system in Iran.
Tani, 2018	This study evaluates factors impacting bio-based economy in Europe, with a specific focus on Strategic Niche Management.
Gürkan, 2015	Main objective of this study is to provide structural and functional analysis of Turkish olive and olive oil industry. Barriers, weak points in structures, and functional reviews are provided from innovation system framework for Turkey.

SPA studies investigated so far are presenting either an introduction of techniques or analysis of the level of enabling environment to adopt such method. Under second type of studies; national policies and use agricultural innovation to address national strategies are also discussed. Even though certain objectives as eliminating CO2 emissions, addressing climate change or effective usage of natural resources are always priority; technology diffusion aspects for greenhouse cultivation remains limited.

SPA involves different tools and methods, which are currently in use in Turkey. Nevertheless, these tools and methods are not always known as part of SPA. Therefore, boosting SPA relevant technologies is not elaborated as part of policy studies. To address this lacking, this thesis asks the following research question: in comparison to Japan and the Netherlands, how should Turkish technology policies be designed to adopt SPA in greenhouse operations?

To answer this question, a systematic policy design method should be adopted. It is, therefore, required to define innovation systems and how innovation system approach is applicable to policy design. In the academic literature, policy designs – involving technological chance and innovative solutions – are studied under innovation systems, divided into four categories: national innovation system, regional innovation system, technological innovation system, and sectoral innovation system. Next section provides a short summary of historical development, characteristics, and evolution of innovation system approach.

2.4 Evolution of Innovation System Approach

The story of innovation system (IS) approach goes back to 1841 to Friedrich List's work named "The National System of Political Economy" (Jun et al., 2016). List was in fact a strong name for the political economy studies but his work influenced innovation system approach and technology policies along. According to Freeman, he was one step ahead of contemporary theorists in terms of emphasizing the importance of learning and formal academic institutions as part of economic growth (Freeman, 1995). Thereafter, List's perspective towards the determinants of economic growth is shaped innovation system approach.

Innovation system approach – initially introduced as national innovation system – started to gather attention by the middle of 1900s. Leontief's 'input/output analysis' and Dahmén's 'development block' approach represented two sides of the IS concept within the evolutionary transition path (Bo Carlsson et al., 2002; Erixon, 2009; Kurz & Salvadori, 2006).

While Leontief emphasized more static approach in parallel with neo-classical Ecole, Dahmén's marks on structural tensions highlighted the role of entrepreneurship, alike to Schumpeter's evolutionary perspective (Erixon, 2009; Schumpeter, 2000). Leontief looked from classical economy perspective in which his analytical framework consists of observable and measurable indicators (Kurz & Salvadori, 2006). Even though he reflects systemic and neo-classical perspective, his input-output matrix influenced systemic flow of funds and knowledge (Sener et al., 2017). Dahmén, on the contrary, studied development blocks which indicate structural imbalances or tensions within the economy against industries and firms investing in research and innovation (Erixon, 2009). Schumpeter also incorporated development blocks in the innovation clusters (Schumpeter, 1939).

Towards the end on 1900s, Kline and Rosenberg described 'chain-linked model', to be used in different innovation scenarios (Micaëlli et al., 2014). Their model associated factorial elements in private and public institutions and interaction among them. Assisted by the 'chain-linked model', they introduced 'commercial innovation' concept, which illustrates innovation activities motivated by both market forces and scientific boundaries (Kline & Rosenberg, 1968). Within this concept, they explained the complex nature of innovation centering the importance of analytic design. Based on their study, analytical design is described as: "a study of new combinations of existing products and components, rearrangements of processes, and designs of new equipment within the existing state of the art"(Micaëlli et al., 2014).

Much in accordance with Schumpeter, Kline and Rosenberg opened a new perspective in innovation studies. They argued that design is the initial phase of innovation, next to research and development. Thus, they argued research to be effective to solve problems by feedback mechanisms. Feedback mechanism, within this context, is the initial point of system approach enabling interactive learning and interconnection between different structures.

With such academic foundation, three scholars namely Freeman, Lundvall and Nelson became the crossroad for today's innovation system concept. Innovation system was mainly associated with national innovation system at first. Nevertheless, regional, sectoral or technological innovation systems are proposed as studies expanded. As result, innovation system approach became more complex, yet more holistic. To understand the whole concept, sometimes it is required to divide the overall system into sub-system (Edquist, 2013).

2.4.1 National Innovation System

National Innovation System (NIS) involves cultural values, norms, regulations, and policies in national borders, linked to technological change and innovation (B. Å. Lundvall, 1998). Accordingly, Freeman (1995) emphasizes innovation as a condition in economy for competitiveness, both among firms and nations. Even though there are certain common points between both, Lundvall studies national innovation system from more micro-perspective.

As the main difference, Lundvall (B. Å. Lundvall, 1998) underlines feedback mechanisms under user-producer experience as part of the system. Instead of differentiating nations, he focuses on gaps in capitals and capabilities of users and producers (B. Å. Lundvall, 2010). To apply Lundvall's approach into meso and macro level analysis, learning economy approach is introduced (B.A. Lundvall & Johnson, 2006). Learning economy approach indicates knowledge creation as part of social process of learning. Therefore, innovation said to be happened in interactive environments where firms and markets have mixed nature.

Nelson (1993a) contributed to NIS through examining institutions and mechanisms in innovation process of 15 selected countries. Even though the study had a strong NIS emphasis, Nelson also got into sectoral innovation systems and consideration of internationalization.

2.4.2 Regional Innovation System

Questions remained, however, regarding the dynamics of NIS. To exemplify, Malerba (2002) looked into two innovation systems that co-exist in Italy, and their impact on each other. The study showed smaller systems influencing complex ones through entrepreneurship and networks. As result, questions arise as how NIS impacts even more advanced systems?

Globalization perspective and regional economy concept are not described solely by geographical borders, but also by localization of firm groups. Silicon Valley or Route 128 are examples applying knowledge/resource network as a way of clustering (Asheim & Isaksen, 2002; Enright, 2000; Saxenian, 1996). Globalization enlarged the conceptional borders of innovation. For instance, Schumpeter emphasized innovation being linked to entering new markets and experiencing interactive learning (Cooke et al., 1997). There were also suggestions on multinational organizations having local characteristic, reflecting 'home-based multinationals' (Enright, 2000).

In any case, opportunities of regional system are far more convincing for the modern world, in regard to cooperation opportunities, access to sources, grounding an adaptive behavior for global-scale competition, effective information exchange network and short feedback loops (Enright, 2003). In a way, NIS was seen as less developed sub systems of regional innovation systems, or RIS (Cooke et al., 1997; Nelson, 1993b).

2.4.3 Sectoral Innovation System

NIS and RIS teach us to ask how to identify borders and boundaries for a system. Beside of the firm localization and clustering approaches, sectoral dimensions are highly used to study economy, business management, history, and innovation. There are several approaches to deal with sectoral dynamics, regardless of the geographical location. Geroski (1998), to exemplify, studied market boundaries through trading markets, anti-trust markets, and strategic markets. Breschi and Malerba (2001), on the other hand, perceived the sectoral system as group of entities using sectoral technologies to develop sectoral products.

Sectoral innovation system (SIS), arise from changes in sectoral dynamics, is based on the interactivity among firms. Due to its main focus on learning process, knowledge and interactive nature, SIS is part of the evolutionary perspective of IS approach. Only boundedly rational actors can act, learn, and search in uncertain and continuously changing circumstances (Malerba, 2002). As result of such sectoral interactive clustering, certain nations or regions gain the competitive advantage in the global economy.

To analyze the dynamics of advantages of this system, Porter (Porter, 1998) represents ‘diamond’ approach. According to him, industrial competition depends on four factors: (i) factor conditions; (ii) demand; (iii) complementary, subsidy and supporting sectors; (iv) firm strategy, structure and rivalry (Jin & Moon, 2006). This was reflecting a modern approach to the ‘commercial innovation’ concept of Kline and Rosenberg (Micaëlli et al., 2014). In sum, Porter’s approach considers innovation as a commercial activity, generated as a result of firm interaction within the same industry, regardless of being within or without national borders.

2.4.4 Technological Innovation System

Understanding boundaries of innovation system is an evolving concept. Technological innovation system (TIS), within this concept, can be defined in a similar manner of sectoral innovation system, only by focusing on specific technology dynamics, rather than an industry (B Carlsson & Stankiewicz, 1991). Having much in common with sectoral and national innovation system, technological innovation system considers a variety of institutions to generate, diffuse and store skills and artifacts to create innovation. Yet, it is different from others due to its applicability to emerging markets in addition to matured market systems (Markard et al., 2015; Negro, 2007).

TIS is initially introduced by Carlsson and Jacobsson (1994) as a research program of Sweden’s technological system and factory automation. Covering both empirical and theoretical framework, it became an important source for not only academicians but also policy designers for governments and international organizations. TIS tries to understand technological changes and how to respond existing problems against such change. As Metcalf (1994) puts in words: “Science is international, user-supplier links are increasingly international, and multinational corporations make deliberate choices about the national location of R&D facilities” (Metcalfe, 1994, p. 940).

In sum, innovation system approach develops within a continuum. Not only the target sector, but also the system-based factors should be elaborated to design a methodology for policy development. Under agricultural innovation and precision agriculture context, SPA requires different technologies and technical skills for sustainable operation in greenhouses. Dynamics of SPA are best suited with TIS. The reason is, main focus of SPA is to transform traditional production methods through technology. Therefore, technology-driven policy design for greenhouse cultivation is needed. Next chapter summarizes analytical literature and details most-suitable methodological approach.

CHAPTER 3

THEORETICAL FRAMEWORK AND METHODOLOGY

This chapter introduces research method, based on the theoretical framework of IS approach. There are three sub-sections. First, reasons behind the choice of conceptual framework are roughly defined, coupled with the terminology used in this thesis. That is to say, using functional analysis to understand TIS is further discussed. Second, elements in designing a tailor-made functional analysis are elaborated. Conceptual framework is redesigned to be compatible for research question. Therefore, each function and sub-function are detailed by its definition and relevance with research question. This section also involves main limitations. Third, methodological approach compelling functional analysis is described. To that end, research methods and their interpretation in policy analysis are justified.

3.1 Functional Analysis in Technological Innovation Systems

TIS involves different components of processes between actors and their interaction. While they all vary on the environment, technological infrastructure, socio-economic or cultural elements, they also serve to same purpose: technological development. On a conceptual level, all “functions” are used to classify and define a technology as dynamics of creation, development, and diffusion (Bergek, et al., 2008).

Initially, functional analyses studied resistance to change, market information stimulation, information exchange and function specifications (Bergek, et al., 2008; Markard et al., 2015). While identification and performance assessment behave as a strong foundation, functions are not static structures by meaning. On that ground, studies evolved to interaction of functions in IS (Bergek et al., 2005; Bergek & Jacobsson, 2003; Hekkert et al., 2007; Jacobsson et al., 2004; Liu & White, 2001), which led market failure approach to become systemic failure approach (Woolthuis et al., 2005). Market-failure approach suggests that actors within a certain environment are independent from each other. Therefore, boundaries within the system are quite straight forward and interaction is excluded from the analysis. Systemic failures, on the other hand, are observed through the interaction of actors, institutions, and infrastructures. Main objective is to understand complementarities and mismatches within the system (Bleda & Del Río, 2013). Above all, Bergek and Edquist draw a compelling view in understanding functionality of IS (Bergek & Jacobsson, 2003; Edquist, 2013). Through comparative studies; functional performance mapping enables to make feasible policies, either between systems in the target area, or similar systems in elsewhere (Bergek, Jacobsson, et al., 2008). That is to say, functional analyses continue to re-shape the scope of IS approach and policy making.

Functional analysis in this thesis consists of dynamics in diffusion of advanced greenhouse technologies. Therefore, following questions are asked:

- What are the characteristics of market for this TIS?
- What are the applicable functions?
- How functional performance of TIS could be measured?
- Are there any limitations in this theoretical framework? If yes, how they could be minimized?

3.1.1 Characteristics of TIS

Greenhouses in Turkey are generally using traditional and low-cost methods (Sevgican et al., 2000). Technologically advanced greenhouses exist, albeit in a limited number. There are several reasons of not switching to automated or advanced method of production. Starting with good weather conditions, routines adopted to traditional solutions for generations and unavailability of investment capital are among first in mind reasons. As result, quality of production is also dependent on climate conditions and existing natural resources.

SPA is not commonly known concept, but still in use for some greenhouses. For that reason, approaching this TIS as a 'nursing state' market is found fitting (Bleda & Del Río, 2013). Nursing state market is mainly characterized with its limited size, awareness, and scientific information exchange. In this framework, SPA-related technologies are labelled as “new technologies” and market is not fully developed for technological diffusion. While nursing states carry specific difficulties in it, a great potential for learning space is still attractive in policy making.

In short, nursing state markets have complex natures to examine. Balance between being selective in applicable functions and still being comprehensive has the upmost importance. As a way of policy level adoption in such cases, a combination of functional and structural elements are suggested (Wieczorek & Hekkert, 2012). Therefore, identification of functions is the core concept for theoretical framework.

3.1.2 Functions of TIS

Functions within TIS are studied by numerous scholars (including but not limited with Bengt-Ake Lundvall, Christopher Freeman, Charles Edquist, Staffan Jaconsson, Bo Carlsson, Anna Bergek). Table 3 shows five selected studies showing the core concepts of functional analysis in the literature.

Table 4: Functions in different IS studies

(Borrás, 2004)	(Johnson & Jacobsson, 2001)	(Chaminade & Edquist, 2006)	(M. P. Hekkert et al., 2007)	(Bergek, Hekkert, et al., 2008)
Production of knowledge Diffusion of knowledge	Creation of ‘new’ knowledge	Knowledge inputs	Knowledge development Knowledge diffusion through networks	Knowledge development and diffusion
Guidance of innovators	Guidance of the direction of the search process	Support services	Guidance of the search	Influence on the direction of search
		Constituents of ISs	Entrepreneurial activities	Entrepreneurial experimentation
	Formation of markets	Markets: demand side factors	Market formation	Market formation
Control of knowledge usage		Constituents of ISs	Creation of legitimacy	Legitimation

Table 4 (continued)

Appropriation of knowledge				
Reduction of technological diversity				
Reduction of risk				
Financial innovation	Supply of resources		Resource mobilization	Resource mobilization
Alignment of actors	Positive external economies			Positive externalities

There is no right and wrong categorization in literature. All studies are depending on their own research question and targeted IS to work on. Thus, they are overlapping in terms of conceptual coverage. To exemplify, constituent of IS involves entrepreneurial activities and regulative measures together. This thesis is influenced greatly from Hekkert et al., 2007 because the systemic components are differentiable based on those functional titles.

3.1.3 Performance Measurement of TIS Functions

There is no straightforward method to evaluate functional performance. Functional dynamics provide detailed description for the whole TIS through identified strengths and problematic areas (Borrás & Edquist, 2013; M. P. Hekkert et al., 2007). Interpreting functional dynamics for performance measurement, requires examining existing methods (Carlsson et al., 2002).

Identifying problem categories under each function is suggested by Hekkert et al (2007). Wieczorek (2009) goes one step further and describes these categories as policy rationales to replace market failure approach. In this framework, 5-level scales are proposed to be assigned to each function and its systemic instruments (Bergek et al., 2010).

At the very end, either to handle problems or to maintain advantageous courses of action, identified problems are linked to policy instruments (Borrás & Edquist, 2013; Smits & Kuhlmann, 2004). This thesis defines policy instruments as services to facilitate changes in a dynamic environment. They are useful to stimulate learning process, to articulate demand, to foster interaction, to develop necessary infrastructures and to develop strategies.

3.2 Limitations in Theoretical Framework

Limited market dynamics are found challenging to work on because of uncertainty, underdeveloped market functions and perceptions on financial risks. Innovation is an act of human – without the perfect information – and that is why it always encloses uncertainty (Smits & Kuhlmann, 2004). Nonetheless, policy instruments exist to promote the learning process and raise awareness. This is in even a greater level for unmatured markets. Afterall, actors are not perfectly rational agents. They build their own rational based on the information they receive. This creates an opportunity for public policies to both initiate and enlarge the learning process in a system. Thereafter, they eliminate the uncertainty in the system.

Additionally, policy design perspectives are criticized for searching one solution for everyone. Main argument is that policy instruments become independent from goals and focused on fixing the market failures. Market failure approach does not apply to every case, especially between developed and underdeveloped market studies. Instead, policies should be designed around the existing market functions to establish correct linkages. On that manner, policies are suggested to drive innovation in a particular direction within the market dynamics (Park, 1999).

Financial risks, at last, are correlated with high investment costs, which is even higher for early-stage technologies. Thus, availability of relevant skills and relevant infrastructures sometimes increase the risk of investment. For sectors like agriculture, governments play a leading role to diminish financial risks that private institutions take. As Mazzucato expresses:

> *the state has played a role that goes beyond the Keynesian emphasis on taxation, subsidies, spending and regulation, and the Schumpeterian emphasis on creating the 'right conditions' for innovation and growth* (Mazzucato, 2011).

State interventions for early-stage technologies do not require direct support as tax incentives, especially in sectors like agriculture. States should rather create a market by exploring networks, interactions, and opportunities. Only then first movers become more active in network alignment and demand articulation (Bergek et al., 2010; Bleda & Del Río, 2013).

While all have a reasonable point, these challenges should also be considered as parts of the innovation process in a system. All in mind, the goal is to answer how to structure policies so that greenhouse technologies in favor of SPA are diffused and adopted. Before jumping into any conclusion, mismatches and barriers in the overall TIS must be identified. Thus, functional dynamics of the target TIS must be understood, so that policies are feasible and applicable for all involved actors. To that end, this thesis is structured on functional analysis method in a comparative study. Functional analysis involves both static performance of sub-functions and the interaction among involved actors. In that sense, there is a hint of structural analysis, yet without identifying strict categories like financial or infrastructural structures. Comparative study, on the other hand, has a role to establish an optimal point to see whether target system is advantageous or lagging behind. While comparing different systems, systemic characteristics are taken into consideration. After all, it is neither possible nor aimed to find one-fit-for-all solution.

There are different uncertainties and underdeveloped conditions in targeted nursing state market. Such limitations encourage this thesis to redesign the existing theoretical framework. Functional dynamics in target system should be elaborated; however, borders of functions must be set at first. At this point, the question is: are there any data on functional elements in the system? Hence, this thesis involves a comparative study. Therefore, same question is asked to all involved systems in order to establish a comparative baseline. Theoretical Framework is again explained in the next section, answering: (i) What are the applicable functions? (ii) How can we measure functional performance of this TIS? and (iii) What are the characteristics of comparative systems?

3.3 Redesigning Theoretical Framework: Applicable Functions

Similar to the evolution of functional analyses in IS, several approaches (Bergek, Hekkert, et al., 2008; M. P. Hekkert et al., 2007; Johnson & Jacobsson, 2001) are combined in this thesis, to find the best-fit functional frame. That being said, seven functions are identified in this thesis. Each given function aims to find problems in the TIS for greenhouse sector in Turkey. Short glimpse of functions in this thesis is given by Figure 4, followed by detailed explanations.

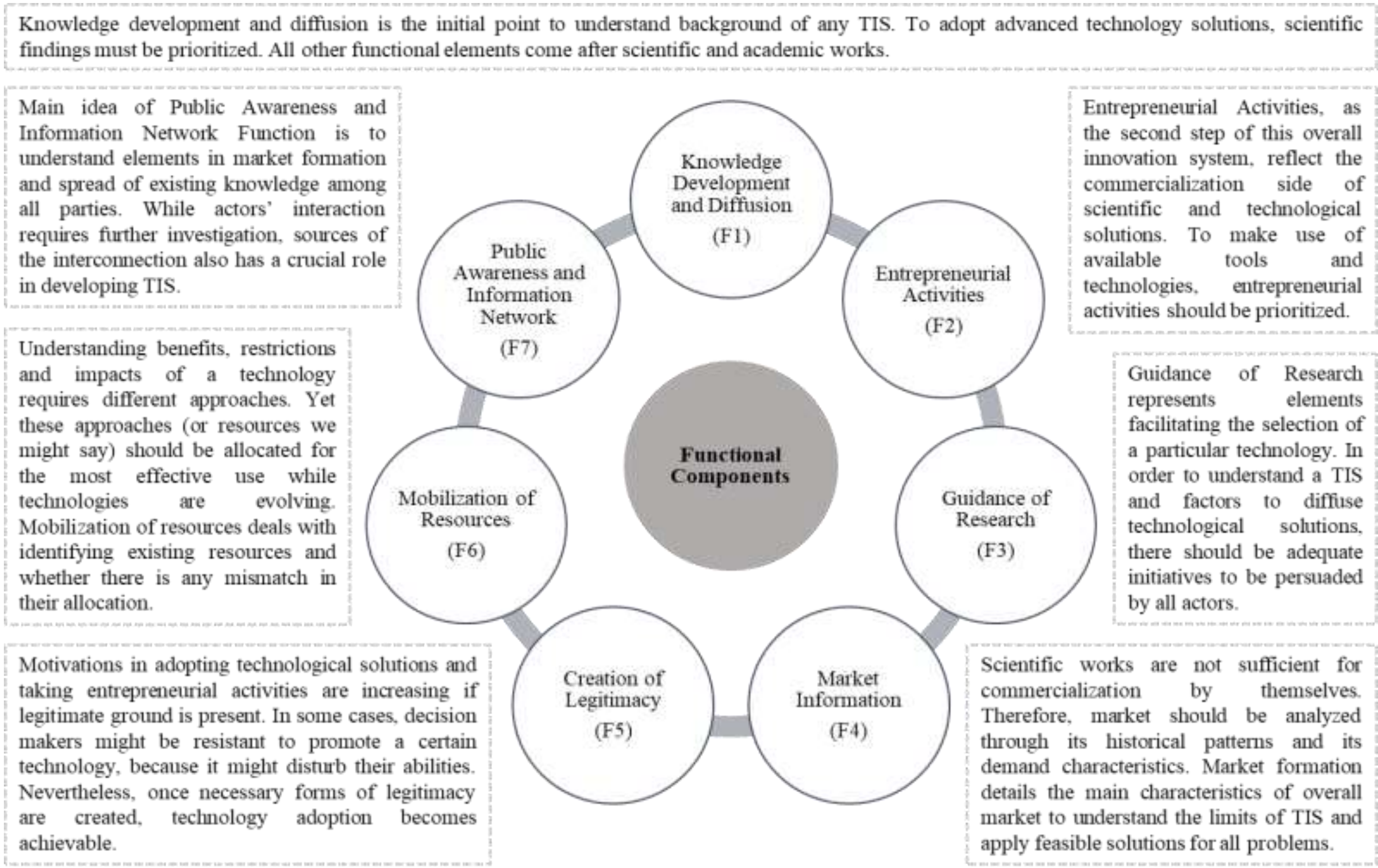


Figure 4: Functions Identified and Explanation

3.3.1 Knowledge Development and Diffusion (F1)

Knowledge development activities address how well the system develops scientific and technological information. As the title speaks for itself, knowledge diffusion activities represent the level of exchange of this information. This thesis elaborates knowledge creation and diffusion together, unlike studies like Hekkert et al (2007). To simply put, one is considered meaningful only when other exists.

To understand functional performance of F1 in this TIS, eight sub-functions are identified: academic studies, agricultural knowledge creation rate, agricultural knowledge transfer rate, university concentration to agricultural studies, university-industry collaborations, researchers in agricultural sciences and patents in agricultural operations. Academic studies, agricultural knowledge and transfer rate, researchers in agricultural sciences and relevant patent applications are presented to understand the level of knowledge development and diffusion. In that sense, these sub-functions are close to quantitative analysis. University-industry collaboration and concentration to agricultural studies, on the other hand, investigates the capabilities of existing knowledge and scientific abilities. University concentration is upmost the crucial sub-function of this capability analysis. Main consideration of the emphasized concentration is given whether top ranked academic institutions prioritize agricultural studies. In short, this function looks into both the availability and the quality of academic work in agricultural technology.

3.3.2 Entrepreneurial Activities (F2)

Entrepreneurship is the point where innovation searches its commercial value. There are different concentrations on entrepreneurial subjects. To exemplify, Robert Solow sees entrepreneurial activities as a tool for economic growth. Scholars close to Schumpeter's Ecole might interpret entrepreneurship as the ability to combine existing things in a creative manner (Schumpeter, 2000). On the other side, some scholars define entrepreneurship as an academic concept (Rothaermel et al., 2007; Siegel et al., 2007). That being considered, this thesis considers entrepreneurship as a commercial act of innovation.

At first, overall entrepreneurship ecosystem is defined and elaborated. It is important to understand the universe that this function deals with. Once the border lines are set, agricultural entrepreneurship can find its share in the ecosystem. In that sense, functional performance of F2 is evaluated based on both general entrepreneurial activities and agricultural entrepreneurship. Academic entrepreneurship is not given among sub-functions of F2, due to unavailability of data. While data unavailability might implicate presence problems in a system, it is still a hypothesis to be tested by other methods.

3.3.3 Guidance of Research (F3)

When a new technology is at the initial stage for diffusion, limits in market must be examined. Technological tools are limited and simply cannot answer each and every need (M. P. Hekkert et al., 2007). The reason of that, diffusion policies and/or strategies must be aware of market needs and market limitations concurrently.

Main question that F3 asks is: in which market this technology can reach out the final user? The answer involves not only incentives given, but also overall market behavior and existing infrastructure. Accordingly, Hekkert and Negro (2009) exemplify this function as announcement of a policy goal to show some sort of legitimacy and to promote resource allocation. Therefore, the interactive process between producers, consumers (end-users), and other actors are detailed under F3.

That is being said, six sub-functions are identified for F3 performance evaluation: agricultural producer supports, complementary goods and services, demand characteristics, greenhouse manufacturing sector, and digitalization policies applicable to agriculture. Current state of agricultural production is showed through simple supply and demand indicators. Complementary factors and available greenhouse manufacturing sector, on the other hand, reflects the factors pushing businesses to invest in themselves. Digitalization policies, at last, provide an insight on infrastructural elements on technology adoption in agricultural businesses.

3.3.4 Market Formation (F4)

"From Schumpeter to Porter innovation-thinkers have recognized the importance of an advanced market, of well-articulated critical demand as a driving force for innovation" (Hekkert, et al., 2011, p. 7). Institutional changes for innovative applications often require an evolved market (Bergek, et al., 2008). Nevertheless, an early-stage technology might have constraints in competing with existing technologies. For that reason, a learning market should be established, in accordance with the knowledge development function.

Five sub-functions are identified under F4, explaining market size and characteristics, productivity level, value of agricultural activities, industry associations, agricultural trade, and bilateral relations. Market characteristics, productivity, and the rate of return of this productivity in agricultural operations are used for descriptive manner. Industry associations and trade relations, on the other hand, shows the interactions between different actors in the market. Based on the existing actors involved in these interactions, answers to following questions are searched: On what ground these interactions happen? Are they enough to maintain a knowledge transaction in the market? Are there any barriers in trade relations? To sum up, having a supportive side to F3 through market-specific drivers, this function's role is to understand the sequence on market formation.

3.3.5 Creation of Legitimacy (F5)

F5 reflects compliance with institutions through regulations, national agendas, and policies. Hence, legitimacy is a strong influence on perception, expectation, and strategic decisions to formulate new industries or to develop an existing one (Bergek, et al., 2008).

There are no sub-functions under F5. Rather, objective is to draw a picture on system's history in agriculture, how it reacted to change and development before and motivations behind agricultural development. While there are numerous indicators to make quantitative analysis to evaluate a functional performance, this function investigates the background and the evolution path of systems. That is why F5 is slightly different than the rest of the functions. Instead of identifying and elaborating the dynamics between actors, F5 is designed to see the interaction of past and the present. Objective is to make a prediction on future, of course, because every action in a system should have a reaction – which is fed by the past.

Taking a technology diffusion policy as example, market research does not necessarily provide sufficient data on how to respond user (consumer) needs. Culture, history, sociology and even psychology are necessary to make such research "holistic". In this thesis, factors affecting the TIS and agriculture in the past are detailed. Not to make any conclusion, but to have a better insight on the unwritten systemic elements as societal behavior, cultural aspects, and motivations.

3.3.6 Mobilization of Resources (F6)

TIS involves a number of layers to analyze, therefrom mobilization of resources is also a wide concept. Again, the balance between making a comprehensive evaluation and selecting the best-fit sub-functions requires careful examination. Initially, resources necessary to answer research question are identified. Available data and its potential to make a meaningful argument resulted in considering two sub-functions: financial and human resources.

First, the allocation of human resource and skills are analyzed. Main focus on human resource mobilization is given to the level of newly graduate employment. Education opportunities are not meaningful without transforming the technical knowledge into economic activities. Thus, the way youth interpret career opportunities in greenhouse cultivation draws important notes on mismatches and waste of resources, if any.

Second, financial resources will be taken under consideration. Objective is to see whether TIS is able to allocate necessary financial sources to promote entrepreneurship, management, and innovation in greenhouse cultivation. In that framework, available financial resources are backed up with whether they are reachable or not.

3.3.7 Public Awareness and Information Networks (F7)

While most of the functions given in the literature are kept as they are, F7 is specific to this thesis. At most, awareness level or channels of information share are studied under other functions to see the interaction level between actors. Yet, working in a developing market challenges to fully understand interactions and information flows of involved actors in each function. To make a fair and comparable study, degree of information exchange is detailed separately. Therefore, F7 is the core methodological contribution of this thesis.

F7 is not solely concerning with information spread. Communication channels, availability and usage frequency of those channels are also necessary to emphasize common needs of potential users. Even though advanced greenhouse technologies are only a part of a large agricultural operation chain, attitudes towards new technology are shaped by the information share. That being said, four sub-functions are selected to observe F7: google trend analysis, website evaluations, social media analysis and selective network events.

Google trend and social media analyses are selected to describe public awareness level towards a new technology. The search and sharing preferences might not be directly linked with a new technology; however, they provide hints from sectoral needs. Website evaluation, on the contrary, is not a generic analysis but is rather specific to selected sources. This sub-function is chosen to see whether website designs and information given are sufficient and well-promoted for public.

From another angle, it also asks whether there is an attention gathering online infrastructure to promote any new technology? To answer this question, selective network events are presented from a simple online search for someone who wants to get more information on technologies for greenhouse cultivation. This sub-section aims to highlight different ways to increase public awareness on new technologies.

As part of this function, website evaluation method has been presented. Evaluation methods of websites have different scope of measurement framework, indicators and weighted score depending on the sectoral focus and strategical priorities of research (Avouris et al., 2003; Orji, 2010). To establish an objective comparative ground, official web pages of ministries of agriculture in comparative countries are evaluated based on their: identity, loading & viewing performance, navigation option, interactivity, comprehensibility, personalization & content, information quality & up-to-datedness, and security & miscellaneous.

In case of agricultural websites, studies show that usability and quality are among the most important indicators in evaluations (Havlíček et al., 2013; Raikar et al., 2017) because it directly impacts users' comfort and time spending. Urban areas, where agricultural activities are mainly present, do not have the same broadband connection as the metropolitan cities. Since climate and available arable land factors are applied to all farms regardless of their size, promotion of eye-catching and easy-follow enabling parameters have substantial impact on information sharing in this sector.

Bearing this prioritization in mind, a website evaluation matrix has been designed and presented in Chapter 4.7.2. All indicator categories involve several sub-indicators, showing on what ground a specific website is evaluated, indicating whether automated or individual evaluation is used.

3.4 Comparative Analysis

Agricultural innovation in TIS, consists of processes involving economic capabilities, technological solutions, technical abilities, social values, and institutional changes (Lamprinopoulou et al., 2014). Technology adoption under agricultural innovation, therefore, requires a systemic understanding between new solutions and existing structures. With this in mind, different methods are available to map functions in the market as cross-country comparison, game theory modelling, evolutionary economics modelling, and social network analysis (Klerkx et al., 2010; Rajalahti et al., 2008; Spielman et al., 2009). In this thesis, cross-country comparison is selected to measure performance of Turkey in adopting SPA for greenhouse cultivation.

On the methodological manner, this thesis does not look for prescriptive conclusions as: Functional performance gets 2 point out of 5. At this point, a question must be asked: on what ground a function gets a certain point? Since there is no optimal and one-fit-for-all calculation method for technology diffusion policies, comparative study method is selected in this thesis.

Comparative studies are found quite effective in numerous similar studies (Woolthuis et al., 2005; van Mierlo et al., 2010; Weber & Rohracher, 2012). Accordingly, since this thesis focuses on a nursing state market, lessons to be learnt from best practices are as useful as understanding the TIS. Thus, making strict comparisons with a different TIS would not bring applicable conclusions. Therefore, policy instruments given in this thesis built upon presence and capability problems along with system level motivations and prioritizations. Identification of best practice countries is entirely depending on empirical studies on Speaking Plant Approach. While being a niche concept, SPA is interlinked with numerous disciplines as plant sciences, lab experiments, biology, agricultural engineering, software and hardware development, management systems, horticulture, agronomy, computer sciences, artificial intelligence and so on.

SPA is studied since 1978, by more than 30 countries. Udinkten Cate et al (1978), based in the Netherlands, first suggested this approach in academic literature. Over years, Japan became main developer and contributor for academic works in this subject. In total, seven sources are scanned[2]: Web of Science (23), Google Scholar (446), Science Direct (65), Academia (22), Springer (13), Semantic Scholar (106) and Sage Journals (1). Results of the analysis are shown in Figure 5.

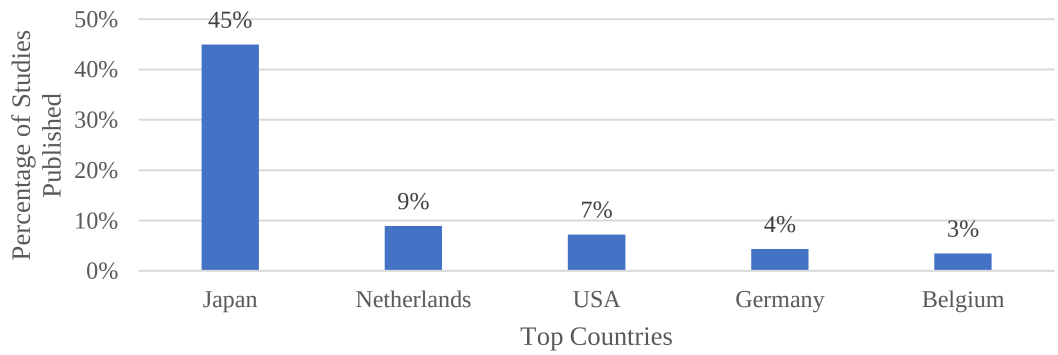


Figure 5: Countries by Percentage of Online Academic Results for "Speaking Plant Approach" between 1978-2020

Source: Web of Science, Google Scholar, Science Direct, Academia, Springer, Semantic Scholar and Sage Journals, filtered with “Speaking Plant Approach”

[2] Sources are given with the total number of results. Among all results, a total of 320 studies (articles, conference papers, dissertations, theses, and books) are selected in the empirical work.

As shown above, most of the academic studies on SPA are published in Japan and the Netherlands. Accordingly, scientific collaboration rate between the Netherlands and Japan is at highest. Scientific collaboration rate shows a frequency of knowledge transfer in academic literature. To make benefit of such accumulated knowledge, these countries are selected to make a comparative study with Turkey.

Selection of countries are based on the scope of policies that addresses technology and knowledge diffusion. Netherlands and Japan have different dynamics in terms of applying precision agriculture and optimizing agricultural inputs, however, they have different approaches in diffusing necessary technologies. Looking both from state-controlled and individual entrepreneurship promotion policies, Japan and Netherlands provides different perspectives that Turkish policies could follow based on national dynamics.

In that sense, the following question is asked: what are the actions taken by those countries so that they result as the two important scientific sources? Historical background of each country and their path towards advanced agricultural technologies are detailed in the next section.

3.4.1 Japan

Agriculture was always an important part of Japanese history of democratization and modernization. Initial agricultural policies were introduced to cope with war and post-war circumstances (Food Control Law of 1942, Agricultural Land Act in 1952 and Agricultural Basic Law of 1961). In 1960s, agriculture was counted 9% of economy and 28% of labor force in Japan (OECD, 2009).

Economic recovery after post-war period, however, affected farmer income. They became unable to keep up with the economic growth, as other industries do. Agricultural Basic Law enacted in 1961 with numerous initiatives to cope with this challenge (Masayoshi, 1993). Products with higher demand were prioritized, price supports are applied, and trade policies are strengthened (Hirasawa, 2017).

In a way, first steps in modern agriculture operations and large-scale management are taken, but productivity growth did not raise enough to narrow urban-rural income disparities. Mechanization trends created a sector mixed with small and diffused farm households (Hirasawa, 2017). Several acts and regulations are enacted to protect farmers and allocate existing resources in the most efficient manner. These interventions focused on different issues as minimizing competitive advantages, share of agriculture in economic growth, international trade, etc.(Masayoshi, 1993).

By the mid of 1990s, Japanese SMEs became more skilled in new technologies (Shapira & Rosenfeld, 1996). Meanwhile, scientists and engineers headed towards to large-scale organizations. Changing dynamics in overall system, brought updates on existing regulations. To exemplify, New Basic Law on Food, Agriculture and Rural Areas (1999) replaced the Basic Law on Agriculture of 1961. New regulations broadened agricultural policy objectives via food security and multi-functional operations (OECD, 2009).

In 2005, second basic plan centered community-based farming cooperatives. Objective was to improve farm management systems and to promote new entrants (OECD, 2009). Thus, Farm Management Stabilization Programme is initiated to cope with price fluctuations (Gilmour & Gurung, 2007). In a way, agricultural operations are promoted to youth and new entrants. Inevitably, skill transfers came into scene using agro-informatics and agriculture became one of the most intervened and protected sectors in Japan (OECD, 2015; Shibusawa, 2011).

Meanwhile, earthquakes, tsunamis, typhoons and cloud-bursts had a considerable effect on agricultural businesses (Bachev & Ito, 2017). Farmlands started to disappear and natural disasters remained a great risk national self-sufficiency rates. Against all, traditional practices shifted to precision agriculture to maximize the potential of existing resources.

Precision agriculture was applicable in different scales of farming, thanks to variety of crops and high level of individual plant management (Sasao & Shibusawa, 2000). Inevitably, precision agriculture became appealing not only for farmers, engineers, or scientists, but also for politicians, business enterprises, and policy makers. Japanese government introduced policies addressing precision agriculture through direct funds, regulations on IPRs or boosting collaboration among actors. Nevertheless, success of precision agriculture practices in Japan remained a result of existing technology platforms and farmer wisdom .

Challenges of Japanese farmers and farming sector are still present. Isolation of competition, inability to respond market signals, labor shortage and aging are among most prominent ones ("Agriculture in Japan New Developments in Smart Agriculture," 2018; OECD, 2015). Against all, Japanese government now prioritizes technological improvement, innovation, cross-disciplinary policies, and infrastructural development in agriculture (Fukuyama, 2018). In fact, smart agriculture market is foreseen to be valued 33 billion of Japanese Yen by 2023 ("Agriculture in Japan New Developments in Smart Agriculture," 2018).

3.4.2 The Netherlands

Challenging times, as happened in Japan, became a push factor for Dutch government to intervene agriculture. While a large economic crisis hit in 1930s, Europe were suffering from low food-supplies after World War II. Farm sizes were small, incomes were low and only efficient food suppliers were able to earn adequate income in the market (Bont et al., 2003).

At first, Dutch Government facilitated deployment of machines, promoted yield harvest by using artificial fertilizers, and adopted land consolidation policies (Van der Heide et al., 2011). Small and mixed farms are replaced hereafter by specialized and intensive farms. While number of farms decreased, production level maintained an augmenting momentum (Smit et al., 2015). This was the point of modernization and mechanization in Dutch agriculture.

Other EU countries also joined to this transforming process. At the beginning of European integration, various economic community foundations were proposed. Common Agricultural Policy was one of them (Van der Heide et al., 2011). Sicco Mansholt, who is the founder of the idea of CAP, had the ambition to avoid food shortages that might happen in the future and to guarantee agricultural efficiency (EC, 2018). Setting minimum prices, supporting exports, promoting research, and enabling the merge of farms were some of the initial intervention areas.

Afterwards, policy focuses turned to product-level needs. Measures are adjusted to efficiency related production factors. Hence, rural development and protection of environment came to stage as cross cutting issues. As an example, during 1980s, European Community needed to introduce a quota on production to stop agricultural surpluses (Van der Heide et al., 2011). As of 1990s, set-aside policies became subject to CAP, as part of MacSharry reform (Bont et al., 2003). Therefrom, environmental protection and pollution reduction also became an important part of CAP (Van der Heide et al., 2011). Still today, agricultural policies in the Netherlands are mainly shaped by CAP and established (Holthuis & Velden, 2019).

There are several aspects of Dutch agricultural policies worth emphasizing. Government's role has been shifted to a more passive position (Diederen et al., 2002). In other words, farmers are considered as entrepreneurs in the market. Government rather focused on creating an enabling environment for innovation in agriculture. On that ground, Ministry of Agriculture, Nature and Food Quality published 'Going for Agriculture' report in 2005. Report was setting a baseline for an interactive environment for policy makers, researcher, private sector, and farmers.

As a contradictory consequence, remaining small sized farms became incapable to innovate and compete with larger businesses on international markets (Diederen et al., 2002). To cope with those challenges, farmers searched ways of higher productivity methods. Precision agriculture started to diffuse in the country to eliminate business level imbalances. It allowed farmers to operate in a more heterogenous environment (Schrijver et al., 2016). Additionally, this transformation promoted selective management practices, reduced costs, and guided ways against environmental degradation (Zhang et al., 2002).

Main difference between Japan and the Netherlands was the degree of government involvement. Following different policy approaches, both countries became successful cases by achieving successful technology diffusion and adoption. Examining their experiences and rout paths are found useful to address needs and opportunities in greenhouse sector of Turkey.

3.5 Performance Measurement

Measuring performance of each country in terms of their functional dynamics could easily become complicated. That being said, findings of each function are transferred to problematic issues that target TIS (Turkey) has. At the end, policy instruments are identified and linked to those problems. Therefore, Table 4 is designed to summarize existing problems and relevant policy instruments.

Table 5: Functional Performance Table

Function	Sub-Function	Problems	Policy Instruments
F1	University concentration to Agricultural Studies, R&D Collaboration, Researchers in Agricultural Studies, Patents Relating to Agricultural Technologies	..	..
F2	Entrepreneurship ecosystem, Agricultural entrepreneurship	..	..
F3	Support for Producers, Complementary Products and Services for Producers, Characteristics of Demand, Greenhouse Manufacturers, Public Policies and Strategies on Digitalization in Agriculture	..	..
F4	Market Size and Characteristics, Productivity Level and Value of Agricultural Activities, Industry Associations, Agricultural Trade and Bilateral Relations	..	..
F5	Laws, regulations, policies and national strategies for agriculture and agricultural technology	..	..
F6	Financial resources, Human resources	..	..
F7	Google trend analysis, Website evaluation, Social media analysis, Other networking events	..	..

Inputs presented in Functional Performance Table are not graded, as several scholars suggest (Bergek et al., 2010). Instead, problems are given based on data gathered and comparative results. Measuring success or weaknesses might require scaling inputs on hand. Nevertheless, TIS differs from each other and scaling would not bring accurate results in this case. Functional Performance Table, different from quantitative measurement methods in literature, provides a generic summary for:

- Problems found in the system, and
- Policy instruments to eliminate these problems.

Turkish agricultural policies are quire comprehensive, but somehow greenhouse related policies are not well defined. Therefore, once again, how policies should be structured for adopting SPA in greenhouse operations? Bearing in mind steps taken by comparative countries and national dynamics and needs of the target TIS, this thesis provides a tailor-made research framework to identify most applicable policy instruments. Methodology used for data collection and analysis is explained in the next section.

3.6 Methodology

In this thesis, a couple of methodological tools are applied to answer the research question. Similar methodological mixes are used in previous IS studies, simply because the context involves interdisciplinary research varying by the research question.

There are three different data sources in this thesis. First, publicly available data gathered from official statistics and publications. Second, primary data gathered from semi-structured interviews. Third, primary data gathered from questionnaires. Details of all selected data and collection method are detailed in next sections.

3.6.1 Secondary Data Analysis

Secondary data is collected to establish a comparable baseline and to see country-based changes since 2010. Sources of secondary data include OECD, World Bank, FAO and EuroStat. These sources are prioritized not only because they are available for three countries at the same time but also, they are universally accepted data banks for different types of analysis. Additionally, academic literature and publicly available online sources are included when it is necessary to answer a particular question. Reason of emphasizing functional analysis on secondary data is to see key development areas of Turkey, in comparison to Japan and the Netherlands. With this in mind, relevant indicators are eliminated if they are not applicable for one or more comparative countries.

3.6.1.1 Semi-Structured Interviews

Researchers argue that until today, the focus in the policy making was given to identify difficulties to reach desired outcome, such as systemic failures, weaknesses, and block mechanisms (Chaminade, 2010; Johnson & Jacobsson, 2001). Yet, through describing functional and influencing structures, comprehensive picture of desired innovation system could be drawn (Wieczorek & Hekkert, 2012). Since comparative analysis limited the selection of data, additional evidence through primary data collection is found useful to confirm and enrich functional analysis.

Semi-structured interviews are conducted to understand what the perceptions of involved actors towards current technological solutions and overall greenhouse cultivation sector are. To this end, greenhouse workers and owners are involved to this research along with a representative public body: TAGEM (General Directorate of Agricultural Research and Policies). Participants are selected based on their base of operation, size of their greenhouse and educational background in order to grasp different perspectives and needs in the overall sector. Interview participant from TAGEM is selected based on the responsibility level and departmental relation to agricultural technologies.

Pilot interviews are conducted before data collection to get a feedback on the set of questions. For the sake of reaching out to as many interviewees as possible, interviews are conducted in Turkish.

Interviews are designed to understand needs of current workers, their perception towards greenhouse operations in Turkey and recommendations on how they can work better than this. To analyze potential impact of a new technology, actors' perception towards theoretical and practical concerns and past experiences matters greatly. Rather than providing theoretical recommendations, such as technology can improve your existing business, interviews mainly searched whether there is a need to improve current techniques.

30 questions are designed, showing parallel subject titles of given functions. Set of questions and their linkage to functional analysis are detailed in Table 6.

Table 6: Questions Designed and Link to Research Objective for Semi-Structured Interviews

Questions	**Related Function(s)**	**Main Objective of Question(s)**
Could you tell us about the dynamics of your profession? How long have you been working in this field? How your business changed during the pandemic?	N/A	To have a descriptive and introductory data on interviewees

Table 6 (continued)

How can you describe the overall market in the greenhouse sector? How many people are currently working in this greenhouse?	N/A	To differentiate cases by the scale of operation
Can you tell us about the equipment and production methods you use? Have there been changes in equipment/methods since you started to work? Have you visited other greenhouses around you before? Had you any observations about other cultures, employees and business processes? What are the reasons of preferring the products you produce now? Is the infrastructure at your location sufficient for your operations?	F2, F3, F4	To understand the production method applied in different scales of greenhouse operations To see common and different needs of greenhouses
Do you think those who are engaged in greenhouse cultivation turn to agricultural education because it is a family business? Or are there people who studied in this field and then entered this sector?	F1,F2,F4, F1, F3	To see the initial motivations in this sector To understand the dominant source of knowledge
Are there any news channels about this sector that you follow? In addition to them, are there any sources you follow technological developments? Are there any applicable technical and technological solutions for you?	F1,F2,F4, F1, F3	To identify communication and information sharing channels To see whether existing technologies are applicable for different scales of operation
Where do you buy your work equipment? Where do you supply the fertilizers, pesticides, seeds and equipment from?	F3	To understand whether there are sufficient complementary goods and services
By whom is the adjustment and control of these equipment are made?	F1, F3	To see technical knowledge on the equipment
Are there any incentives to buy equipment and technological tools? Has there been any government support you have ever received? Do private investors invest in this sector?	F2, F3, F5, F6	To elaborate existing incentives and business opportunities for greenhouses
Where do you mainly sell your products? What do you pay attention to when establishing commercial relationship?	F2, F4	To see how greenhouse workers establish their business relationship

Table 6 (continued)

What do greenhouse growers need to be an effective company? How can you describe the competition in the greenhouse sector?	F2, F4	To understand overall market competition
What are the benefits of agriculture chambers?	N/A	To cross-match the data with questionnaire
Is there an awareness or consciousness about greenhouse cultivation ? Does your greenhouse have a website? Do you share your experiences with people ? If yes, on which channels? How do you think policies in this sector should be developed? How do you see the future of this sector in Turkey?	F1,F7	To show the level of technology usage in knowledge sharing and awareness raising To see level of sufficiency of existing policies To get personal opinions

In total, 10 interviews are conducted. Characteristics of interviewees are given in Table 7.

Table 7: Interviewee Characteristics

Interview No.	**Graduated from**	**Working as**	**Greenhouse Size**
1	Agricultural Engineering	Greenhouse owner	Small-medium size
2	Molecular Biology	Greenhouse R&D firm owner	Medium-large size
3	Agricultural Engineering	BD Manager	Large size
4	Horticulture Sciences	Greenhouse Owner	Medium size
5	Not Applicable	Public Servant	Not Applicable
6	High School	Greenhouse Owner	Small size
7	High School	Greenhouse Owner	Small-medium size
8	High School	Greenhouse Owner	Small size
9	Agricultural Engineering	Greenhouse Owner	Small-medium size
10	Agricultural Engineering	Greenhouse Owner	Small size

Sizes of greenhouses are categorized based on the overall land size and operation scale (production size and export size). Within a limited number of interview opportunities, different greenhouse operation scales are included in research. Due to protection of privacy, personal information of interviewees is not given in the thesis.

Interviews are analyzed in QDA through 155 assigned codes, which are provided in Appendix. There are two different code categories: General Information and Function Specific Information. The reason for that is, some questions are asked to understand solely the interviewee while others are structured with functional and sub-functional dynamics.

General Information codes describe details on products soiled, problems of greenhouse productions and advantages of operating greenhouses. Sub-categories are listed as: 'Generic', 'Advantages on Technology in Greenhouse' and 'Problems of Greenhouse Operations'.

Function Specific Information, on the other hand, involves function specific codes clustered in accordance with given 7 functions. Context-specific clustering also applied under each function clusters, all of which are detailed in Table 8.

Table 8: Clustering of Semi-Structured Interviews

Function Clusters	**Context-Specific Clusters**	**Explanation**
Knowledge Development and Diffusion	Problems	Problems in knowledge, education, knowledge diffusion and tacit knowledge
	Needs	Types of knowledge needed to effectively operate greenhouses
	Sources of Knowledge	Sources of necessary knowledge to effectively operate greenhouses
Entrepreneurial Activities	Large-Size Firm Activities	Entrepreneurial activities in large-size greenhouses
	Medium-Size Firm Activities	Entrepreneurial activities in medium-size greenhouses
	Small-Size Firm Activities	Entrepreneurial activities in small-size greenhouses
Guidance of Research	Business Culture	In-firm culture, other than operational routines
	Complementary Services	Problems/ issues related with complementary services rather than technology itself
	Competition	Overall competition in market, both among producers and intermediary actors

Table 8(continued)

	Demand	Comments on demand in high quality agricultural products
	Characteristics of Trade Relationships	Important issues to establish and maintain trade relationships
	Infrastructure	Availability and/or problems related with the necessary infrastructures
Market Information	Pricing	Pricing impacts on greenhouse operations and their investment
	Market Size	Overall characteristics of market such as size, diversity and level of maturity
	Relationship Characteristics with Foreign Market	Relationship between producers and international firms to see export and import dependency along with government relations' impact on agriculture
	Relationship Characteristics with Domestic Market	Relationship between producers and local intermediary or complementary actors
Mobilization of Resources	Human Resources	Problems and individual perceptions towards human resources in agricultural production and greenhouse operations
	Social-Integration	Reflections of greenhouse production on social-integration
	Land Resources	Issues related with arable lands and greenhouse lands on production
	Technology Resources	Availability and appropriateness of technology resources impacting adoption rates
Public Awareness and Information Network	Society Awareness	Perception of producers towards society awareness on agricultural production systems and greenhouse production systems
	Greenhouse Websites	Level of website usage by greenhouses, main advantages and problems
	Greenhouse Information Network	Producer interactions for operational or technical issues

Table 8(continued)

	New Technology Follow/ Sources Followed	Whether producers follow new technology solutions and if yes, through which channels
Policy, Regulation and Government Support	Government Support Characteristics	Details on government support for agricultural producers
	Policy Needs	Recommendations given by producers and public servant on key priority areas
	Support Availability	Types of available government supports and whether producers can apply them
	Regulations of Foreign Countries	Regulations applied by export countries or foreign firms on Turkish producers

3.6.1.2 Questionnaires

Questionnaires, different from semi-structured interviews, are conducted to understand perception of Chambers of Agriculture in Turkey. While greenhouse workers or owners are the main target, it is impossible to conduct interviews with hundreds of them, located in different regions. Chambers of Agriculture representatives, on the other hand, have both region-level knowledge and connection to actively working greenhouses.

This thesis included a sample group of Chamber of Agriculture representatives coming from different cities of Turkey. Participants are selected whether they have access to greenhouse workers on field and whether they are currently giving advisory services for agricultural workers for their business. During a join convention in Ankara on December 2019, all Chamber of Agriculture representatives are asked to participate to this research. In order to reach out as many respondents as possible, questionnaires are preferred instead of interviews, which again prepared in Turkish to avoid possible language barriers.

Thus, chambers of agriculture are among important actors for agricultural policy design by the nature of their job. Chambers of Agriculture were legally established to support agricultural sector to be developed in accordance with general interests and to realize the state's agricultural plans and programs. In more detail, responsibilities of Chambers of Agriculture[3] include: (i) to gather news and information about agriculture and farmers, to examine them, to gather relevant indices and statistical studies and to disseminate them; (ii) to make recommendations and collaborate to public and private institutions and organizations regarding their fields of activity; (iii) to make proposals to the Union about making legislative changes required for the development of agriculture or creating new legislation; (iv) to carry out all kinds of training and consultancy activities for the development of agriculture and rural areas; (v) To keep farmer records, to organize information and documents related to farming, to give the necessary information and documents related to all kinds of agricultural support to farmers and related organizations; (vi) To cooperate with other professional chambers and organizations abroad; and (vii) To meet all kinds of needs of farmers regarding their production and professions. Therefore, inputs of representatives give this thesis a further perception on the prioritization areas that are applicable to the majority of target audience.

Through a parallel perspective to interviews, questions are designed to understand both respondent perspective and functional dynamics from the public body angle. 25 questions, in which 2 question were open ended, are asked to respondents. Table 9, once again shows the set of questions and their linkage to functional analysis.

Table 9: Questions Designed and Link to Research Objective for Questionnaires

Questions	Related Function(s)	Main Objective of Question(s)
What is your age? Which department of Ministry/Chamber you work in? What is your title? What is your title? How long you have been working in this institution? What is your highest degree?	N/A	To have a descriptive and introductory data on respondents
How would you evaluate the value / opportunities given to higher education in your institution? How much R&D work in the agricultural field is done in your institution?	F1	To understand current R&D activities in relevant institutions

[3] https://www.tzob.org.tr/odalarin-gorevleri

Table 9 (continued)

Did you contribute any R&D work before in your institution? Do you know the Precision Agriculture concept and application examples? Is there an official definition used for the concept of smart agriculture in your institution?	F1, F7	To see different terminologies
Does your institution have any application for smart agriculture? If yes, to what extent?	F5, F7	To elaborate current or planned strategies for smart agriculture
Do you think agricultural production in greenhouses are effective in Turkey? Could you evaluate the potential success of greenhouse production after applying appropriate financial / technological investment and control tools?	F4	To understand sector-level needs for improving greenhouse operations
Success of agricultural production in greenhouses depends on what? Can you list the following points from the most important to the least important in increasing the applicability of agricultural policies? Do you think it is necessary to increase the use of technology in agriculture? If yes, how it should be applied?	All Functions	Functions are asked to be evaluated
How would you evaluate the use of technology in agricultural areas (other than communication and social media)?	F7	To evaluate technology adoption
Do you think increasing the use of advanced technologies in agriculture should be prioritized by ministries and government policies? How effective are agricultural policies in terms of increasing digitalization and technology use in agriculture? To what extent do you think agricultural policies support applications for technology and digital solutions? Do you think the update period / content of agricultural policies provide maximum benefit?	F5	To discuss about existing polices and regulations
What result can we achieve if agricultural policies encourage the use of advanced technology in agriculture?	N/A	To get personal opinions

In total, 401 representatives of Ministry of Agriculture and Chambers of Agriculture are asked to answer these questions during a training gathering in Ankara in December 2019. Among them, 280 answers are collected and analyzed. According to the missingness map of collected answers, there is a 92% response rate (Figure 6).

Figure 6: Missingness Map

Respondents are introduced in this thesis based on the mean value of their descriptive characteristic. Descriptive summary is made in SPSS and given below.

Table 10: Descriptive Statistics of Survey Respondents

		Age[4]	**Years of experience**[5]	**Degree Level**[6]
Total	Valid	279	278	279
	Missing	8	9	8
Mean		2,695	3,67	2,16
Median		3,000	4,00	2,00

Respondents have an average age of 30s, considering mean as the baseline. Having a majority of young and junior-level workers is both advantages and

[4] Answer categories 1: [18-25]; 2: [26-35]; 3: [36-45]; 4: [46-55]; 5: [56-65]; 6: [65+]

[5] Answer categories: 1: [< 1 year]; 2: [1-3 years]; 3: [3-5 years]; 4: [5-10 years]; 5: [> 10 years]

[6] Answer categories: 1: [Pre-Bachelor]; 2: [Bachelor]; 3: [Master]; 4: [PhD]

disadvantages. While they might be more open to improve existing procedures, it is possible for respondents to have limited experience to propose achievable policies.

Even though, there is a young respondent profile, they have at least three to five years of experience on average. Respondents have numerous work titles. There are consultants, agricultural engineers, managers, field worker, public servants, sociologists and technical personals. Yet, majority of respondents are working as agricultural engineers and agricultural consultants.

On average, respondents have a bachelor’s degree. Thus, only 4 people over 280 respondents indicated that they have a PhD degree. In parallel to low level of academic degree obtainment, 5/7 of respondents said they did not participate to a R&D activity before. Relatedly, 45% of respondents believe that their institution does not value for R&D activities.

Questions asked in the questionnaire are designed to make a simple correlation analysis in this research. To understand the perception of respondents, following question asked: “How many of respondents answering A is also answered B”. While overall market understanding is addressed to secondary data and semi-structured interviews, questionnaire analysis aims to prioritize.

To summarize, questionnaire and interviews aim to understand problems in target TIS. While publicly available data provides a comparative analysis with best practice countries, interviews deepen the understanding of greenhouse sector in Turkey. Policy instruments, linked to identified problems, are supported by the results acquired from questionnaires. That being said, this questionnaire has two contributions to overall research. One, perception of relevant public body respondents is elaborated. Interlinked subjects between greenhouse workers and relevant public servants are analyzed to find any mismatches or additional problems. Two, prioritization for identified policy instruments are made through questionnaire analysis. While all functions are important to diffuse advanced technologies in greenhouse cultivation, questionnaire provides insights on where to start. This is especially important for nursing state market analyses. Next chapter details the findings from three data sources for each function.

CHAPTER 4

FINDINGS

Findings are presented under seven functions proposed in Chapter 3. Under each function, sub-functions detailed in Table 4 are explained. Publicly available data is supported by additional evidence through primary data analysis. Additional evidences are presented under separate sub-function titles. Comparative data provides a baseline to see shortfalls of Turkey against best practices. Historic data is also presented to understand the agricultural development path in Turkey. Main difference between Turkish greenhouse sector and best practices are shown to identify barriers and advantages. Yet, each system has its own dynamic. Meaning that, Japan, the Netherlands, and Turkey have different advantages and barriers to diffuse advanced greenhouse technologies. To propose strong and feasible policy instruments, each system is examined with their dynamics, bearing in mind common success factors of Japan and the Netherlands.

Additional evidence through primary data mainly contributes to describe greenhouse sector in Turkey. Hence, it shows the perception of greenhouse workers and relevant public bodies towards theoretical and practical concerns in greenhouse cultivation. Greenhouse owners and workers are identified as the main subjects for this analysis. The reason is, they can reflect practical concerns and personal experiences in applying new methods and technologies in controlled environments. Comments from government bodies, on the other hand, are involved to this thesis to see overlaps and mismatching points between design and implementation of agricultural and technology policies.

This chapter details main problems and strengths identified from comparative analysis, from interviews and from questionnaires. After a short summary of key findings, a performance measurement of Turkish greenhouse cultivation is presented. Alongside, policy instruments are detailed against identified issues.

4.1 Knowledge Development and Diffusion (F1)

Knowledge development and diffusion represent initial step in technology diffusion as these functions address how well the system develops scientific and technological knowledge and its diffusion tools. Apart from available scientific knowledge, provided by academic institutions, this section looks into sources of agricultural knowledge. Simply put, what type of knowledge greenhouse workers or relevant stakeholders use? Also, what are the knowledge sharing channels for them?

SPA involves a variety of research areas; however, social sciences are not contributing to this subject as engineering and computer sciences. For that reason, this function is not solely focusing on number of academic studies or research works. To have a generic picture, government expenditures for agricultural vocational schools, agricultural programs in higher education, trainings and agricultural services are detailed in Figure 7-a and Figure 7-b.

Japan

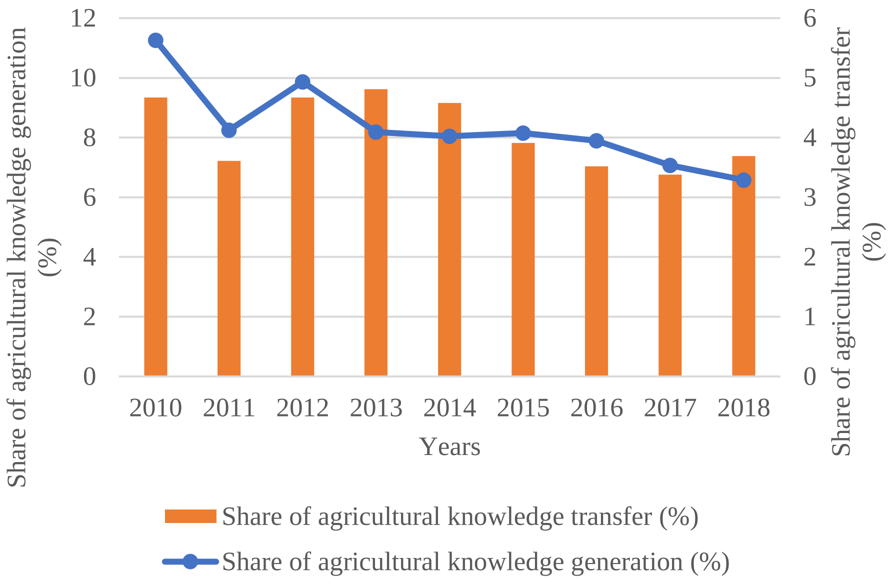
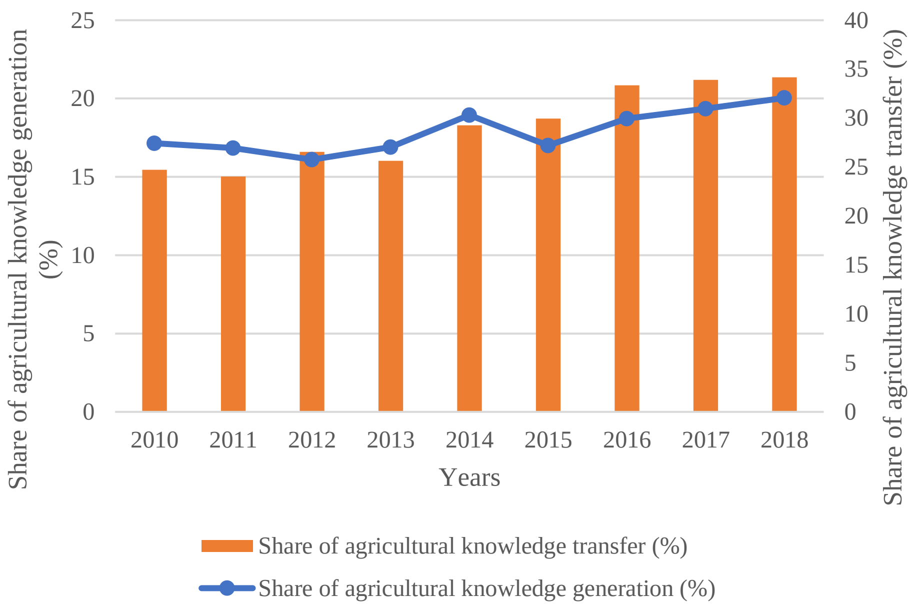


Figure 7-a: Agricultural Knowledge Creation and Transfer Rates of Turkey

Source: OECD, Agriculture and Food Data.

EU



Turkey

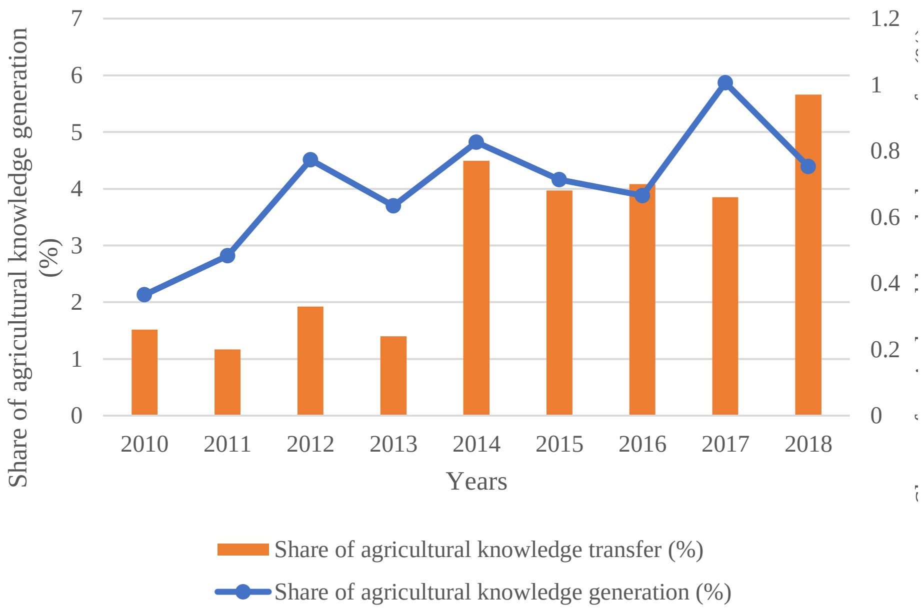


Figure 7-b: Agricultural Knowledge Creation and Transfer Rates of EU and Japan

Source: OECD, Agriculture and Food Data.

As per above figure, both agricultural knowledge generation and transfer percentage are higher in EU countries. Even though the individual data for the Netherlands is not available, this observation indicates the importance of knowledge diffusion among EU member countries. Such enabling environment creates an important advantage for the Netherlands.

In Turkey and Japan, on the other hand, agricultural knowledge generation fluctuates at a higher level than diffusion. Meaning that, knowledge generation in agricultural sector is not breeding other institutions or stakeholders in the market.

To strengthen observations under F1; university concentration to agricultural studies, R&D collaboration, researchers in agricultural studies, and patents relating to agricultural technologies are taken into consideration as sub-functions.

4.1.1 University Concentration to Agricultural Studies

University concentration considers availability of agricultural faculties in top ranked universities. To have a comparative picture, top 1000 ranked universities (as of June 2020) in Japan, the Netherlands and Turkey are identified and those with faculty of agriculture are listed in Appendix 1.

In Japan, 40% of identified universities have Faculty of Agriculture. Thus, Tokyo University of Agriculture and Technology specifically focuses on agricultural technologies. Departments involve different fields in agriculture and engineering in favor of technological improvement and its application to agricultural practices. Different from Japan, there is only one top ranked university in the Netherlands and Turkey, in which there is a Faculty of Agriculture.

In the Netherlands, Wageningen University & Research is the most prestigious university for agricultural studies. It has been taken over by the state in 1876 and considered as a start of National Agricultural Education. Today, Wageningen University & Research is a unique and important education institution for agricultural studies in Europe because of involving many research institutes so that scientific breakthroughs are put into practice and incorporated into education.

In Turkey, Ankara University was established in 1933, with a Higher Agricultural Institute. Today, its Faculty of Agriculture is providing a curriculum for horticulture, agricultural machinery, agricultural biotechnology, and precision farming. The curriculum includes a variety of agricultural fields; however, Ankara University is not an agricultural focused institution as Tokyo University of Agriculture and Technology or Wageningen University & Research.

4.1.2 R&D Collaboration

University-industry collaboration contributes the level of knowledge diffusion. In parallel to observation made by Figure 4, highest university-industry collaboration on Research and Development is recorded in the Netherlands (Figure 8).

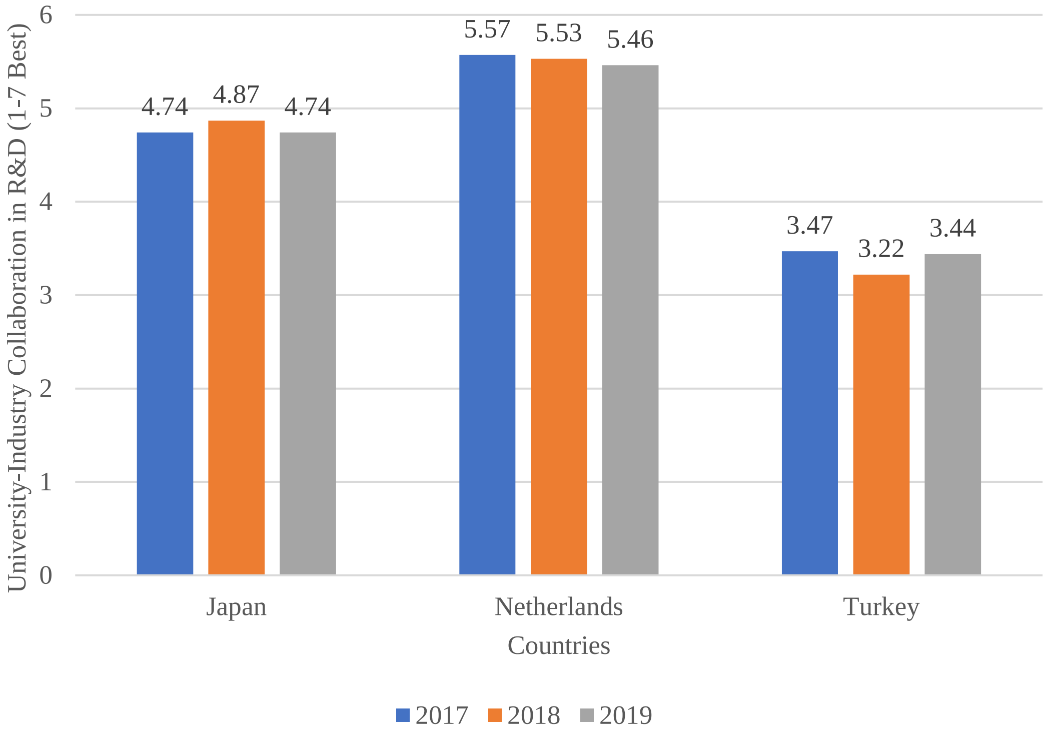


Figure 8: University-Industry Collaboration Rates for R&D

Source: Global Competitiveness Report. 2020. The World Economic Forum.

Similar to R&D collaboration activities, latest cluster development rates are recorded at highest for the Netherlands (5.22/7). Japan (5.06/7) and Turkey (3.85/7) lay a little behind of the Netherlands (Appendix 2). Bearing all in mind, the Netherlands shows once again the most enabling environment for agricultural knowledge diffusion. Turkey, on the other hand, has the weakest in university-industry collaboration rate compared to high income countries median (Schwab & Zahidi, 2020). One of the reasons of weak university-industry collaboration is the limited budget for agricultural R&D in government. To exemplify, the amount of grant supported projects in agricultural fields covered 0.06% of total in 2019[7], which is the third lowest priority area. While private sector actors expect government to support farmers and producers, financial resources on agricultural R&D remain limited.

Coupled with the R&D collaboration rates, Turkish agricultural strategies are found more knowledge-creation oriented than knowledge-diffusion. Reorganization of Ministry of Food, Agriculture, and Livestock supports this argument via plans and strategies applied as of 2011 (*Strategic Plan 2013-2017*). Those strategies mainly involved recruitment of agricultural researchers, establishment of R&D centers and training centers. While agricultural knowledge creation rates seem to be influenced by them, agricultural R&D collaboration and knowledge diffusion remains behind of Japan and the Netherlands.

4.1.3 Researchers in Agricultural Studies

Full-time agricultural researchers are mainly recruited by government institutions (Appendix 3), especially in Turkey and Japan. That is to say, concentration of Japanese national strategies for agricultural development make sense with high number of researchers in public bodies. Since agricultural initiatives are mainly on state's hand, agricultural researchers might be allocated to serve policy related works as well.

In Turkey, on the other hand, overall agriculture market is highly dependent to business enterprises and small farm investments in their own capacity. Therefore, high number of agricultural researchers and low rate of government R&D expenditures on agricultural objectives should alert to misusage in human resources.

4.1.4 Patents Relating to Agricultural Technologies

Patent is a strong indicator to observe improvement of agricultural technologies as patenting shows the level of machinery and technology usage for agricultural development. Technology patents relating to Agriculture, Livestock or

[7] https://www.tubitak.gov.tr/sites/default/files/18842/tubitak_2019_yili_faaliyet_raporu.pdf

Agroalimentary Industries, over the total population are recorded highest for Japan (Appendix 4). Hence, patent claims for greenhouse technologies are considerably higher compared to the Netherlands and Turkey (Figure 9).

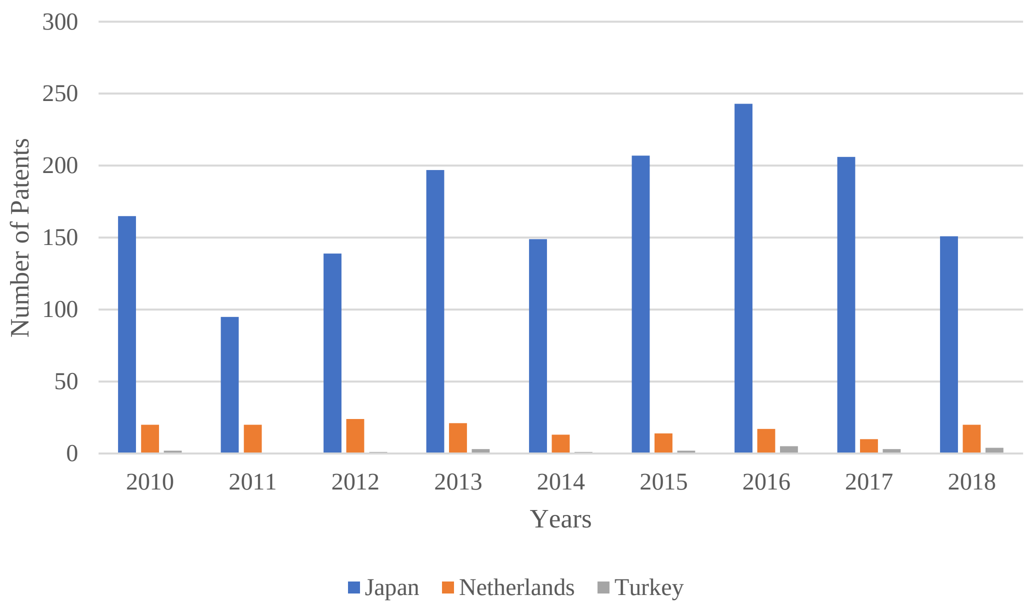


Figure 9: Patents for Greenhouse Technology

Source: OECD Stat, Environment Database Technology Diffusion. Patents – Technology Diffusion.

While agricultural knowledge creation and diffusion rates (Figure 4) show persuasive arguments for the Netherlands' enabling environment, Japan seems to have greatest focus on greenhouse technology development. Greenhouse technology patents in Japan were approximately eight times higher than the Netherlands and 38 times higher than Turkey in 2018. The fact that Japan has the highest population rate among three countries, highest patenting rate might be justified. Nevertheless, Turkey remains low in greenhouse technology patents even though total population and government researcher rates are higher than the Netherlands.

4.1.5 Additional Evidence through Surveys and Questionnaires

Greenhouse workers have four grand sources of knowledge. These are (i) family-business related knowledge, (ii) knowledge obtained from experience in other firms, (iii) associations sharing new development and technology and (iv) knowledge acquired from advisory services (Appendix 5). While there are different sources of knowledge, neither of cases linked knowledge to academia.

Interviewed agricultural engineers criticize university courses being theory-focused, rather than practical. Theoretical knowledge, acquired from universities, are said to be forgotten on field due to lack of practical learning:

> *We were thinking about having a diploma, that's all. In fact, if your family has a greenhouse, going to university is like a vacation, because when you work in agricultural sector you need to practice what you learn. You get experience through practicing, and that's only possible in the field. If you don't go to the field, there is no usage of theoretical knowledge.* (Interview No 2)

Hence, overall quality of education and sufficiency level are recorded as lowering, especially compared to past decades. As results, students started to enroll different departments, either to pursue non-agricultural career or to approach agricultural business from other aspects (e.g., genetics). In general, Figure 10 summarizes perception of interviewees towards knowledge development and diffusion, emphasizing academic and scientific knowledge.

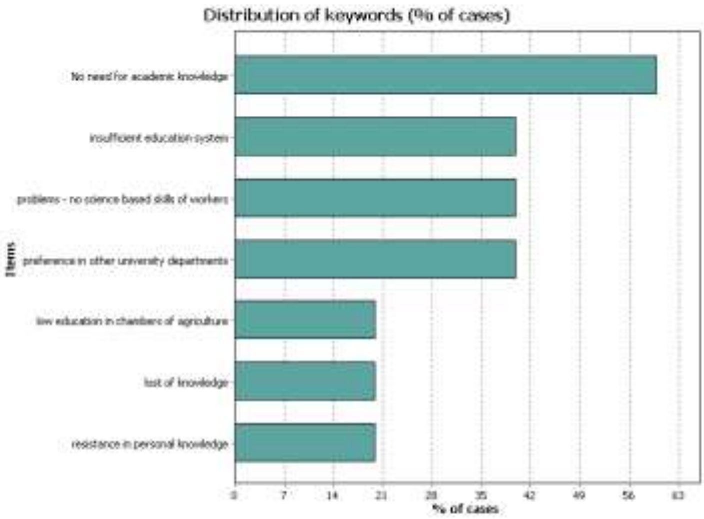


Figure 10: Problems in knowledge development and diffusion

‘No need for academic knowledge’ is recorded at highest by number. This is an expected result considering the students enrolled in agricultural faculties usually have a family-owned business where they have an advantage to learn on field. Yet, the perception of no-need is reflected aside with insufficiency of academia on practical experience. While knowledge development and diffusion are considered among core concepts, sources of knowledge seem to be limited with personal network (e.g., family business) or individual effort to interlink existing knowledge sources.

Greenhouse workers also emphasized civil servants, who are assigned to mission after graduation, having insufficient practical knowledge. To understand the state of knowledge and awareness, representatives from Chambers of Agriculture asked to define “smart agriculture” and “precision agriculture”. 63% of respondents said that there is no official definition/description for smart agriculture in their institution. Rather, “Good agriculture” is the term popularized for smart agriculture. Furthermore, 3/4th of the respondents was unaware of precision agriculture practices. Those who approved that they know precision agriculture, are asked to give examples. Answers were mainly involved “soil analysis, “good agriculture” and “organic agriculture”. Yet, there were also some indirect examples as “social media usage”.

Respondents declared that their institution has a moderate level of R&D activities (by 2.3 over 5 on average). Relatedly, 72% of respondents said they are not involved to any R&D work in their institution. One of the public servant respondent proposed following on this issue:

> *In order to adopt smart agriculture practices, it is necessary to have a certain education and knowledge level (on the government side). This is also the case for producers and farmers. Since it is not possible to move forward to a new application suddenly, it is more appropriate to apply new methods gradually. For example, awareness of agricultural activities can be increased by starting from agricultural engineers and technicians who have received necessary training and from enterprises with large corporate working opportunities.* (Interview No 5)

Combining all, there is a gap for the conceptual framework for government representatives on how exactly precision agriculture and smart agriculture practices applies. Relatedly, agricultural education in Turkey is found inefficient and outdated. University curriculums and academic concentration indicate the same. Even though government takes promotive attempts to pursue higher education, public servants are also aware of insufficient educational infrastructure. 59% of respondents were holding bachelor’s degree while 13% has only two-year degree.

As a consequence, “learning from doing” is perceived more valuable by all parties. In some extreme cases, this learning path might lead to resistance to scientific knowledge. One of the cases exemplifies this resistance with:

> *Mrs Ayşe has expertise on fertilizer, and once some man asked advisory support regarding fertilizer. She advised to put 2 kilograms and he replied as ‘I cannot sleep at night if I don’t put 30 kilograms each night’. Then he left, and he probably used 30 kilograms that night.* (Interview No 5)

While field knowledge carries substantial importance, it also eliminates the technological value added. This might result as a lock-in to traditional methods. In that sense, value of personal knowledge and resistance to scientific information prohibits technology adoption or scientific reasoning. Yet, in an environment with insufficient academic quality, it is inevitable for agricultural workers to abandon or improve traditional production methods.

Under F1, there are two main issues to discuss. First, knowledge diffusion is not at the same level as knowledge generation in agricultural fields. While there might be different reasonings for this observation, it alerts a misusage of existing academic and technology resources. Second, university curriculums are not updated with current field practices. For that reason, existing greenhouse owners do not prioritize academic learning or scientific advices. Such outdatedness creates a dependency on personal and tacit knowledge to pursue agricultural operations.

Next chapter proceeds with F2: Entrepreneurial Activities.

4.2 Entrepreneurial Activities (F2)

Innovation system approach prioritizes entrepreneurial activities to establish an experimenting ecosystem and to reduce uncertainties (Bergek, et al., 2008; Hekkert et al., 2007). Entrepreneurship could have different scope and context to eliminate existing uncertainties. For that reason, selection of entrepreneurial activities is required for analysis. Based on the findings of F1 and available data, entrepreneurial activities are filtered by existing business behaviors and enabling factors.

Agricultural entrepreneurship is a niche concept. It is influenced by different sectors, academic disciplines and overall entrepreneurial behaviors in the market. To fully grasp dynamics behind this concept, entrepreneurial ecosystem is elaborated as a generic concept. Agriculture-specific factors are specified afterwards.

Entrepreneurship ecosystem became part and focus of numerous studies and reports; therefore, relevant entrepreneurial indicators are filtered for three countries as in Appendix 6. A generic evaluation indicates the Netherlands to have more entrepreneurship-friendly characteristics. All entrepreneurship indicators together reflect an improvement for the Netherlands, diminishing trend for Turkey and fluctuating dynamic for Japan. On an indicator-based level, reasons and perceptions behind entrepreneurial activities are observed. The reason for that is that the perceptions and motivations are among the primary entrepreneurship-boosting factors in business and academia.

First, dramatic decreases are worth observing especially for Turkey's opportunity perception rate and risk acceptance rate. Opportunity perception rate of Turkey, showing the level of understanding of entrepreneurs for the favorable circumstances to take action, diminished from 0,6 point to 0,3 as of 2019. In parallel, opportunity start-up rates rate is fluctuating at the lowest for Turkey. Having said that, Turkish entrepreneurship environment seems challenging for individuals to enter and survive. Yet, entrepreneurial intention rates are highest in Turkey[8].

Second, Japan shows considerably lower results in start-up skills; even though, technology absorption rates are at highest. This indicates that technology absorption and technology diffusion are important factors to stimulate entrepreneurial activities, but not enough. High fear of failure rate and low early-state entrepreneurial activities for Japan also justifies such argument[9]. Nevertheless, based on entrepreneurial aspiration rates, Japan has more or less the same enthusiastic human capacity to pursue entrepreneurship as Turkey.

At this point, it is important to see reasons behind entrepreneurial aspirations. Motivational index and societal value indicators are crucial to understand the driving force for entrepreneurship, either motivation by improvement or economic necessity (Appendix 7). In Turkey and also in Japan, entrepreneurship is depending on financial

[8] https://www.gemconsortium.org/economy-profiles/turkey-2

[9] https://www.gemconsortium.org/economy-profiles/japan-2

or well-being necessities for individuals. Dutch entrepreneurs, on the other hand, are mainly motivated by self-improvement through starting a business. High entrepreneurial aspiration rate also influences the perception of entrepreneurship as a good career for the Netherlands[10].

While entrepreneurial characteristics provide an ecosystem-based understanding, agricultural entrepreneurship has different dynamics. These include marketing, farm size, product variety, reaching new customers and customer segments (Yoshida et al., 2019). They are not entirely measurable by quantitative indicators though; available data provides rather qualitative and case-by-case understanding. Different from the majority of the structure of functional analysis, this function is elaborated based on country-based historical background, rather than sub-functional categories in the next sections.

4.2.1 Entrepreneurship Ecosystem in Japan

Japanese government initiated numerous policies to boost entrepreneurship since 1990s. These policies were mainly addressing SMEs, science and technology relevant fields, angel investors, technology transfer offices, universities, industrial technologies, entrepreneurial trainings, and newly established businesses (Shinato et al., 2013). To exemplify, removal of minimum capital regulation, provision of training and education for entrepreneurs, enabling start-up loans without collateral, guarantors, personal guarantees, expansion of the upper limit of free property, based on the New Bankruptcy Law (Yasuda, 2009, p. 4) and announcing the act on technology transfer promotion from universities to private sector are among them(Kim, 2016).

Additionally, in order to attract foreign entrepreneurs, business eases are actualized by Japanese government. Easing the visa obtainment, out-of-charge advisory services for administrative documents and bureaucratic issues and tax incentives could be given as example (*Tokyo Government Eases Regulations to Attract Foreign Entrepreneurs*, 2016).

All initiatives seemed as success factors, yet few considerable results are recorded after the measures taken. Pioneering electronic companies, risk averting

[10] https://www.gemconsortium.org/economy-profiles/netherlands

culture (Hu, 2015), and preference of stability in work life (Choudhury, 2018) could be counted as reasons for that. The concept of success is a baseline in almost every social and commercial area in Japan, which leads society to follow defined life paths and creates a fear of failure.

As a result, government focus has been shifted to education system and youth employment to prevent the perception towards entrepreneurship as a risky and last option plan. Ministry of Economy, Trade and Industry introduced the Hiranuma Plan to establish university-oriented ventures for IT, environment, biotechnology and nanotechnology (Kim, 2016). Main objective was to cope with the societal concerns on changing the concept of defined roles and risk aversion.

As of 2001, with the boost of R&D commercialization as part of university-private sector collaboration, start-up ventures increased consistently until 2008. By 2008, government decreased the financial support for university ventures, resulting not only the decrease in ventures but also bankruptcies (Kim, 2016). This led government bodies to adopt additional policies for students, scientists, and workers. Open Network Lab (Onlab) is; therefore, established to provide mentorship, physical office spaces, and financial investment for start-ups. Today, students in Japan are said to have more positive approach to conduct their own business rather than involving in a salary-based works (Kushida, 2018).

4.2.2 Agricultural Entrepreneurship in Japan

Aging demographics, labor migration, low profit, decreased self-sufficiency rates and industrialization are among factors pushing young entrepreneurs away from agricultural sector (Haga, 2018; *Japan' s Food Self-Sufficiency Rate Hits Lowest Level in 25 Years Due to Drop in Wheat Production*, 2019; Saito, 2019; Yoshida et al., 2019). For that reason, Japanese small farmers generally experience transgenerational entrepreneurship to reach potential customers and to promote their businesses (Yoshida et al., 2019, p. 28,66), rather than grasping new entrants.

To cope with these risk factors and threats on agricultural activities, Japanese government initiated an industry-university collaboration structure, namely Field for Knowledge Integration and Innovation. Objective was to increase agricultural business competitiveness as part of industrialization and commercialization goals (Goto, 2019). As a complementary part of this initiative, researchers are also promoted to conduct entrepreneurial activities in existing farms (Haga, 2018; Kiminami, 2019).

Entrepreneurial activities of farmers, whether they newly started their businesses or taken over the business from their families, seem to be focusing on collection, marketing, transport, food processing and online sales (Kawasaki, 2019).

Thus, human resource and management skills of farmers also found to lead to entrepreneurial activities through breaking the limits of family business characteristics, improving business culture, and conducting further collaborative activities. Nevertheless, there are certain critics on agricultural entrepreneurship. These are lack of leadership characteristics, involvement of several stakeholders in same land, fear of facing different challenges, individualistic profile of farmers, and lack of local government contribution (Haga, 2018).

4.2.3 Entrepreneurship Ecosystem in the Netherlands

Dutch government promotes entrepreneurship in several aspects. These include the support for the financial scope, contribution to the university-private sector collaboration, reduction of regulatory challenges, facilitation of networking, reforms in education, and cooperation with retail and franchise sectors (*Supporting Ambitious Entrepreneurs and Startups | Enterprise and Innovation*).

With this in mind, main approach towards entrepreneurship is to provide access to capital, knowledge, innovation, and global market. In parallel to digitalization policy, government support for entrepreneurship consists of many stakeholders and their effective operation for further growth. Accordingly, Dutch government announced the Ambitious Entrepreneurship Action Plan (*Supporting Ambitious Entrepreneurs and Startups | Enterprise and Innovation*). As part of the action plan, early-stage finance opportunities at the idea stage are invested, foreign start-ups and new businesses are promoted, platforms to facilitate networking are developed and multi-country partnerships are funded.

Hence, with an objective to increase efficiency, business procedures eased in the Netherlands since 2010. This lead to save time in starting up a business for 50%

(*The Global Information Technology Report 2016*, 2016). Since 2013, business reforms are announced as abolishing minimum capital requirements, eliminating the non-objection declaration requirement before incorporation, introducing a new law for approval of related-party transactions, and announcing a new web-based platform for cargo releases for trade related operations (*Economy Profile of Netherlands Doing Business 2020*, 2020).

4.2.4 Agricultural Entrepreneurship in the Netherlands

Agricultural sectors, especially greenhouse cultivation has a mature market in the Netherlands. Relatedly, farmer-entrepreneurs have complex operation environment and have different motivations (Kahan, 2013). To give an illustration, business owners are pushed to be more market-oriented, better in farm-management for economy of scale and act with entrepreneurial skills to increase the profit (Kahan, 2013) . Stimulation of sustainable agriculture, in parallel with requirements of such competitive environment, remains to be part of national objectives since 1950s. As a result, Dutch agriculture came into a transition path through economies of scale, food security, nature conservation and intensification (McElwee, 2005; Seuneke et al., 2013).

Industrialization trend in agriculture brought economic concerns and pressure to farmers. It also led farmers to start entrepreneurial activities out of their farms and to integrate science into daily operations. According to a survey made by Lauwere (2005), agricultural entrepreneurs in the Netherlands could be divided into five categories based on their characteristics: prudent, social, traditional, new entrant, indecisive farmers. Through different motivations, farmers focus on non-farming activities as care-farming, agro-tourism and farm shops to go one step further from where they stand (Seuneke et al., 2013).

Alongside producer (farmer) and customer (end user) relationship started to gain more importance in agricultural businesses, Dutch government started to see farmers as service providers (McElwee, 2005). Accordingly, EU CAP also shifted its policy instruments to market orientation, rather than price support for farmers. With the increasing awareness of agricultural entrepreneurship and government support for sustainability in agriculture, farmers started to take greater responsibilities (Rudmann, 2008). To promote farmers during such transition, several programs and initiatives are announced by different actors. ‘Food Valley’ in Gelderland, for example, is created by Wageningen University & Research, gathering private companies and government agencies in the same location to accumulate knowledge, promote collaboration and support venture companies (Goto, 2019).

Within such collaborative environment, agricultural entrepreneurship went one step further and broke barriers of traditional agriculture practices. Social entrepreneurs and new entrants in agricultural sector are found as better matches in the concept of entrepreneurship to respond market demands, understand trends, seek new ways of doing things and find opportunities (Lauwere, 2005). Even though personal characteristics of entrepreneurs have high impact in entrepreneurial activities, associations started to gather different actors to promote collaborative work and to act as a bridge between entrepreneurs and opportunities. The Netherlands Agricultural and Horticultural Association is the first-found roof for agricultural entrepreneurs and employees from different fields as arable farming, dairy farming, flower bulb cultivation, greenhouse horticulture, tree cultivation and pig farming (*LTO Netherlands*).

Agricultural entrepreneurship in the Netherlands involves collaborative actions, knowledge sharing and freedom to take risks, especially when an opportunity arises. To support such ecosystem, the Netherlands has clear and detailed regulations for agricultural entrepreneurship. For example, as of 2020, the Netherlands launched an addendum for agricultural entrepreneurs to acquire necessary funds (*Law Changes 2020: Entrepreneurship*, 2019).

Combining the enabling environment with public awareness and prioritization on agricultural development, agricultural entrepreneurship in the Netherlands is in process of improving even further.

4.2.5 Entrepreneurship Ecosystem in Turkey

Turkish government set a variety of policies and agendas to support young entrepreneurs and newly established businesses (KOSGEB, 2015; Özeke, 2018).

These policies generally aimed to establish an entrepreneurial ecosystem to promote innovative entrepreneurship, entrepreneurial culture, support systems and capacity building activities (KOSGEB, 2015). To be more specific, rewards for successful entrepreneurs, portfolio guarantee systems, companies to be defined as start-up if incorporated by an owner under the age of 29, tax exemption opportunities, signature alternatives for Articles of Association before the trade registry offices to save money and enlarged intellectual property rights were among actions taken. Thus, patent rights are also regulated in favor of universities to retain ownership over employee for scientific research (Özeke, 2018).

In accordance with the vision 2023, Small and Medium Enterprises Development Organization (KOSGEB) remains one of the key actors to increase competencies of small businesses and start-ups. KOSGEB defines entrepreneurial ecosystem through six interventions: developing entrepreneur friendly regulatory framework, supporting innovative entrepreneurship, developing and applying a sustainable support system for prioritized thematic areas, developing a culture for entrepreneurship, generalizing entrepreneurship trainings and facilitating access to finance (KOSGEB, 2015). Combining all, Turkey approaches to entrepreneurial ecosystem from business-related initiatives and supportive measures (financial, skill development, administrative) for entrepreneurs.

4.2.6 Agricultural Entrepreneurship in Turkey

While entrepreneurial measures apply to a variety of sectors, agricultural entrepreneurship is not specifically part of any policy. Rather, agricultural entrepreneurship remained a choice to make profit out of family-owned businesses (Gökçe, 2010).

Studies for agricultural entrepreneurship in Turkey describe this concept through several characteristics: education level, family characteristics and socio-economic differences between rural-urban communities. A brief summary of Turkey's case in agricultural entrepreneurship is given in Table 11.

Table 11: Characteristics of Agricultural Entrepreneurship for Youth in Turkey

Impact of Family-Owned Businesses	Many of students in Faculties of Agriculture have first degree relatives who own their own business. With such role models, students are enthusiastic to attend agricultural entrepreneurship trainings.
Agricultural Investment to Apply Innovative Solutions	Perception of youth for investing in agriculture is to apply agricultural innovations, more than increasing the labor force or earning money.
Managerial Skills Show Top Priority to Run Individually Own Businesses	In order to be successful in individually own businesses, managerial skills and good ethic are found the top priorities for youth. Thus, technical knowledge, capital and trust are also found considerably important.
No Gender Difference	Women in agricultural sector are found as many enthusiastic as men to be part of entrepreneurial activities.

Source: (Can & Engindeniz, 2017)

First, education level in rural areas is not high as urban cities, which directly impacts entrepreneurial activities of farmers (Ağızhan & Bayramoğlu, 2018; Karakayacı & Bayramoglu, 2013). Even though education and technical skills are among main requirements within the nature of entrepreneurship, there are few studies on the effects of agricultural entrepreneurship and education. Farmers, who usually take over their family businesses, are learning-by-doing, rather than applying theoretical studies taught in universities (Can & Engindeniz, 2017).

Second, family characteristics also has an important impact on entrepreneurial activities, especially in allocation of resources. Farms owned by families or more than one stakeholder might challenge owners to keep records on used and saved (Ağızhan & Bayramoğlu, 2018), which also influence level of investment and saving as business. Numerous titles of an individual farmer (entrepreneur, owner and worker at the same time) or several individuals having the same title hamper the decisions making process for entrepreneurship.

Third, demographic factors impact agricultural entrepreneurship in a negative way due to migration of youth to urban cities. Children of land owners, seem to prefer to take part in non-agricultural businesses (Ağızhan & Bayramoğlu, 2018). Aging demography of farmers, therefore, pushes businesses to outsource human resources, especially during harvesting.

While agricultural entrepreneurship remains at farm-based operations, policies targeting agricultural improvement are also limited (*Performance Programme for 2018*, 2018). As result of this non-prioritization, enabling factors of agricultural businesses and agricultural entrepreneurship stay at lowest for Turkey (Appendix 8).

4.2.7 Additional Evidence through Surveys and Questionnaires

Interviewed cases indicated that entrepreneurial activities should be separated based on greenhouse size. R&D activities, therefore, elaborated separately for different sizes of greenhouses.

Large sized operations seem to have their own R&D departments to provide scientific and technological reasoning for production. Businesses having several greenhouses in other countries, seem to share in-house R&D across nations to reach the highest productivity level. Main need of those greenhouses is to transfer to full automated operations using robotic solutions. Thus, rate of younger employees is also highlighted. While number of young and educated employees seems sufficient for daily operations, a need for integrating different disciplines is found. For example, to adopt robotics in greenhouse operations, employers or greenhouse owners do not require agricultural engineers or molecular biologists in addition to enrolled ones. Rather, there is a lack of interdisciplinary workers to support businesses in this transaction.

Middle-sized greenhouses seem to take large and modern greenhouses as role models. While there are ongoing R&D activities in those greenhouses, main objective is to optimize input costs for higher productivity. Due to high investment costs, financial barriers became more significant factor in adoption of advanced technologies. One of the interviewees explained the grant they applied and earned regarding adoption of more advanced operations in greenhouses:

> *There is a method named hydroponic farming, meaning that agriculture without soil. You may think simply pipes transferring water, vitamin, and fertilizer to plants. This method can be applied to strawberries. Since you don't use any soil, system has a high cost in this production method, but you will get high quality products. We have applied to a TUBITAK grant transforming this method to our own agricultural practices. Usually this method is applied horizontally, but we designed it vertically to increase the productivity rate from the available land.*

> *We designed automation system as well. The grant was approved, but we couldn't convince any farmer to use this technique because it was simply too costly. You may explain how much they will profit but when you say how much it costs, nobody agrees to change their business.* (Interview Number 3)

Even though engineering and technology infrastructure is sufficient to design and develop similar solutions, producers main concern is always the costs. In small-sized greenhouses, such as glass greenhouses, financial constraints are getting even higher.

The reason is that small-sized greenhouses have higher operation costs per decare. To profit from technological investment, greenhouses should have a certain size. Small sized lands divided to shareholders for agricultural work are not always feasible.

Bearing in mind different greenhouse sizes brings separate needs to address, there is a considerable difference between the number of small and large size greenhouses. Number of producers in "good agriculture" increased by 95 times since 2007[11]. Agricultural lands, within the same time period, also increased 101 times. Parallel increase in producer and lands indicate that there are new producers in the market rather than expanded businesses.

While there is no official data of existing greenhouse sizes in Turkey, number of modern greenhouses are limited (Almost 2% of decares in total land under protective cover as of 2018[12]). To understand the state of production methods of middle and small sized greenhouses, representatives from Chambers of Agriculture are asked to evaluate the level of technology usage (Figure 11). To do that, technology involvement for social media sharing purposes is specifically excluded in questions.

[11] https://www.tarimorman.gov.tr/Konular/Bitkisel-Uretim/Tarla-Ve-Bahce-Bitkileri/Ortu-Alti-Yetistiricilik

[12] Ministry of Agriculture and Forestry/TUIK, Areas for land under protective cover by type, 1995-2019

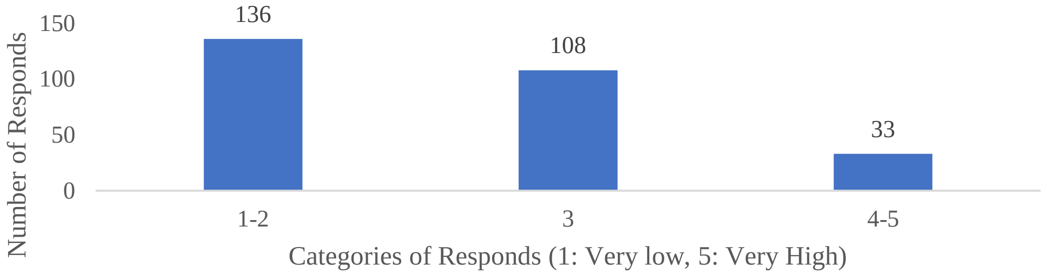


Figure 11: Technology Usage Rate in Agricultural Operations

Majority of agricultural operations, in this framework, depend on traditional methods and individual knowledge to cope with uncertainties. Innovative activities, on the other hand, said to be copied from Western countries without location-based evaluation. This issue is detailed as an observation during interviews:

> *Statistics say that 75 percent of people working in the village or doing agricultural works are above 65. Maybe they exaggerate the percentage level, but we see the demography on field. 4/5 of family farmers are almost at that age. Blocking this generation means disappearance of traditional experiences. So, they copy Western countries. For example, palm is one of the biggest mistakes' architects make. Palm trees filled all over. Why is that? Just because the European landscapers modeled planting palm trees. It's necessary to get into traditional methods and why certain things are done while others not.* (Interview Number 2)

To cope with this issue, role of government policies is observed. Ninety-five percent of respondent argued that agricultural technology usage must be prioritized by government policies. Yet, more than 50% of respondents believe that existing government policies are not effective enough to digitalize agricultural operations or to increase agricultural technology usage.

As a response, representatives are asked to prioritize functions given in comparative analysis. Majority in each category respondents (1 to 5) selected education as the most important concern to increase agricultural technology usage. Especially 75% of those believe government policies are not effective (marked as Very Low), highlighted education as up most important function in policy development.

Under F2, there is one grand issue, integrating different aspects of agricultural entrepreneurship: lack of a system to manage and promote entrepreneurial activities. Japan and the Netherlands have different characteristics and different systems to promote entrepreneurship. In Turkey, on the contrary, greenhouse cultivation is not proceeding as an entrepreneurial field. As result, potential business owners switch to other career opportunities, which creates a risk to lost tacit knowledge on the field.

Next chapter proceeds with F3: Guidance of Research.

4.3 Guidance of Research (F3)

Technological innovation systems require initiatives and promotive measures to be pursued by relevant actors. By its characteristic, this function is highly linked with interactive process between producers, consumers, middlemen, and other actors. In that sense, actor behavior, perceptions, and enabling environment are necessary to elaborate.

Market studies projects precision agriculture to grow 12.7% between 2020 and 2025 (*Precision Farming Market by Technology (Guidance, VRT, Remote Sensing), Application (Crop Scouting, Field Mapping, Variable Rate Application), Offering (Hardware—Sensors, GPS, Yield Monitors; Software; Services) and Geography - Global Forecast to 2025*, 2020). To understand the reasons behind this market growth, driving forces must be understood at first. Elements of this function, accordingly, address producers' effort to reduce costs and factors pushing them to apply innovative solutions (Viatte, 2002). Advanced tools and technologies are found as a choice for economies of scale in agriculture (Jouanjean, 2019). Therefore, facilitating environment of the agricultural growth is observed via following elements: support for producers, complementary products and services for producers, characteristics of demand, greenhouse manufacturers, and public policies and strategies on digitalization in agriculture.

4.3.1 Support for Producers

Agriculture is a sector that requires government support because of high capital requirements and sensitivity of external factors as climate and water. Agricultural producer support rates, calculated by annual monetary value of gross transfers to agriculture as percentage of gross farm receipts, are given in Figure 12.

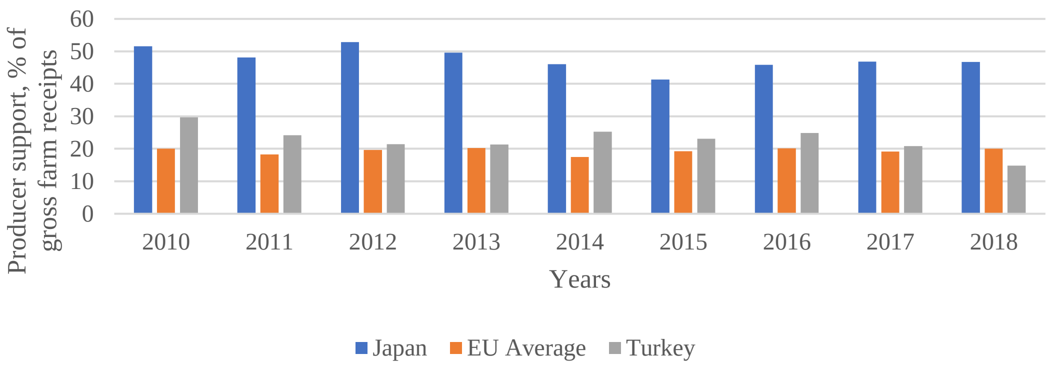


Figure 12: Agricultural Producer Support

Source: OECD, Agricultural support estimates (Edition 2019)

The highest rate of producer support in Japan should not be mis-interpreted by excluding the impact of total population and agricultural labor force. To exemplify, total support remains at 1% of GDP between 2015-2017, showing a decrease more than 50% since 1988 (OECD, 2018). As government policy, Japanese agricultural support is shaped by the market price and general service expenditures, which makes agricultural sector highly dependent on government policies and support mechanisms (for infrastructure and facilities).

In the Netherlands, agricultural support rates experience a slight diminish between 2015 and 2017, which could be a result of declining agricultural labor force and low budgetary payments (OECD, 2018). Nevertheless, overall support still remains just above OECD average, which enables farmers to collect higher effective prices than international prices. Hence, general service expenditures seem to be spent on knowledge development in the Netherlands, rather than facilities.

In Turkey, overall agricultural producer support has a fluctuating structure, comparing with overall OECD countries. To exemplify, as of 2010, sharp declines are observed in terms of producer support. Yet, records showed 25% of gross farm receipts between 2015- 2017, which was above OECD average (OECD, 2018).

Even within decreasing path, 85% of producer support is allocated to individual farmers to promote their survival in the local and international market. In addition to overall agricultural support, greenhouses (and glasshouses) also receive different funds, subsidies, credits, and other public investment opportunities. These support mechanisms apply to modernizations, management support and energy efficiency objectives in all three countries (*Netherlands Doubles 2020 Green Subsidies in Rush to Hit Climate Goals*, 2020; *TR63 Bölgesi Seracılık (Örtüaltı Bitki Yetiştiriciliği) Sektör Raporu*, 2015; Richter, 2019; Sijmonsma, 2016).

4.3.2 Complementary Products and Services for Producers

Complementary products and services have a promotion-factor for new technologies to potential users. Greenhouse cultivation technologies, therefore, requires different machineries and services to be available. This thesis looks into farm machineries and agricultural insurances only, in order to provide a comparable framework.

Total units of farm machineries and machinery capital are found at highest in Japan and lowest in the Netherlands[13], whereas machinery capital per worker is at lowest for Turkey (Appendix 9). Available machinery resources are covering only around 20% of total agricultural workers in Turkey. This observation indicates a need for stronger diffusion and promotion mechanisms. On the contrary, for the Netherlands both machinery capital and number of agricultural employees are at lowest but more than 70% of agricultural employees (on average) are using farm machinery. This is one of the examples in which resources are better distributed.

In case for complementary services, Japanese government has a leading role in reinsurance, regulation, and design of agricultural system. Hence, all available insurance schemes are specified by law, especially by Disaster Countermeasure Basic Act of 1951 (FAO, 2011). As result, farmers are able to get low interest loans, exemptions, and tax reductions in case a natural disaster negatively impacts their business . Greenhouse producers are also able to apply for Voluntary Subscription System Insurance to benefit from similar services specific to greenhouse operations (FAO, 2011).

In the Netherlands, contrarily, private companies are active as government to provide greenhouse insurances. N.V. Hagelunie, for example, is one of the largest insurance company, which provides its services against agricultural risks with a

[13] U.S. Department of Agriculture – International Agricultural Production. Machinery - Farm Machinery Capital (number of units)

specialty in greenhouse horticulture (*Hagelunie : Your Partner in Risk Management How Well Do You Know Your Greenhouse Insurancy Policy ? Hagelunie :*, 2014). Greenhouse insurance sector is covering technological risks as much as natural risks, specifically addressing high-tech cultivation equipment installation (Boersma & Nl, 2005).

Turkey, different from all, uses an insurance pool system called TARSIM, to which agricultural insurance agencies are registered. TARSIM conducts the risk assessment and acts as a bridge between greenhouses and insurance companies, covering building materials, equipment, crops, and losses arising from a natural disaster (*TARSIM*). In addition to TARSIM, banks – as Denizbank – also provides greenhouse insurances in accordance with article 12 of Agriculture Insurances Law number 5363.

4.3.3 Characteristics of Demand

Food expenditures provide a simple but important insight on the consumer expenditure behaviors. Consumer demand on agricultural products is, therefore, observed by these expenditures (Figure 13).

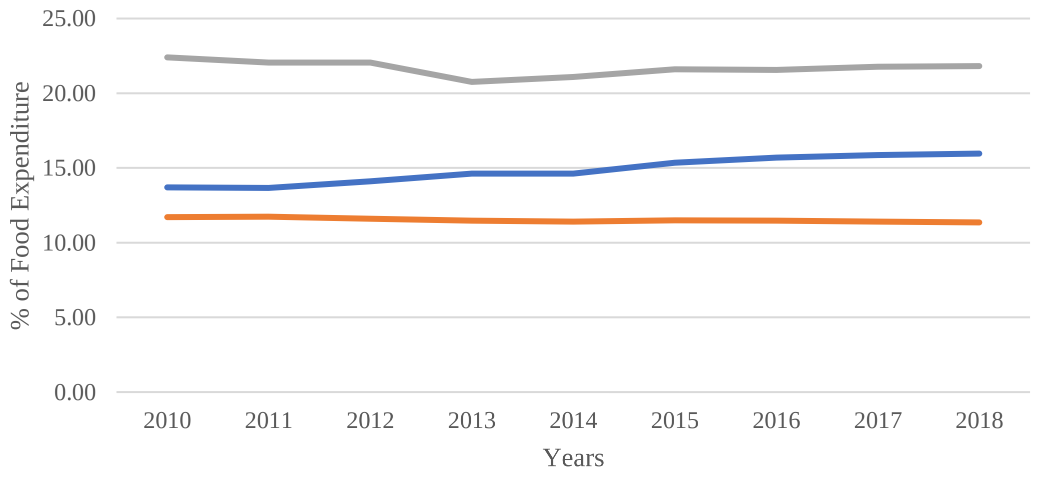


Figure 13: Consumer Expenditure on Food over Total Consumer Expenditures

Source: Euromonitor International. Expenditures Spent on Food by Selected Countries. May 2019

Share of food expenditures indicates how much each country spends on food under their total consumption rate. While food expenditures have the highest rate for Turkey, it must be kept in mind that food expenditures are at lowest in terms of US dollars (Appendix 10). In simple words, even though Turkey has the lowest GDP per capita among these three countries, it still has the highest food consumption rate because of low food prices. In terms of national demand, Japan seems to spend more on food compared to all three.

4.3.4 Greenhouse Manufacturers and Construction

Modern greenhouses are built either from scratch or on top of the existing infrastructure. Either way, farmer skills and availability of necessary engineering should be somehow available in the first place.

For Japan, greenhouse manufactures seem to outsource necessary infrastructure[14] (*Greenhouse Manufacturers Companies and Suppliers Servingin Japan*), even though there is a strong mechanical and engineering infrastructure. In that market structure, Japanese greenhouse manufacturers are benefiting mainly from Dutch greenhouse technologies (Innoplex, 2015; *Marktscan Moderne Glastuinbouw Japan*, 2018; Sijmonsma, 2016). Yet, the integration of engineering solutions to local concerns is highly prioritized, so that external risks (as earthquake risks) are mitigated (Sijmonsma, 2014). Hence, Japanese government is sponsored a research program in collaboration with Wageningen University & Research (located in the Netherlands) in order to provide solutions for location-based challenges when producers are introduced to a new greenhouse technology (Kruger, 2017b).

In case for the Netherlands, private institutions' contributions are worth mentioning to boost national competitiveness in greenhouse production. Boot & Dart Nurseries, as an example, combined their experience of cultivation for more than a century on one side and experience in landscape project management for over 65 years on the other side (*Boot & Dart*). BVB Substrates, as another example, provides opportunities for growers to take masterclasses in Hogere Agrarische School and

[14] From UAE, Jordan, USA, China, India, Spain, Italy, Israel, the Netherlands, Canada, UK, France and Turkey

Wageningen University & Research or to take short training courses (equivalent to college education) tailored for customer needs to make growers better assessment and increase the rate of return from their production (*Kekkilä-BVB Research - BVB Substrates*). Similar to Japan, the Netherlands also integrates up-to-date solutions and scientific & professional experience to address local requirements in greenhouse construction. Nevertheless, both product and service delivery seem to be arranged through national sources, as oppose to Japan.

In that manner, Dutch greenhouse sector seem to be interested to both product sales and knowledge diffusion on how to integrate new technologies and solutions to traditional production. Bearing all in mind, one of the main characteristics for Dutch greenhouse manufacturers is the availability of training, coaching, mentorship, and education programs provided by private firms. The reason is to emphasize that there are different disciplines and staff responsibility levels which requires specialized skills and knowledge. Even though this argument cannot be applied to all cases, 40% of most recognized Dutch greenhouse construction and manufacturing firms are providing crop care assistance, necessary training for growers or simply knowledge sharing tools, and sources benefiting from scientific studies[15].

Turkish greenhouse industry has shifted to modern production techniques after 1975 (Yilmaz et al., 2005). Engineering and manufacturing firms also expanded accordingly. Until the 2000s, construction of greenhouses was handled by foreign companies. Yet, today almost all plastic and glass greenhouse construction could be made by local firms. Such improvement results for Greenhouse Construction and Hardware Sector to become one of the fastest growing sector in Turkey in the last 25 years (Silleli et al., 2020).

Looking from international market, a simple internet search from Europeages.co.uk shows that Turkish greenhouse manufacturing firms are at highest in number compared to Japan and Netherlands. While there is limited information on the characteristics of Turkish greenhouse manufacturers, it is found that there is a competitive engineering level in terms of developing advanced technologies to be used in greenhouse production. Yet, preliminary search indicates that only limited firms are

[15] Dutch Greenhouses, Venlo Projecten, Agricultural Projects Holland BV, Avag Greenhouse Technology Center, Hortilife, SAARLUCON, BOM GROUP); HANS BRANSEN TUINBOUWTECHNIEKEN & ADVIEZEN, VITOTHERM B.V. and ROVERO SYSTEMS B.V.

providing a technical service – or only a limited number of firms provide satisfactory technical services – for growers after the construction or manufacturing works are done. In comparison with the Netherlands, lack of technical services indicates a great loss of knowledge on how to integrate new technologies with the current production systems. Thus, it creates a large mistrustful environment for farmers. As a result, there is a good chance that competent engineering and technological improvements stay unused or non-diffused.

4.3.5 Public Policies and Strategies on Digitalization in Agriculture

Regulatory environment and supportive policies for greenhouse cultivation are detailed in Function 5. Yet, this sub-function examines ICT-relevant policies and strategies that might have an impact on modernizing agricultural practices in general.

Japan, as one of the leading countries in the path for societal digitalization, currently shifting to "Society 5.0". This transition means integration of existing technologies to almost every part of life (*Innovation Japan | The Government of Japan - JapanGov -*). Many industries in Japan are also transforming in parallel to such integration, including agriculture and greenhouse cultivation. Specifically, Society 5.0 aims to develop and adapt digital farm technologies to respond global concerns as water shortages or inefficient natural resource management. Bearing that in mind, SPA is a great scientific contribution to Japan's national agenda and innovation trends in agriculture.

In the Netherlands, Dutch Digitalization Strategy is adopted to emphasize sustainable agriculture through protection of privacy, advanced cybersecurity measures, improved digital skills, maintaining equality in business competition and investment on research and innovation. Together with that, European Commission has launched a long-term strategy for agricultural research and innovation initiatives to create a collaborative environment for farmers, researchers, private businesses, non-profit organizations, NGOs, advisors and government bodies. Nevertheless, Dutch agricultural firms are not necessarily integrating R&D and innovation objectives to their business strategies. Based on the survey results made by PwC in the Netherlands, R&D spending is mainly made by the large multinational companies. In fact, eight investors are account for one-third of total R&D business expenditures ("Innovation in the Netherlands," 2016). In that sense, available digitalization policies seem less effective for agricultural R&D as large firms' operations.

In Turkey, on the other hand, there are positive steps toward a strengthened digitalization. Yet, most of the initiatives are addressing manufacturing and services (Bicer, 2020). Relatedly, majority of Turkish farmers has only basic and outdated technologies on hand (Kaygusuz, 2010). There are several exceptions in poultry industry, in which sectoral leaders are closely monitoring EU's and USA's best practices on fertilizer and machinery usage to increase vegetable production (Eklund & Thompson, 2017). Nonetheless, there is not a digitalization strategy in Turkey, that could contribute specifically to greenhouse cultivation.

4.3.6 Additional Evidence through Surveys and Questionnaires

While existing technologies and equipment are more or less the same in everywhere, business culture in Turkish greenhouses differs from other countries. This difference is observed especially for small and medium sized greenhouses. Safety measures and health cautions are taken as an example. It is observed that Turkish greenhouse owners are not sensitive yet as foreign greenhouse owners. To be more specific, arranging a visit to a medium sized greenhouse without sterilization could be easily made. In foreign countries, on the other hand, plant diseases have higher concern. Therefore, arranging similar visits require further effort and precaution.

In terms of complementary services, there is a lack of technical services to repair and adjust advanced greenhouse systems in Turkey. For that reason, farmers seem to suffer from technological adjustments.

> *This problem is frequent in animal husbandry, especially in milking machines. Firms come and adjust the equipment and never look back. They don't care whether animal udders are damaged, whether there is a high pressure or is there a disease, they don't care. Farmers, on the other side, don't know what causes the problem and thinks that the milk they had is what it is. See, one equipment that supposes to help you in your operations, in fact might harm your animals or decrease the productivity when you don't have a technical service to consult.* (Interview No 4)

While there are different dynamics in greenhouse market, producers are not exactly in a competition with each other. In fact, producers are acting like colleagues, rather than competitors. Competition factor is actually arising on prices. Having a strong and chained impact, price competition has a potential to harm all relevant actors. Simply put, to lower the product price, quality level also diminishes.

Pricing has a crucial impact for greenhouse operations on: what to grow, where to establish the greenhouse. While there is no standardized control mechanism, financial risks also increase. Deferred payments and intermediary product prices increase financial risks even more. Following issue is expressed in interviews:

> *Right now, there is not a system that can track the farmer, producer, pesticide seller and fertilizer seller. In other words, the state says that I do not charge 18% VAT on fertilizers, and gives them with 0% VAT. But since we buy it through the dealers in between, we have to buy it in an expensive way as if there is no VAT discount.* (Interview Number 9)

As result, even large greenhouses try to stabilize product selling prices at a certain rate. To make benefit out of their production, all greenhouses are working to balance price-quality ratios.

Trade relationships, similar to competition characteristics, are based on timely payment capabilities and trust. Producers do not want to risk their earning with uncertain buyers. As result, they prefer to work only with intermediary firms that they trust. This preference also applies to when producers need to buy medicines or fertilizer. They usually prefer foreign brands to ensure the quality.

Another interesting fact about cost minimization is about location of the greenhouses. Not depending on the climate, but closeness of market sale place has an important role in producer decisions. City of Aydın is given as one of the examples for this issue:

> *The first concern of farmer is how to make money out of his/her product. They say they want to grow tomatoes, especially cherry tomatoes, in Aydın. If you ask why, they would say 'they pick tomatoes up in front of my door'. They prepare tomatoes to sale; market car comes and picks them up. At that point, farmer doesn't care about pricing. Government supports farmers for the tomato prices for 1.25 TL, but those farmers sale for 1 TL. Why? They don't have to deal with the transportation, fuel, extra labor force and so on.* (Interview No 1)

According to representatives from Chambers of Agriculture, there is a difference of opinion for the effectiveness of greenhouse cultivation in Turkey. 54% of respondents believe that greenhouse cultivation is a beneficial source of production, while 46% believes the opposite. Also, respondents who claimed that they are aware of PA practices ranked Turkish greenhouse potential at moderate level.

To have a deeper understanding, success rate of greenhouse operations is re-evaluated on a scale from 1 to 5 (Figure 14). Only this time, financial barriers and technological investments are considered as applicable for all.

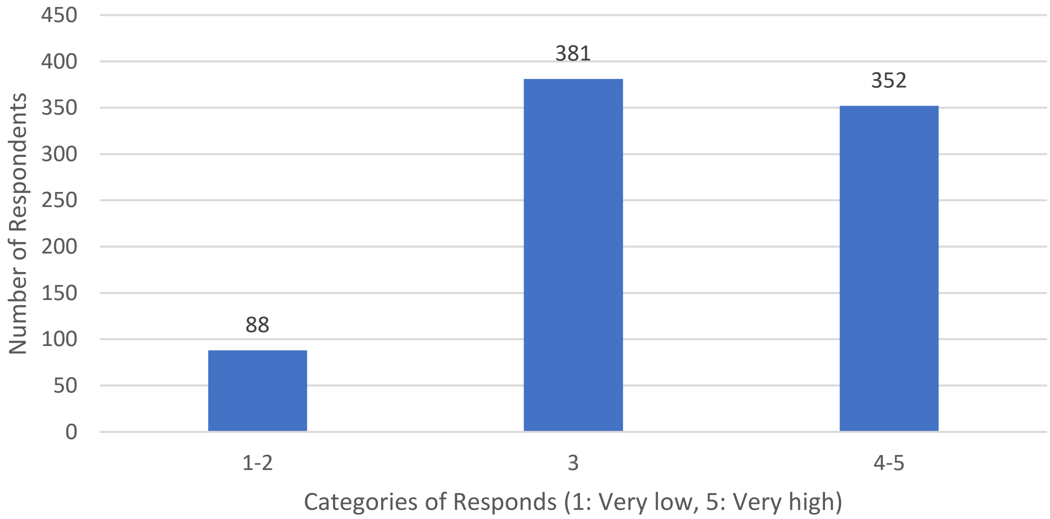


Figure 14: Potential of Greenhouse Sector Success Rate

Once necessary investments are in place, perception on the potential of greenhouse cultivation increases substantially. These results demonstrate a development area for agricultural development through greenhouse cultivation in Turkey. By meaning of investment, financial initiatives should be accompanied with other complementary factors. Technical support services are among the most important findings from lacking complementary factors.

While technical support services stay at firm level responsibilities, Chamber of Agriculture representatives are asked what to prioritize in this environment to increase greenhouse cultivation success. Fifty percent of the respondents emphasized again education as the main policy focus to ensure success of greenhouse cultivation in Turkey. While there are numerous factors in the path of success, education is ranked again as the first.

Under F3, there are four major issues that should be addressed. These are (1) the perception towards food health, (2) inability to adopt engineering and technology solutions, (3) lack of digitalization policies in greenhouse sector, and (4) financial constraints influencing business decisions. While these issues are interlinked with a variety of operational concerns, they also summarize major deficiencies of greenhouse operations in Turkey.

Next chapter proceeds with F4: Market Formation.

4.4 Market Formation (F4)

"From Schumpeter to Porter innovation-thinkers have recognized the importance of an advanced market, of well-articulated critical demand as a driving force for innovation" (M. P. Hekkert et al., 2007, p. 7). Institutional changes for innovative applications often require an evolved market (Bergek, Jacobsson, et al., 2008). Drivers for market evaluation involve market type, market size, industry associations and export & import rates.

Market information of greenhouse sector could be drawn by different factors as market size and characteristics, productivity level, value of agricultural activities, industry associations, agricultural trade, and bilateral relations. Main issue is to provide a sectoral understanding of greenhouse operations. While main elements of this function are elaborated with secondary data analysis, several problems are observed with interviews and questionnaire analysis.

4.4.1 Market Size and Characteristics

Market size comes in mind at first when any product or service is introduced. Similar to adoption of a marketing strategy, market size differentiates the content, opportunity, and limitations of technologies. This function looks from producer (supply) side to drive a simple conclusion on whether producers are or will be able to respond the demand.

Once again, each country has its own dynamic and behavioral pattern based on their socio-economic, cultural, and historical nature. For example, after extreme events like earthquake, tsunami, and Fukushima Daiichi Nuclear Plant crisis, Japanese government extensively promoted production of food even though there has been 20%

less arable and greenhouse floor areas since 2008 (Chris Mosby, 2015; *Marktscan Moderne Glastuinbouw Japan*, 2018). As result, greenhouse market is an important source of crop supply, especially for vegetables and fruits.

To balance diminishing number and aging characteristic of greenhouse producers, Japanese government announced next generation greenhouse horticulture models to adopt adjustable controlling systems (*Market Scan: Japan's Modern Greenhouse Industry*, 2018). Currently, these modern greenhouses are part of the different controlled environment categories in Japanese agriculture as open field growers with cloud computing services and plant factories using artificial lights (Chris Mosby, 2015).

Such sectoral transformation also brought greater cost of facility and management for greenhouse operations. Objective is to increase overall production, as well as to catch up Dutch production and quality scale (*Situation of Greenhouse Horticulture Ministry of Agriculture, Forestry and Fisheries*, 2018). To cope with existing challenges, large firms in greenhouse industry started to collaborate to empower their resources (including but not limited to labor work and technologies) through joint work.

The Netherlands, justifying Japan's motivation, is among the leading agricultural markets thanks to the application of advanced technological solutions and modernized cultivation methods (*The Netherlands Greenhouse Cultivation Market Outlook to 2019 - Declining Profitability to Hamper Growth*, 2015) yet, this does not mean that Dutch greenhouse farms do not face challenges. A large number of greenhouse farms have financially troubled after 2010 and number of greenhouse horticulture farms decreased around 85% since 1980 (*Netherlands: Number of Greenhouse Horticulture Farms 2007-2019 | Statista*, 2021). Still, merger of large local growers protected overall greenhouse sector from more damaging troubles.

Different from many others, Netherland's success with fewer number greenhouses is a result of applying market-oriented concepts and advanced technological solutions (*The Netherlands Greenhouse Cultivation Market Outlook to 2019 - Declining Profitability to Hamper Growth*, 2015). In fact, ten largest greenhouse production holdings are adding up to 10% of total greenhouse cultivation area (*Upscaling of Greenhouse Vegetable Production*, 2018).

Thus, quality audits, food safety and pesticide residues are also major concerns in agricultural production due to high volume of agricultural exports (Cantliffe & Vansickle, 2009). To get necessary certifications and verifications, overall commercial market in the Netherlands is expected to grow up to 1 billion USD by 2024 (*The Netherlands Commercial Greenhouse Market Size, Share, Opportunities And Trends By Type (Plastic, Glass), By Component (High-Tech, Medium-Tech And Low-Tech Commercial Greenhouse) And By Application (Fruits And Vegetables, Flowers And Ornamentals, Nurse*, 2020; Wilms, 2020).

In case for Turkey, total greenhouse farmlands increased by 40% since 2010, including glass and plastic greenhouses along with high and low tunnels (*Örtü Altı Yetiştiricilik*), which covered around 25% of total vegetable production in 2019. Thus, business sizes in greenhouse cultivation doubled in terms of land areas within the last decade (*Örtü Altı Yetiştiricilik*). As being ranked second largest available greenhouse lands, greenhouse farmland area might increase even more in the upcoming years. In fact, Turkish greenhouse market is expected to reach 32 million USD by the end of 2021 by fruit, vegetable, flower and ornamental plant growing greenhouses (Silleli, et al., 2020).

While engineering and manufacturing works of advanced greenhouse technologies in Turkey is found quite competitive, share of modern greenhouses in the overall market remains between 1-2% (Matlı, 2019; *TR63 Bölgesi Seracılık (Örtüaltı Bitki Yetiştiriciliği) Sektör Raporu*, 2015). Even though current materials and techniques are well-suited to apply modern greenhouse operations, financial barriers seem to prevent overall market growth.

The level of technology usage also varies according to the size of greenhouses. To exemplify, small sized greenhouses are benefiting from technological solutions to fight with extreme winter conditions while larger greenhouses are applying advanced technologies to ensure food safety and environmentally friendly production (TÜZEL et al., 2020). This contrast indicates that technology adoption in greenhouse operations is still insufficient compared with the potential.

4.4.2 Productivity Level and Value of Agricultural Activities

Productivity in agricultural sector, different from manufacturing and services, fluctuates on annual basis due to changing climate and available natural resources. Figure 15 below and Appendix 11 show annual changes in agricultural inputs and outputs.

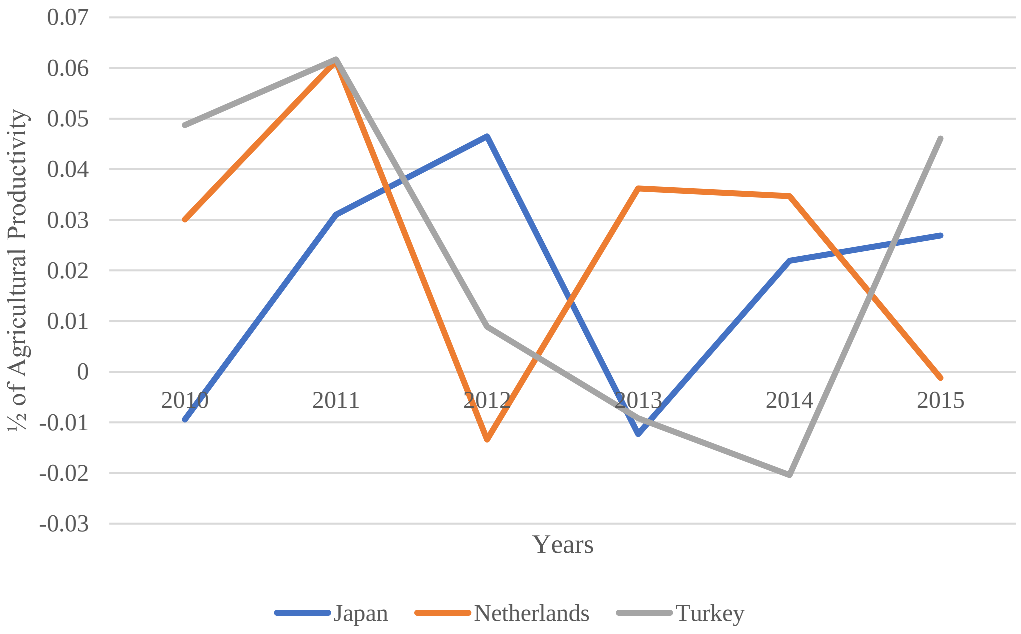


Figure 15: Agricultural Total Factor Productivity

Source: U.S. Department of Agriculture – International Agricultural Production. Agricultural Total Factor Productivity (Ag TFP) - % of Annual Growth Rate

Recorded productivity levels and balance of production factors indicate that agricultural inputs are not necessarily impact outputs, mainly because there are external factors in value chain. While productivity indicates an important element for sectoral development, value of agricultural products is the main driver for decision makers and investors.

Value of agricultural production, different from the productivity rates, has steadier trend in all three countries (Appendix 12), yet it is at highest for Turkey. In parallel, value add for agricultural activities, which indicates the output value minus the intermediate consumption value, are again at highest for Turkey (Jouanjean, 2019).

Value index of agricultural trade shows quite similar and close values for all three countries (Appendix 13), which indicates that the trade indices for agricultural production are not dependent solely on the value of production.

4.4.3 Industry Associations

Industry associations reflect the collaborative work among different agents, which established a bridge to capacity building, network development and to promote industrial collaboration. Therefore, even though it is not always easy to measure association activities and the level of contribution to its specific members, the availability of those associations, their main activities and motivations give informative insight on how the overall market is seeing a particular sector and what are their potentials for future.

4.4.3.1 Industry Associations in the Japan

Japan Greenhouse Horticulture Association is among the main organizations in Japan to gather and to promote greenhouse relevant industries. As per the latest records, there are 80 member firms in construction, covering materials, heating systems, soilless culture, seeds, and seedlings (*Japan Greenhouse Horticulture Association*). To reach out all of those sectors, the association mainly takes part in technical support and safety. Thus, knowledge dissemination through conferences, training sessions and advisory services from academic experts are among frequently announced activities (*Japan Greenhouse Horticulture Association*).

In addition to activities and main operation areas, Japan Plant Factory Association is found an active and well-collaborative association between industry and academia through different R&D projects, trainings, and workshops (*JPFA Japan Plant Factory Association*). Current partnership with Chiba University, specialized in artificial lighting and phenotyping in controlled environment, is one example.

From generic and overall scope of Japanese greenhouse associations, academic expertise and technical improvement of existing businesses (greenhouse facilities) through technology and advanced engineering are seem to be the common focus.

Accordingly, majority of association activities includes training, seminars and conferences to diffuse innovation and up-to-date technological solutions along with developing growers’ skills.

4.4.3.2 Industry Associations in the Netherlands

In the Netherlands, rather than individual greenhouse associations, mergers and joint works grab attention. As an example, five largest greenhouse relevant associations[16] have merged under the name of Federatie Vruchtgroente Organisaties (Federation of Fruiting Vegetable Organisations), which covers bell peppers, tomatoes, cucumbers, and eggplants growers. Even though there are still sole strong organizations as AVAG, Federatie Vruchtgroente Organisaties represent 70% of greenhouse crops and other counterparts in the Netherlands (*AVAG | About Us*; *New Dutch Greenhouse Alliance - Hort News*, 2015; Baltussen & Smit, 2013; Collen, 2015). Similarly, government agencies and Rabobank also made a joint alliance and overall process has been managed by former Minister of Agriculture, Nature and Food Quality (Collen, 2015). Main objective of this merge was to establish long term and strong foundation for technologically advanced, sustainable and tailor-made quality in greenhouse cultivation re in Europe.

In addition to signs of strong collaborative works, advancing current greenhouse operations is among the top priorities of associations in the Dutch market. For instance, with the aim of promoting innovation systems, government and private funds are transferred to a non-profit organization namely Dutch Foundation for Innovation in Greenhouse Horticulture. Priorities of this foundation are based on integrating technological solutions to modernize existing greenhouse systems.

In case for the Netherlands, greenhouse associations emphasize a collaborative work environment, involving counterparts as academia, public institutions, and private sector. For that reason, agricultural entrepreneurship and technologically advanced steps are taken in a smoother manner with the contribution of these counterparts.

[16] Best of Four, DOOR, The Greenery, Harvest House and Van Nature

4.4.3.3 Industry Associations in the Turkey

Turkish greenhouse associations are more business-oriented. Serkonder is the largest association in this market, bringing expertise of greenhouse construction, equipment, and manufacturing firms (Silleli et al., 2020). Objective is to improve greenhouse manufacturing sector in Turkey and export the local expertise (*SERKONDER – Sera Konstrüksiyon Donanım ve Ekipman Üreticileri ve İhracatçıları Derneği*). Main activities include networking among relevant firms, facilitating the information exchange, seeking legal, technological, manufacturing related or export-oriented solutions for its members, studying on new export markets, introducing new technologies, and promoting standardized and energy friendly greenhouse production.

In addition to Serkonder, Sera-Bir is another actively working organization for modernization process of Turkish greenhouse market. The association provides services to bring foreign greenhouse technologies in the fields of infrastructure, marketing, and efficiency (*SERA-BİR*).

Turkish greenhouse associations seem to be established to serve a purpose in relation to greenhouse cultivation, whether for construction and equipment or advisory services for growers. Therefore, rather than observing a collaborative work or scientific contribution, there is more a division of work and services with the purpose of contributing the agricultural trade, commerce and infrastructural development.

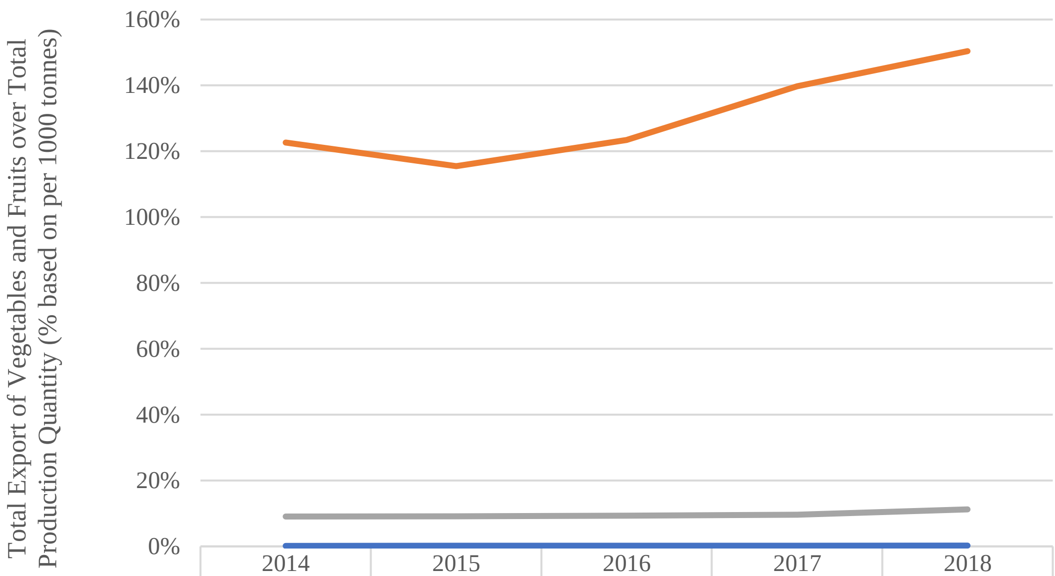
4.4.4 Agricultural Trade and Bilateral Relations

Trade relations, similar to industry associations, indicate an important aspect of partnership for greenhouse production. Yet, trade partnership in agricultural trade is different from institutions and mainly represent factors shaping bilateral relations. Meaning that, each country has its own trade partner(s) for greenhouse production; therefore, international relationship between two parties has direct impact on the greenhouse market.

Trade for greenhouse products is observed through the share of exports within overall production in tones. Higher share of export over production might explain whether product specific export has a significance in international trade. Appendix 12, shows annual changes in fruit and vegetable export share within annual fruit and vegetable production rates. Main reason why those product categories are put ahead of others -as cereals for example-, is the fact that greenhouse production is mainly used to produce vegetables and fruits. While annual changes in fruit and vegetable exports are not a major concern of this study, the difference in export and production rates are worth mentioning.

Fruit production holds greater importance in all three countries compared to vegetables, in terms of their export share. Even though, there is no product-based analysis in this study, the value of fruit production still indicates that governments could make an advantage by focusing on a more specific production chain, which would be a worth taking policy measure in agricultural development.

Figure 16 shows the total export of fruit and vegetables as a factor of total production of those products to understand the level of importance of greenhouse cultivation in agricultural trade.



	2014	2015	2016	2017	2018
Japan	0.15%	0.20%	0.23%	0.24%	0.25%
Netherlands	122.60%	115.48%	123.39%	139.71%	150.39%
Turkey	9.07%	9.10%	9.34%	9.61%	11.24%

Figure 16: Exports over Total Production of Fruits and Vegetables

Source: Food and Agriculture Organization, New Food Balances, Food Balance Sheets

The Netherlands, compared to Turkey and Japan, has substantially higher export of greenhouse products, ranked as around 1.5 times of production. Such enormous export levels might be the result of advanced storage technologies, which is an important practical application of SPA. While the reasons behind for such high export rates are not the concern of this study, it is obvious that the export of agricultural products carries high importance for Dutch farmers and all relevant businesses. To be more specific, while current records indicate that greenhouse cultivation has an export rate of 80% over total production (Breukers et al., 2008), export value of relevant materials and machineries also increased by 8% (*Dutch Agricultural Exports Worth €94.5 Billion in 2019 | News Item | Government.Nl*, 2020).

Germany, in terms of agricultural trade, accounts for the largest share by €23.6 billion in 2019 (*Dutch Agricultural Exports Worth €94.5 Billion in 2019 | News Item | Government.Nl*, 2020) by exporting mainly greenhouse products as fruits and vegetables from the Netherlands. In return, the Netherlands is one of the greatest export countries for Germany in cars, electrical and electronical appliances, chemical products, pharmaceutical products, and food products (*Half of Dutch Production of Greenhouse Vegetables Goes to Germany and the UK*). While further bilateral relationship between two countries could be seen in Appendix 13, it is worth emphasizing that today more than 80% of businesses located in the Netherlands are found interested in increasing their exports to Germany (Boata, 2016). Such strong trade linkages, as in all sectors, benefit for current and forecasted greenhouse production in the Netherlands.

Export rates in Japan, on the other hand, is part of national priority to ensure self-sufficiency. Geographical characteristics pushes national policies to reserve its own food resources in case of a natural disaster, which has been experienced in an extreme way before in the region. Agricultural production is desired to address in-country businesses as well. Specifically, Japan’s growing service sectors in hotels, restaurants, and food service industries push high quality and safe food demand for foreign tourists and travelers (*Food Export Blog Food Export - Country Market Profile: Japan*, 2019). Therefore, it is expected to encourage cultivation and control on agricultural production even more, via unmanned and robotic solutions in different stages of agricultural value chain (Jetro, 2017).

Even limited, Japanese agriculture has some value in international export. Japan was one of the agricultural product suppliers to United States until 2018, and currently Hong Kong seems to forge ahead that chair ("Agriculture in Japan New Developments in Smart Agriculture," 2018). For the future prospects, it is worth indicating that EU-Japan Economic Partnership Agreement and CPTPP agreement could increase export share of greenhouse products through enabling measures ("Agriculture in Japan New Developments in Smart Agriculture," 2018).

For the case of Turkey, fruit and vegetable production export covers almost 13% of total agricultural export, in which tomatoes' export share is 290 million USD[17]. Today, Turkey accounts for 7% of global total tomato production, mostly imported by Russia (*Turkey Emerges as the Largest Producer of Tomatoes in the Middle East*, 2020). In that framework, bilateral relations are found both strong and fragile. This controversial balance based on the influence of international and political relations on trade. To exemplify, export rates of tomato dropped substantially and severe restrictions made after the political incident in 2016 (*Relations between Turkey and the Russian Federation*; *Turkey Exports to Russia: 1992-2020 Data*). Different from trade dynamics between the Netherlands and Germany, political sensitivities are the driving factors for agricultural export, specifically for horticulture products as tomatoes.

4.4.5 Additional Evidence through Surveys and Questionnaires

Greenhouse cultivation in Turkey differs by size. Such difference impacts on business characteristics, however, 80% of interviewed cases are defining their business as foreign dependent.

At one side, firms prefer to import for subsidiary product and services, in order to achieve higher quality. Local producers who provide same product and service, are perceived as low quality. As result, greenhouse owners prefer foreign brands for business purchases and other business networks. On the other side, producers who buy intermediary products from local sellers, are on a disadvantageous position because there is a lack of selling price audits.

[17] https://trade.gov.tr/data/5b8fd55613b8761f041fee87/345bc7ad67aed10d4ace28ccdf5e4616.pdf

> *We do not have the opportunity to bring it from abroad. There buy it from agricultural dealers. The problem there is that the company and the dealers are making internal deals. One side says that XX Ziraat will sell my product in the Serik region. Dealer says okay, I will sell your product, but you don't sell these to any other dealers. Firm accepts this agreement. What happens as result? Dealer sells the product for 200 lira even though the market price should be 100 lira.* (Interview No 6)

Based on the comments given during majority of interviews, greenhouse owners are not establishing new business relationships unless the buyer has credible references. Businesses are relying on trustworthy sources to establish or improve agricultural trade. Especially small and medium sized greenhouses are dependent on intermediary businesses to reach end user. Therefore, such trust issues are reflected stronger for them.

Market structure in greenhouse cultivation is divided by lands and business owners. There are two types of issues in effective usage of land. First, there are pieced arable lands, given to individuals as legacy. Since there is not high level of collaboration in terms of operations in greenhouses, overall arable land stays small to invest in. Second, new entrants are not quite familiar with the technical aspects of managing greenhouse cultivation. This issue is mentioned by an example of constructing a greenhouse for Mediterranean climate conditions in a region with continental climate:

> *He established a greenhouse in Diyarbakır, in about 100 decares. That's okay, but he hired a consultant from Antalya and he ended up with a greenhouse suitable for Antalya's climate. That's the funny side. These greenhouses are not in condition to make income for producers.* (Interview No 5)

Overall, greenhouse market is evolving but still quite sensitive to changes because of this dependency. To guide existing businesses and improve their operations in such environment, roles of Chambers of Agriculture specifically questioned with greenhouse owners. As per interviewees, relationship between chambers of agriculture and producers as quite limited. For some producers, chambers of agriculture only support paperwork and nothing more. On the Chambers of Agriculture side, some of the respondents complained about the bureaucratic procedures they need to follow. Due to such bureaucratic issues they need to carry on, they are not able to go on field to support producers as much as they want to. This might be an indication of mismatch in roles in government institutions, which eventually influences the performance of producers.

Under F4, all major concerns are linked to two types of dependency. Market dependency on export sales is an important issue, considering the fact that export rates to Russia is highly sensitive to political relations. Dependency on subsidiary product sellers is another crucial issue to observe. While some of greenhouse owners prefer to import necessary fertilizers or medicine, others are struggling with high prices charged by local dealers. In addition to these dependencies, greenhouse owners are not able to find necessary advisory services. Comments on greenhouse dependencies and unavailability of necessary advisory services are explained in Chapter 6: Discussion.

Next chapter proceeds with F5: Creation of Legitimacy.

4.5 Creation of Legitimacy (F5)

Studies show that motivation behind adopting a technology and being an entrepreneur is more favorable if it is driven by legitimate grounds (Rossler, 2019). Also, legitimacy influences managerial perception, expectation, and strategic decisions to formulate new industries or develop certain sector with more advanced tools (Bergek, Hekkert, et al., 2008). In some cases, decision makers might be resistant to promote a certain technology if it disturbs their abilities, but once alternative forms of legitimacy are created, technology adoption becomes more achievable (Coşgel et al., 2012).

Creation of legitimacy is the function reflecting compliance with institutions through regulations, national agendas, and international policies. Each country, or region, has its own history shaped by driving factors and behavioral reactions against measures taken. This function represents history of public measures, policies and regulations to improve agricultural production in terms of efficiency and technology integration. Since each nation has its own regulations and legal structures, sub functions are not applicable in this chapter. Therefore, similar structural changes as Chapter 4.2 are found once again suitable for this chapter. In the next sections, each target country is explained with its own dynamics.

4.5.1 Historical Background in Japan

As of late 1990s, Basic Law on Food, Agriculture and Rural Areas has been introduced in Japan, as an update on the same law announced in 1961 with following main policy priorities (OECD, 2009): (i) domestic production for food supply security; (ii) natural land conservation, natural resources management and maintenance of cultural traditions; (iii) promoting sustainable farmlands, irrigation and drainage; (iv) natural cyclical function and farm operations; and (v) improving production conditions and infrastructures. Even though the law updated regularly, self-sufficiency and sustainable operations remained an important aspect for Japanese regulations and standards in agriculture, influenced by natural disasters happened in the history of Japan and nearby countries (Gilmour & Gurung, 2007; OECD, 2009).

In terms of food supply stability, regulations pushed government to set up and apply an emergency plan for food supply, which was announced in 2002 (OECD, 2009, p. 8). As part of applying the sustainable solutions, food education system -also referred as Shokuiku-, environmentally friendly farming against agricultural chemicals and farmer income stabilization were among the actions taken by policy makers and regulative powers (OECD, 2009).

Agricultural development was part of different public institutions' KPIs, in addition to Ministry Agriculture, Forestry and Fisheries. To exemplify, Japan Revitalization Strategy involved objectives to promote agriculture as part of its national growth strategy and established Public Corporation for Farmland Consolidation to Core Farmers in 2014 (Harayama, 2017). Also as of 2016, Policy Package for Enhancing Competitiveness of Japan's Agriculture has been introduced with several reform areas for (i) cost reduction for product inputs; (ii) distribution and processing of structural reforms; (iii) enhanced human resource; (iv) improving the export; (v) transparency in ingredient origins; (vi) systemic changes for quality monitoring and check offs; (vii) insurance; (viii) land improvement; (ix) increased agricultural employment; (x) agricultural product promotion (*Summary of the Annual Report on Food, Agriculture and Rural Areas in Japan*, 2017).

In parallel, technological tools, equipment and knowledge are harmonized to agricultural value chain through automated system adoption for farm operations (Jetro, 2017). Main reason for such integration was due to increase in large-scale farming, especially after 2010s. Yet, there were certain technical barriers as farmland area limits for feasible investments, need for more farmland workers and lack of effective farm management systems (Harayama, 2017). As a response, cross-ministerial Strategic Innovation Promotion Program (Technologies for Creating Next Generation Agriculture, Forestry and Fisheries) and 5th Science and Technology Basic Plan took some steps to integrate ICT solutions in each and every aspect of agricultural operations (Harayama, 2017).

5th Science and Technology Basic Plan is designed to create a data driven society through integrating physical and virtual space, including agricultural sector. Therefore, Agricultural Data Collaboration Platform and National Agriculture and Food Research Organization has been established "FFTC Agricultural Policy Platform" to achieve labor efficiency by using robotic solutions, optimization of the production values and reduction of waste via stabilizing supplies (*Examples of Creating New Value in the Field of Disaster Prevention (Society 5.0)*).

Combining all, technology policies are found quite comprehensive for each sector, including but not limited to agriculture. Public bodies are expected to develop their strategies and activities in accordance with national innovation system. For instance, newly established Council for Science, Technology and Innovation is expected to assure STI policies are systematic and comprehensive in parallel with national strategies (Jouanjean, 2019).

Together with technology policies in agricultural operations, initiatives also specify greenhouse related agricultural development with the usage of ICT. Precision agriculture is among the most observable area along with reducing the greenhouse operation costs, promotion of climate resistance, facilitating tools and models for better farm management and information & technology diffusion in greenhouse sector (*Situation of Greenhouse Horticulture Ministry of Agriculture, Forestry and Fisheries*, 2018).

4.5.2 Historical Background in the Netherlands

After the World War II, Dutch government prioritized the access to global export market to address post-war suffering, which resulted as an increase in agricultural production as of 1950s (Bont et al., 2003). Eventually, agricultural development policies and strategies emerged, as Land Administration Foundation controlling agricultural price value and as agricultural credit funds to improve farm businesses (Bont et al., 2003; Devienne, 2002). Such enabling environment for farmers and agricultural operations also cleared the path to intervene value chain via scientific and technological inputs. In that sense, one of the most important incidents of late 1950s and 1960s was the discovery of increasing productivity through technical innovations by peasants (Devienne, 2002). As a result, peasant economy started to receive large investments, including coastal areas which is almost 50% of overall farmland area in the Netherlands (Devienne, 2002) .

As of late 1950, six Member States initiated integration process (called as Treaty of Rome) and Common Agricultural Policy, which took the place of national agricultural policies (Bont et al., 2003). Objectives of Common Agricultural Policy, at first, included productivity increase, ensuring well-living of farmers and stabilizing agricultural market including food supply and end-user prices (Bont et al., 2003). Meanwhile, Dutch government announced its support to agricultural research, education and training along with subsidizing establishment of agricultural mutual saving banks. Thus, further directives came to force for nitrate in ground water (Regulation 1991/676), pesticides (Regulation 1991/414), water framework, Integrated Pollution Prevention and Control (Regulation 1996/61) and animal welfare regulations (Bont et al., 2003).

While these policy mixes brought various difficulties to manage, global concerns started to be adopted in national strategies. Dutch policies, therefore, started to focus on ecological, climatic and welfare problems in addition to agricultural production as livestock, greenhouses, and daily farming ("Facts and Figures 2010: The Dutch Agricluster in a Global Context," 2010; Larosse, 2017). Main concerns of these policies covered sustainability, food quality, knowledge infrastructure, innovative approaches, international trade facilitation, bio-economy, and biotechnology ("Facts and Figures 2010: The Dutch Agricluster in a Global Context," 2010; Holthuis et al., 2020). Influence of climate change, protection of biodiversity and environmental degradation became even more visible after 2000s. This transformative approach is seen in 4th National Environmental Policy Plan, announced in 2001 (Smith & Kern, 2009). Plan emphasized the need of system innovation to address such concerns.

Hence, the need integrates policy makers, researchers and private firms in the process of agricultural transformation also became a subject.

The Netherlands was not the only country experiencing such agricultural transformation. Member states following CAP also impacted by changing dynamics of the world. As a result, CAP shifted to more flexible and result oriented nature for each member, rather than trying to be a standardized fit for all (EC, 2018).Relatedly, supportive initiatives for farm income, competitiveness, promotion of innovation, acknowledging environmental public goods, and mitigating climate change have been re-structured by new CAP (EC, 2013).

Promotion of circular agriculture is one of the examples of such country-based shift in the Netherlands, which enabled farmers to make experimentation, utilize public lands and food nutrition in a repeated way (*Could High-Tech Netherlands-Style Farming Feed the World?*, 2019b). Similarly, 2030 Plant Protection Vision is now addressing innovative breeding and optimization of pesticide usage as part of precision agriculture (Weppner, 2019). Today, precision agriculture holds a great part of Dutch policies and national strategies, with the objective of modernizing farms and agricultural operations. In that sense, uptake of precision agriculture has been found effective only if knowledge, application and perceptions are addressed together (Panagos et al., 2012). Accordingly, the Netherlands continues to announce policies and regulations integrating agricultural operations into technologically advanced methods to integrate scientific and technologic solutions to agricultural practices[18] (EC, 2013; Jouanjean, 2019).

18

Farm modernisation and intensification as per Article 17 of Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013

Shift to environmentally suitable systems as per Article 28 of Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013

Cooperation among farms to mitigate climate change or adopt water management as per Article 35 of Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013

Vocational training and skill development activities in precision agriculture as per Article 14 of Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013

4.5.3 Historical Background in the Turkey

Turkish government has been promoting agriculture and agricultural operations since 1980s, especially via market price support and input subsidies (Kaygusuz, 2010). Yet, during the economic instability in 1990s, government reduced its overall government expenditures, which also affected farm inputs (Kaygusuz, 2010, pp. 26, 32). In 2001, Agricultural Reform Implementation Project has been introduced by World Bank to support government's agricultural policy and reform programs via reduction of subsidies, maintaining a support system for producers and providing incentives for production increase (*Agricultural Reform Implementation Project (ARIP)*).

While Agricultural Reform Implementation Project continued to promote agricultural operation, environmental concerns were also emerged. To address global environmental concerns, programs as Environmentally Based Agricultural Land Protection program has been announced, targeting fragile lands against climate change and environmental degradation (Kaygusuz, 2010, p. 31). Relatedly, programs like South-Eastern Anatolian Project and Anatolian Watershed Rehabilitation Project are announced and implemented in different regions. Nevertheless, these initiatives continued to be dependent to international donors with a limited fund (Kaygusuz, 2010, p. 27). Therefore, government of Turkey adopted Agriculture Law in 2006, which was aiming to provide sustainability in agricultural development through regulative measures (*Structural Changes and Reforms on Turkish Agriculture (2003-2013)*, 2013).

After the adoption of Agricultural Law, a number of plans and basic laws has been announced to contribute agricultural development. While Ministry of Agriculture's plan was to promote agricultural productivity, food security, plant and animal health, rural development and capacity building for relevant institutions, basic

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Coalition Agreement of 2017 to boost public-private partnership on climate, energy, agriculture, food, water through key enabling Technologies

Knowledge and Innovation Contract of 2018-2019 to focus on national innovation system in target sectors including agriculture laws were targeting transformation in overall agriculture sector (*Structural Changes and Reforms on Turkish Agriculture (2003-2013)*, 2013).

Inevitably, advanced techniques and technologies took part of agricultural development in Turkey. Good agriculture practices have started to take part in regulations as of 2004 and kept updated with more specific targets. For example, Regulation on the Application of Controlled Cover Production[19] has been prepared to improve controlled and systemic value chain of agricultural production, which is supported by Regulations on Registration of Greenhouse Cultivation[20][21]. Similarly, even though there is no direct indication of precision agriculture on legislative level, regulations on vegetables, fruits and flowers[22] are appearing via protection of soil, decreasing dependence on agricultural medicines, applying right treatment based on soil and plant requirements, obligation to optimize fertilizers, and water resource management.

Today, as per National Agricultural Vision for 2023, Turkish government encourages sufficient and safe food with best quality, exportation of agricultural products and increase in competition power (*Structural Changes and Reforms on Turkish Agriculture (2003-2013)*, 2013). Accordingly, 11th Development Plan also involves support measures to modernize existing greenhouses, by addressing to both sectoral development and taking of the pressure on natural resources. Specific focuses of these measure are given to CO2 emission reduction and effective usage of existing water resources (*Eleventh Development Plan (2019-2023)*, 2019). Similarly, performance indicators for sustainable agriculture for 2018-2020 Strategic Plan include increasing greenhouse land areas, geothermal energy usage in greenhouses, and improving plant health treatment (*Strategic Plan 2018-2022*).

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[19] First "Regulations for the Implementation of Controlled Greenhouse Production" prepared and published in the Official Gazette dated 27.12.2003 with number of 25328

[20] https://www.resmigazete.gov.tr/eskiler/2010/08/20100825-1.htm

[21] https://www.resmigazete.gov.tr/eskiler/2014/06/20140625-1.htm

[22] https://www.resmigazete.gov.tr/eskiler/2004/01/20040105.htm

4.5.4 Additional Evidence through Surveys and Questionnaires

Government support characteristics are questioned at first. In general, government supports are divided between consumers and producers. For example, 'tanzim satışı[23]' mentioned as one example for consumer supports:

> *If products are available more than demand, prices fall down. System works like that. If farmers don't earn enough money, they cannot grow for the next season. In my opinion, government tried to slow down exports to have sell products in domestic market with lower prices, compared with supermarkets. So that consumers could purchase same products at lower prices. It's a good intention of course, but farmers are financially harmed from this support because they had additional costs or couldn't sell enough products to prepare their business for the next year.* (Interview No 10)

Producer supports, on the other hand, could be listed with credits, machine support, and market expanding supports for greenhouse-rare geographies. Hence, public institutions like TAGEM collaborate with universities to develop prototypes of robotics and advance technologies to be used in greenhouses.

Nevertheless, 80% of cases stated that government supports are not available to address producer needs. One of the interviews involved a detailed proposition of a policy instrument, which also highlights needs and lacking of current operations:

> *I thought a tracking and audit system. A barcode system that will inspect the producer, fertilizer, seeder, and all other parties involved until my product goes to the end user. In this way, producer can see where the product is sold. In such way, the whole system can be monitored and recorded, and if it is recorded, health and food safety related responsibilities will be on the producer. As a producer, I would prefer such system and responsibility as oppose to current practices.* (Interview No 9)

In that framework, there is a two-fold trust issue perceived from preliminary data. Producers are not entirely happy about existing supports and systems, because they are not addressing their needs. On the other side, interviewed cases represented stories of producers taking advantage of existing supports. Meaning that, some producers are motivated to receive the support, rather than actually contributing their business.

[23] Sale of food by a municipality so as to regulate the prices

In any case, a standardized, transparent and auditable system is not present. On the Chambers of Agriculture perspective, agricultural policies are not addressing technological advancement (Figure 17).

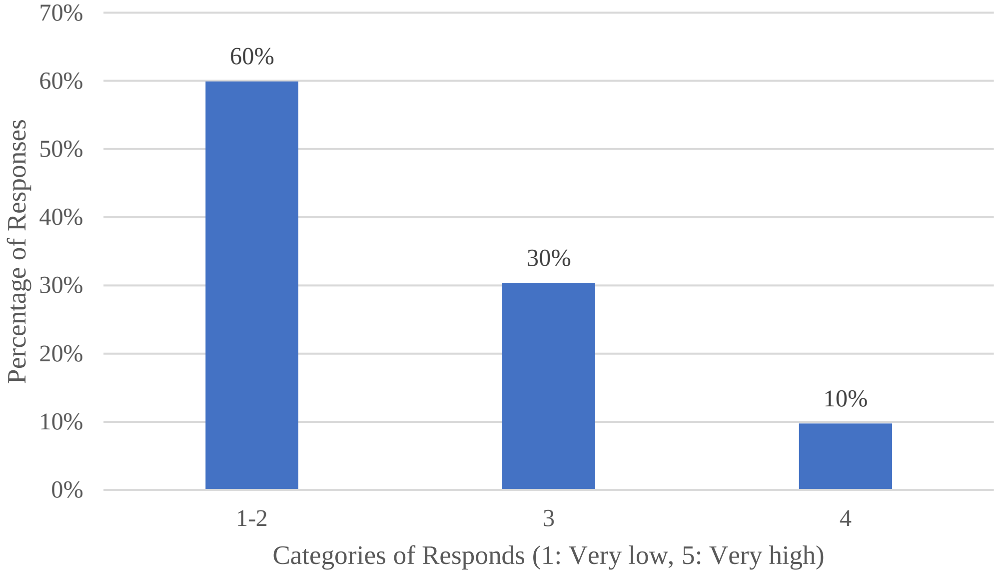

Figure 17: Agricultural Policies addressing Technological Advancement

Also, 77% of respondents stated that there are two issues concerning inefficiency of existing agricultural policies. These are long-lasting updates and policy content missing optimal benefit for producers. To address those concerns, respondents are asked to point out specific issues in existing agricultural policies. Following quotes are selected for to show representative examples for common mentioned issues:

- *The constant change of ministers in agriculture hampers the continuity of policies and projects. New ministers always start from scratch as he could not continue the project of the former minister.*
- *If the marketing leg of agricultural policies is lacking, there is no value in increasing production. State must deal with marketing difficulties.*
- *Agricultural policies in force are far from developing national agriculture. They provide minimum benefit by serving the interests of individuals or specific regions at the local level.*

- *It is necessary to transfer the legal dimensions and disciplines of policies to those living in rural areas.*
- *Farmer organizations are insufficient. Cooperatives do not work efficiently. Ministry should give power to farmers' organizations and lead public organizations.*
- *Policies are promoting to export, so they are not convincing us as been constructive.*

Based on those exemplary issues, Turkish policies and legal regulations could be improved from different aspects. To see the common opinion on where to start this improvement, respondents are asked to prioritize comparative analysis functions. On average, 50% of respondents in each category (Ranking 1 to 5 in Figure 13), prioritized education to develop policies for agricultural digitalization.

Under F5, diverse issues are pointing out a necessity of standardized and transparent public governance in all steps in greenhouse cultivation. Trust issues in the overall market is detailed under F4, but they are also reminded in this function as well. Meaning that, producers are not entirely trust government authorities to protect them. This untrustful environment and reflections on policies are further elaborated in Chapter 5: Discussion.

Next chapter proceeds with F6: Mobilization of Resources.

4.6 Mobilization of Resources (F6)

Resource, by meaning, covers a variety of elements as finance, human, nature, technology, etc. Without allocating and promoting necessary resources, it is not meaningful to discuss the level of investment and development. Therefore, mobilization of resources is useful to identify priority areas. While a comprehensive study should examine all existing resources and their status, data specific to precision agriculture in greenhouse operations is not available for all countries. For that reason, only financial and human resources are taken into consideration to make a general snapshot.

4.6.1 Financial Resources

Analysis of financial resources starts with government expenditures on R&D. Allocation of government budget to certain sector/development area does not necessarily indicates effective usage. Even so, availability of financial resources influences the comparative analysis. For that reason, government expenditures on agricultural R&D are important to examine (Figure 18).

In general, performing counterparts of GERD are government, business, higher education, and private & non-profit organizations. Nevertheless, available and comparable data includes only government as performing actor.

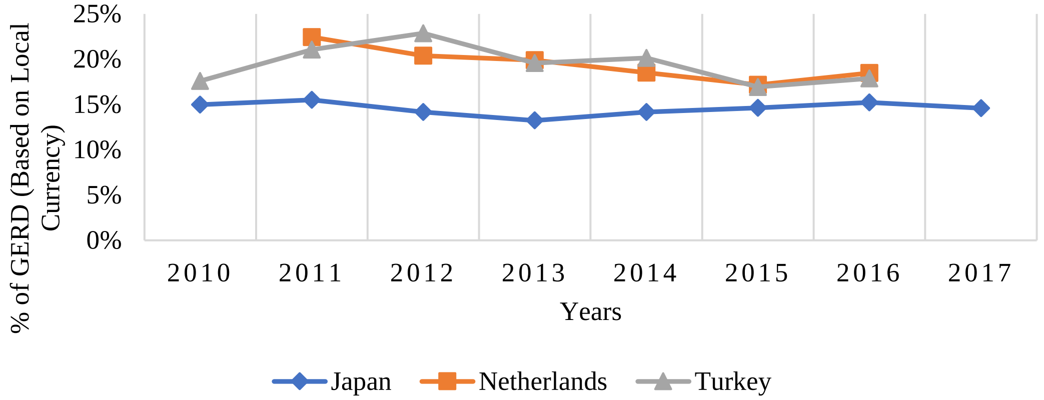

Figure 18: GERD in Agricultural and Veterinary Sciences performed by Government

Source: UNESCO Science, Technology and Innovation Statistics Data

While annual GERD shares are not descriptive enough to argue on prioritization of agricultural development, a generic picture is drawn for three countries. First of all, GERD allocated to agricultural science in Japan has the lowest fluctuation. This observation might indicate that agricultural and veterinary sciences have a structured share in research and development expenditures. In other words, agricultural fields have a certain level of importance in Japan, regardless of sectoral shifts in global.

Turkey and the Netherlands, on the other hand, has fluctuating R&D expenditures in agricultural sciences. This is an indication of budgetary decisions changing according to national focuses. Argument is also supported by changing R&D

expenditures of other sectors. For example, percentage of GERD in engineering and technology fields seem to gain importance over natural, medical, agricultural, and social sciences in Turkey since 2010 (Appendix 14). As for the Netherlands's case, increase in GERD is observed for natural sciences, engineering and technology since 2011 (Appendix 15).

4.6.2 Human Resources

Human resource of a country is based on the available human capital for a specific purpose. Studies indicate that agricultural landscape usage and overall demand to contribute to agricultural businesses is highly dependent on demographic changes, not only by mean of aging population but also urban-rural population differences (Müller et al., 2008). Therefore, sector specific factors are examined by both age groups and urbanized lifestyles.

From the largest framework, Turkey has the youngest demographic profile and highest percentage in labor force (*OECD ILibrary | Elderly Population*). As per the mobilization of labor force, Figure 19 further shows the share of agricultural labor within the total labor force.

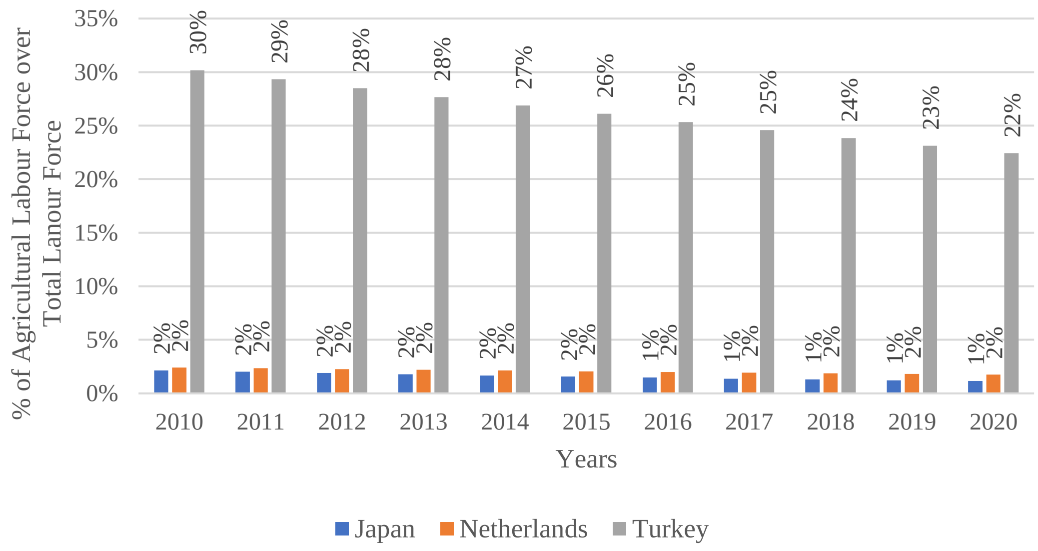

Figure 19: Agricultural Labor Force as Percentage of Total Labor Force

Source: United Nations Conference on Trade and Development

Japan is among aged countries, with the 28% of elderly people aged 65 or older, recorded at 2015 national census (*OECD ILibrary | Elderly Population*). Aging population might be a result of low fertility trends (Kumagai, 2015). Regardless of the reason, aging society has an effect on agricultural labor. For example, decline in newly born rates and increase in overall life expectancy encouraged the capital accumulation, especially in favor for non-agricultural business sectors as of 2000s. Industrialization, in addition to the demographic characteristics, promoted service and manufacturing sectors within the society. Through the augmentation in aging population and transfer to industrialization, negative impacts -as decreasing agricultural labor force- became visible as of 2010s. Today, agricultural labor force in Japan experiences a sharp decrease; even though, agricultural production (especially rice) addresses both sectoral and cultural values of the country.

On the other hand, demographic characteristics in the Netherlands and Turkey draw a younger population profiles compared to Japan. The Netherlands has a 15% of total young population (*OECD ILibrary | Elderly Population*), whereas aging trends show initial signs as of 2000s. Having similar agricultural labor force as Turkey and lowest population rate compared two other two countries, the Netherlands' contribution to agricultural sector stays at a moderate level. In Turkey, age group between 25-54 years counts for the majority of population, followed by 15-24 age group. This demographic characteristic refers to a quite young and dynamic population. Thus, agricultural labor force is substantially higher even with lower population rate compared to Japan. This observation shows Turkey's dependence on agriculture in a clearer way.

Nevertheless, a young demographical profile and high agricultural labor force does not necessarily indicate that agricultural labor force involves youth. To better understand about youth involvement in agricultural businesses, Figure 20 shows share of students graduated from agriculture relevant fields.

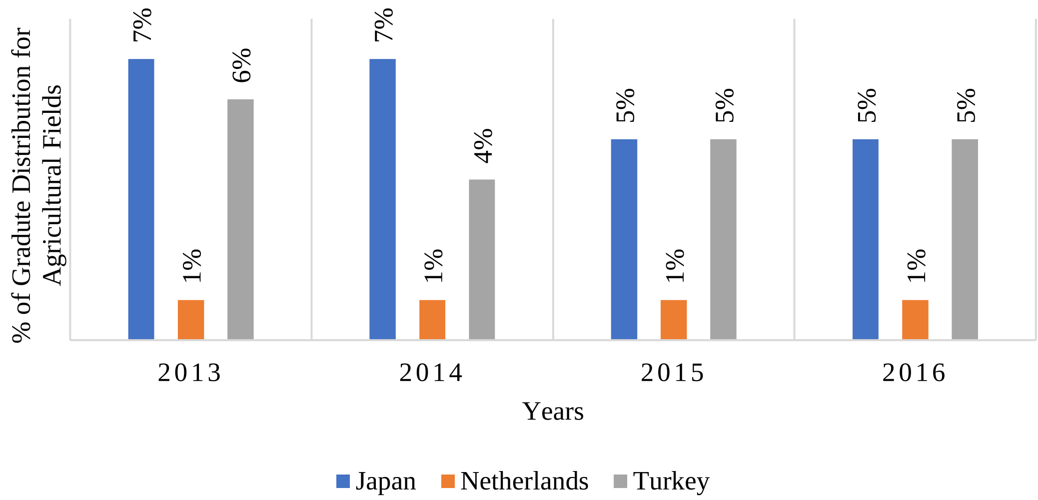

Figure 20: Distribution of Graduates by Field of Agriculture

Source: OECD, Education at a Glance Database. Graduates by Field

As per given in Figure 20, highest share of graduates is in Japan, in parallel with the highest population rate among all three. On opposite side, latest data shows that master or equivalent degree students in Turkey show higher rate of enrolment to agriculture related fields, compared to the Netherlands and Japan (OECD, 2020). Combining all, agriculture seem to be appreciated as an academic field by Japanese society. Turkish agricultural workers, on the other hand, may not necessarily pursue their education to take part of the agricultural businesses.

Part of existing human resource involves Syrian refugees living in Turkey. Refugee responses in livelihood, agriculture, and rural development are not addressed in this thesis. Nevertheless, Syrian refugees is now an important part of agricultural labor force (Kavak, 2016). To address socio-economic results of such immense migration flow, many countries are supporting Syrian refugees to ensure their resilience. The Netherlands (as part of EU) and Japan are among those countries (FAO, 2021; *The EU Response to the Refugee Crisis in Turkey*).

Migrants' contribution to labor force is a result of seeking income generation opportunities, rather than reflecting a specialization on greenhouse cultivation. For that reason, Syrian migrants are taking place of local seasonal workers from time to time, which is creating a discomfort in rural regions in Turkey (Kavak, 2016; "Syrian Refugees Harvest Greenhouse Vegetables in Turkey's Osmaniye," 2018).

4.6.3 Additional Evidence through Surveys and Questionnaires

First, human resource and skills allocation are elaborated. Besides educational opportunities, it matters to understand perspective on pursuing a career in agricultural field after graduation. Most mentioned issue about human resource in greenhouse operations is the aging demography of workers. Due to unpopularity of agricultural departments, young labor force prefers non-agricultural labor. In some cases, producers confessed that they were obligated to work in agricultural sectors due to market conditions. For people who have a choice, they prefer to shape their future in big cities with different professions.

> *"Youth in rural areas prefer to go to rural cities and work as security guard in shopping malls instead of doing agricultural or animal husbandry works."* (Interview No 5)

Due to aging labor force, greenhouse operations are becoming more dependent on seasonal agricultural labor force. Main problem of seasonal labor force is the (un)availability at the right time. Harvest periods cannot be skipped because products would be hampered without timing. Seasonal worker availability, on the other hand, cannot be ensured all the harvest period. This creates a risk in overall sector, especially for small and medium sized greenhouses. For large-sized greenhouses, this problem is found manageable thanks to robotic solutions.

Practices to make use of available human resource are also available. Social integration issues in certain cities are addressed through agricultural operations. An example from Bingöl is given during interviews:

> *Currently strawberry production is active in greenhouses in Bingöl. This was a project we started with development agencies to rehabilitate families impacted by terror. Same operations are active in Diyarbakır too. Thus, the majority of workers are female, so it provides a great opportunity in gender balance issues in labor force and they produce very good products.* (Interview No 5)

Promoting minorities, women employment and other vulnerable groups is possible thanks to agricultural activities. Making use of qualified human resource, on the other hand, is not always possible. A smart agriculture expert from Chambers of Agriculture specifically indicated that he/she is not able to work in this field. Coupled with examples from young labor force and smart agriculture expert, a mismatch exists in allocating existing human resources. Instead of being a source of economic development or an advancing sector, agriculture is mainly addressed by needy groups and dependent workers.

In case of financial sources and concerns, 80% of cases see high operation costs as main problem in greenhouse operations. The fact that the majority of interviewed cases were small and medium sized greenhouses, operation costs are major concern for them. Hence, greenhouse owners tend to skip government support opportunities because their operation and land area are not large enough to apply. This hesitation is expressed via following:

> *For example, this year, 15 thousand decares of greenhouses were built in the Antalya region. 15 thousand decares! The cost of a decare of greenhouse is about 80 billion-100 billion of TL. And the state provides 70 percent incentives for them (large-scale businesses). If a small-scale grower goes to the bank and expresses an interest to build a greenhouse, it is impossible for him/her to take this amount of money as credit. There are huge injustices (between large- and small-scale businesses).* (Interview No 6)

This argument is also supported by other problems mentioned (e.g., low socio-economic status of producers, agreements large amount of deferred payments, high financial risks for investment, impacts of inflations in economy, and no self-sufficiency as sector). To that end, producers' main target is to optimize input costs.

This is also confirmed by 90% of cases seeing technology as an advantageous tool for having financial opportunities. Yet, financial concerns are always acting as a barrier. Producers explain their financial concerns to adopt more advanced technologies by following:

- *As in all technologies, greenhouse technologies have high investment cost. Even if we have necessary knowledge and infrastructure, we cannot use it.*
- *We have to act within the limit of our budget.*
- *If there is no government support, we continue with the equipment we have.*
- *People start using technological equipment once they increase their productivity.*

From all, financial incentives and supports given by the government are limited with heating, energy saving and credit application purposes. Direct supports on agricultural technologies to increase productivity are not available at this time. As emphasized in F5, policies and supports are again not addressing productivity problems of farmers and greenhouse owners.

Under F6, three problematic subjects are identified. First, aging labor force in agriculture and shift of youth to other careers creating a risk to lose existing tacit knowledge. Second, agricultural works are not perceived as a promising path for future. For that reason, overall sector responds to mainly survival needs for low socio-economic community and disadvantageous groups. Third, government supports are not directly given for technological improvement. Existing supports and initiatives are limited with energy saving concerns and credit opportunities, all of which are challenging to apply for small-size greenhouses. Along with potential outcomes, these subjects are re-examined in Chapter 5: Discussion.

Next chapter proceeds with F7: Public Awareness and Information Network.

4.7 Public Awareness and Information Network (F7)

Awareness and positive experience sharing have a direct impact technology diffusion, which lead markets to adopt technologies or even to lock-in. In agricultural businesses awareness is shaped by users, rather than technology providers. As Daberkow and McBride (2003) suggest, farm and farmer characteristics play an important role in the strength of public awareness of precision agriculture. Heterogenous characteristics of farms makes awareness level an inefficient function of technology adoption. Yet, efforts to learn about precision agriculture must be explained to predict market readiness level.

This function is highly correlated with market formation and knowledge spread among all parties. To understand the efforts on information sharing on precision agriculture, several mediums and measures are identified: Google trend analysis, website evaluation, social media analyses, and other networking events.

4.7.1 Google Trend Analysis

Google Trend Analysis provides a generic statistical data for google search engine, depending on the keyword and location-based search counts. To ensure a common ground on search trend analysis, keyword searches are analyzed both in English and local languages (Table 12).

Table 12: Subject Specific Searches of Agriculture in Google[24]

Japan	The Netherlands	Turkey
Animal	Glencore Agriculture	India
Pesticide	Deere & Company	Emirate
Agricultural Lands	Tractor	Urban Area
Human	Regenerative agriculture	Iran
Precision Agriculture	Institute	Australia

Source: Google Trends, recorded on June 2020

According to google searches in the last 5 years, Turkey has the highest research effort on "agriculture", in terms of number of searches (Appendix 16). The details on this search effort is elaborated through specific subjects linked with keyword search.

In Japan, 2019 keyword search results involved "science of agriculture", "community supported agriculture", "precision agriculture" and "conservation agriculture". These results indicate a technical and information-focused research. In 2020, "precision agriculture" remained in the top-5 keywords. That being said, public awareness and openness to further development are part of Japan's potential towards agricultural development.

In the Netherlands, 2019 and 2020 specific topic results are almost the same. While "University of Agriculture in Makurdi" and "intensive farming" were added to 2020's results, "Glencore Agriculture" took part in both time periods. Among three countries, the Netherlands is the only location where firm level search is in place. This gives some thoughts about the share of farming in business activities and in overall national economy.

In Turkey, specific results of 2020 involve geographical research, which could be an indication of export and import value of agriculture. Results from August 2019, on the other hand, had "drones", "expo" and "land" as specific search results. Considering all, public search effort seems to be made on the role of agriculture in international trade.

Individual searches on agriculture differentiate three countries in terms of their perspectives towards agricultural development. While Japan focuses on scientific and

[24] Specific search trends are analyzed on both August 2019 and June 2020

technical development opportunities, the Netherlands and Turkey concentrate more on commercialization of agricultural practices.

4.7.2 Website Evaluation

Websites are among the most informative and comprehensive online community mediums. Accordingly, designs and presentation of websites give a far-reaching and target-specific research opportunity. Well-adopted website designs could build loyalty for visitors and support the information sharing (Tahir & Mushtaq, 2015). Different from individual level efforts on agricultural search, website evaluation methods show efforts made by institutions. In that context, website evaluations do not necessarily affect the accuracy or impact of information given, but rather focuses on ability of retaining visitor attention. In this comparative analysis, official websites of ministries of agriculture are selected to evaluate. Performance scores of each website is detailed in Table 13.

Table 13: Visitor-Based Evaluation (Summarized)

Main Indicators	Sub-Indicators	Questions Asked	Best Performance
Identity	Corporate logo available, Organizational chart available, Contact information available, Site map available, Mission and vision available, Website aids, tools, help sources available, Website domain available	*Does the website have its own identity?* *Do users clearly understand corporate identity?* *Do users understand organizational functions?* *Are further assistance tools available?*	All have the same performance
Loading & Viewing	Page size, Page requests, Page speed, Minimal page redirection, Standardized page formats are present, Image Sizes are not taking time to download, Text is downloadable	*What is the speed performance of the website?* *Do users reach the page they search easily?* *Does website enable users to share information?* *Does the website attract user attention?*	The Netherlands

Table 13 (continued)

Navigation	Menu structure is present, vertical - horizontal scrolling minimized, Standard navigation options available, Keyword and advanced search available, Descriptive link texts are available, Links are not broken, Permission to Index available, Clear site organization	*Is the website search-friendly?* *Do the navigation functions seem reliable?* *Does navigation take too much time for user?* *Are navigation results structured and systematic?* *Does the website enable users to reach accurate and relevant information?*	The Netherlands
Interactivity	Printer-friendly version available, Access to data is possible, E-mail communication, Forum/comments and FAQ available	*Is the website informative or communicative?* *Are there platforms to ask further information?* *Does website promote users to spend time to research?*	Japan
Comprehensibility	Forms are self-explanatory, Local language and English options available; Font sizes are appropriate, Mobile friendly tap, Eye-catching	*Does the website attract both national and foreign users?* *Is the website context understandable?*	Turkey
Personalization & Content	User specific services are available, Subscription is possible, No under construction page, User-friendly for disabled users, E-library is available	*Does each user reach to the same content?* *Is it possible to personalize tools for specific usage?* *Is the website comprehensive and carrying for everyone?*	Turkey
Information Quality & Up-to-Date	No incorrect information, Information is up-to-date, Date of information is given, Links to related sources present, Information on planned updates given	*Is the information given trustworthy?* *Is the information given is scientifically useable?* *Does the website provide data release schedule?*	Turkey
Security & Miscellaneous	Includes privacy statement, Updated Javascript Libraries are available, Https secured	*Is the website secured?*	Turkey

Sources: http://www.maff.go.jp, https://www.government.nl/ministries/ministry-of-agriculture-nature-and-food-quality, https://www.tarimorman.gov.tr

While performance evaluations on sub-indicator level is given in Appendix 17, all three websites found to be stronger in different aspects. Nevertheless, main objective of this evaluation is to see which one of these websites is more user-friendly, trustworthy, and attractive to catch largest user pool.

While cultural aspects play an important role in addition to above indicator performances, https://www.tarimorman.gov.tr seem to have the best visual inputs to inform visitors not only about ministry itself but also overall sector through different media sources. Live nature broadcastings and digital agriculture library, to exemplify, are only available for this web site, which considerably attract user attention and time spend in web site.

4.7.3 Social Media

According to GFRAS's global survey in 2015, Facebook is found the most popular social media for people actively working in agricultural sectors (Bhattacharjee & Raj, 2016). Additionally, Twitter and YouTube are also among preferred social media channels for farmers (Brewster Christopher et al., 2018). Main objectives of using social media network, according to this survey, are to share information, publicize relevant events, and find stakeholders for business purposes.

4.7.3.1 Twitter

To evaluate the visibility and communication coverage of precision agriculture, #precisionagriculture has been analyzed through Hashtagify.me website. As of July 2020, #precisionagriculture has 29.2 point of popularity on Twitter, with following related hashtags: #agtech, #bigdata, #agrciulture, #IoT, #farming, #twitter, #UAV, #robotics, #farming and #AI. Hence, Twitter analysis showed that 89% of tweets were written in English while 1% were in Dutch. Therefore, the Netherlands' 7.69% of tweets involving #precisionagriculture indicates a good social media coverage on that subject.

Observations in local languages showed that "*精密農業*[25]" has a popularity point of 11, while "*precisie landbouw*[26]" has 21.2 popularity point and "*hassas tarım*[27]" has 6.7 popularity points (Appendix 18). As a result, regardless of language preference, the Netherlands seem to have the best social media awareness level for precision agriculture, compared to Japan and Turkey.

4.7.3.2 Facebook

Facebook usage differs for each location and members from agricultural businesses. Social media studies in Japan are quite new. For example, social media studies in Japan started as of 2011, after Facebook became a popular social network (Onitsuka, 2019). Even though Facebook analyses are quite new in that context, importance of virtual network is recognized by many farmers as "imperfect but necessary" for business purposes, which makes Facebook a preferable source for information sharing (Zollet, 2018). Similarly, 75% of local farmers in the Netherlands found using Facebook to check the news in the sector, products, and equipment along with tracking suppliers (Gielen, 2014; *More Dutch Agrarians Active on Social Media | AgriDirect*). Turkish farmers, in parallel with others, also use Facebook actively to share their experiences and ask for further assistance from other farmers especially in "Akdeniz Çiftçi Grubu".

In parallel with the population rate, Turkey has the highest Facebook user number and highest number of actions of users by 31.2 million, compared to Japan (19.7 million) and the Netherlands (17.7 million), recorded by https://www.facebook.com/analytics. Nevertheless, based on the Facebook usage analysis between July 2019 and July 2020, user activities as in post sharing, post comments and post reactions are in favor of users from the Netherlands. Thus, post reactions of users are recorded around two times higher for the Netherlands (4.35 B)

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[25] Precision Agriculture in Japanese

[26] Precision Agriculture in Dutch

[27] Precision Agriculture in Turkish

compared to Japan (2.17 B) and four times higher again for the Netherlands compared to Turkey (1.45 B).

In case of the Netherlands, while Facebook usage rate recorded as 78%, YouTube remains the second source with 44.3% usage rate, according to a communication research that AgriDirect conducted in 2019 (*More Dutch Agrarians Active on Social Media | AgriDirect*). Almost half of agricultural workers older than 65 years are also actively using social media, which indicates a good catching up trend for demographical challenges in agricultural field (*More Dutch Agrarians Active on Social Media | AgriDirect*).

4.7.4 Other Networking Events

Even though expositions, conferences or seminars are not quite part of online information network chain – excluding socially distanced events held due to COVID-19 –, these events provide a good source for networking and increasing awareness on the updated practices in agricultural field.

To have a generic comparison, largest cities of three countries are examined by their planned conferences for the next three years in agricultural fields. These conference plans are announced before global COVID-19 pandemic. Istanbul, with 312 planned conferences ranks at first, followed by Tokyo and Amsterdam with 234 and 175 conferences respectively[28]. In addition to quantitative data on network events, scope of planned or completed activities carry up most importance. To understand generic concepts of relevant network events, major event promotions are examined and detailed as following:

- Japan Greenhouse Horticulture Association organizes the largest trade show in greenhouse and plant factory technologies (*ABOUT GPEC | GPEC 2021*).

[28] https://www.conferenceindex.org/conferences/agriculture/japan

https://www.conferenceindex.org/conferences/agriculture/netherlands

https://www.conferenceindex.org/conferences/agriculture/turkey

- “Get into the Greenhouse” weekend has been organized in first week of April, to represent vegetable, flower and plant cultivators especially to children emphasizing high-tech greenhouses (*Get into the Greenhouse - Holland.Com*).
- High Tech Greenhouse event is organized under Dutch trade fair Horticulture Business Days Gorinchem, as part of an initiative of Dutch and German businesses to consolidate their business to produce an integral high-tech greenhouse system (Schlepers, 2016).
- GreenTech, addressing to businesses in horticulture technology, involves exhibitions in the Netherlands and Mexico (*All Eyes on Horticulture | GreenTech*).
- Growtech is gathering exhibitors from numerous countries and businesses on greenhouse technologies, agricultural equipment and machinery, irrigation, seed growing, cultivation, nutrition, biological control and agricultural journalists in Turkey (*Home | Growtech*).

Gathering all, awareness raising events for greenhouses and overall agricultural development are present for all three countries, in which the Netherlands is distinguished by targeting children and general public in addition to government bodies, agricultural businesses and trading organizations.

4.7.5 Additional Evidence through Surveys and Questionnaires

Greenhouse owners are generally following technological developments, regardless of whether they can afford or apply them or not. All interviewees gave exemplary sources, where they keep up new agricultural technologies. Thus, one of them added:

> *Turkish farmers are not easily accepting technological changes. This situation applies to all fields of agriculture. Yet greenhouse workers are more reasonable in accepting innovative approach compared to workers in animal husbandry or plant production.* (Interview No 8)

Several producers mentioned that they select mentors in the same location. These mentors are usually agricultural workers who has long-lasted field experience and no background. Younger greenhouse owners are preferring to discuss business problems they face with them.

Thus, social media is highly in use, especially Facebook groups. Objective is not only to share experience, but also to establish a social network. Sending a picture of diseased plant, sale information of production materials or promotion of equipment used by someone are some examples of Facebook posts.

In terms of networking and experience sharing, greenhouse owners and workers are preferring face-to-face gatherings in addition to social media. Gatherings in local coffee houses are among the most common network hubs. Farmers, greenhouse owners, and other local people are gathering in coffee houses to socialize, yet also to discuss daily issues. Having such medium enables producers to get an advice for their problematic issues and to observe results of new methods. To exemplify, following is shared in one of the interviews:

> *If somebody renews his car often, this might mean that he is profiting with the production method. At that point, rather than asking and discussing, other producers search, find, and apply the same method or tool. This motivates producers because once they saw the good results; they are convinced that it's not a bad investment.* (Interview No 5)

Last, greenhouse owners are asked whether they have their own website. Large greenhouses are handling their operations under a corporate brand. That is why, websites are always available. On the other hand, website usage is seen as another operation cost for smaller greenhouses. Meaning that, they do not always have the time or labor force to check and update websites or similar platforms. Therefore, not having a website sometimes become a part of input optimization. Bearing all in mind, awareness and information networks are not just informative, but also promotional. While online sources are important to examine, face-to-face networks matter greatly to improve current businesses. Under F7, following issues are identified: (1) underusage of existing public information, (2) seeking personal knowledge and experience-based advisory, and (3) seeing promotion as operation cost. Issues seen in this function is interlinked with all other functions in terms of seeking how actor perceptions are shaped. Yet, there are several important points to bear in mind for policy recommendation. These points are given in Chapter 5: Discussion.

Next chapter proceeds with additional findings generated through interviews, but cannot directly linked to functional analysis.

4.8 Additional Findings Generated through Interviews

During interviews, additional topics emerged beside of identified sub-functions. Even though these findings are not directly related with the analysis, they have an impact on policy recommendations.

First, the potential of technological solutions against existing greenhouse operation problems are evaluated. Turkey is located in an advantageous geography for agricultural greenhouse operations. Thanks to soft climate, heating is not a major concern and natural resources are in favor of agricultural production. Nevertheless, there are still areas for further development and productivity.

Second, technical and operational problems are identified under six categories. These are: (1) financial concerns, (2) products without long dates of expire, (3) heating problems, (4) disinfection issues, (5) lack of safety precautions, and (6) product safety problems.

To test the advantage of technological solutions, all problem categories are further elaborated. Objective is to see whether current or more advanced technologies are sufficient to respond producers' problems.

Product expiration dates are strongly related with the time spend by intermediary firms. Spending time to transport or damaging product quality on the road are potential risks in agricultural sale. For fragile products, as fruits and vegetables, those risks carry even higher importance. Expiration date concerns create product safety issues for merchandise sellers and end-users. SPA technologies, in that sense, provide a transparent production system, so that producers become more confident about the quality of their products.

Heating problems is mainly occurring or prevented by the location and level of modern applications in greenhouses. Even though location of greenhouses is not something producers can control, climate arrangements within the greenhouses could easily control even from distant places. Again, greenhouse monitoring, and remote-control systems are providing producers to maintain the most productive conditions and to address plant needs.

Disinfection is specifically mentioned as a problematic issue that can be solved with scientific and technological methods/tools. Not only the ability to identify relevant plant problems, but and efficient disinfection without damaging any other plant is challenging. Identifying diseases on the plant-specific level and precise treatment solutions provide best recipe in greenhouse cultivation. Yet, practical methods have different challenges.

The backbone of SPA consists of methodological approaches to address different types of plants and applying different equipment. Whilst differentiating each plant in terms of the need, disinfection is also applied plant-based level in SPA. Therefore, applying such advanced method would be a beneficial solution for producers.

Safety measures taken by producers are found inefficient, especially compared to practices taken in other countries. This concern takes higher share for small and middle-sized greenhouses. Similar approach in product expiration dates and safety problems comes into light for this problematic as well. Through a transparent and traceable operation system, existing safety measures would be also improved. By applying disease control methods, identification of sources of damage becomes easier.

Throughout the history, greenhouse operations and equipment have shifted towards more technology-oriented solutions. Even though different sized greenhouses have different needs, technical skill and interdisciplinary approach are always required to take the sector to the next level. Solution, in general, is linked to applying technological solutions and new production methods.

As Figure 21 illustrates, advantages of technology are mainly corresponding to financial opportunities, followed by optimizing labor force, increasing food quality and having higher export rate of qualified products.

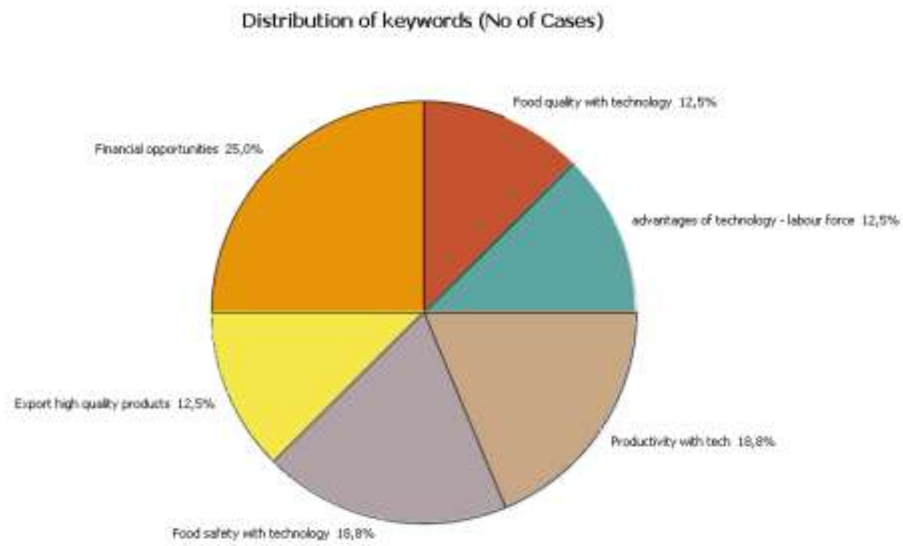


Figure 21: Most common advantages of technology in greenhouses

Hence, advanced greenhouse technologies found to be addressing different technical and operational benefits. Productivity, time saving, optimization, better climate arrangements, promoting food health and safety measures and solution for disinfection are among those benefits.

In Turkey, full automated greenhouses don't not exist. Instead, there are half-automated greenhouses and precision agriculture practices in large and medium sized greenhouses. Medium sized greenhouses are in general using climate solutions, seed production and laboratory practices for agricultural R&D. Large sized greenhouse, on the other hand, seem to pass through these solutions and ready to move on full automated operations. Considering the definition and the way of application of SPA in greenhouses, middle-large and large size greenhouses could have the greatest benefit.

Large-size greenhouses have large trade network. International experience and information sharing, therefore, enables a good knowledge transfer among greenhouse branches. In parallel with the sale and export size of large greenhouses, enthusiasm to move forward to full-automated operations is clearly seen. R&D in these greenhouses are based on seed improvement and human-machine combined monitoring. To go one step further, improved monitoring systems, robotic work force and algorithmic data integration should be integrated to daily operations. While human workforce is desired to keep at minimum level, SPA promoting technologies are quite suitable and financeable for large greenhouses.

Medium-large sized greenhouses, on the other hand, conduct R&D activities either in-house or outsourced for seed improvement. In order to catch up with large-sized greenhouses, existing plant status should be constantly monitored. While improving the quality of greenhouse cultivation, such data collection benefits for tailor-made R&D. This operational change could be handled with the sufficient human resource and technology adoption.

Medium and small-medium sized greenhouses are having difficulties in surviving in the market. None of interviewed cases mentioned a none-sale period, however a constant financial short cut is found necessary. Being located to the farm market to reduce transportation cost is an example to make such short cuts. Yet, some of the medium and small-medium sized greenhouses are willing to put much effort to improve their businesses. Producing cherry tomatoes instead of another kind to reach out high-quality demand is one example. SPA and relevant technologies, with this aim, could be effective in business improvement and in targeting wider customer segments.

Observations in functional analysis has several persuasive conclusions for recommending policy instruments. To re-visit all analyses and design a comprehensive framework, Chapter 5 is discussing functional findings.

CHAPTER 5

DISCUSSION

This chapter re-emphasizes findings from functional analysis and additional findings. Based on the summary of important points, identified issues are discussed to ensure recommended policy instruments are feasible with dynamics of target TIS. Following the order of functions in this thesis, Knowledge Development and Diffusion (F1) is summarized in below Table 14.

Table 14: Summary of Knowledge Development and Diffusion (F1) Findings

Findings for Japan and the Netherlands		**Findings for Turkey**
Japan	– Agriculture and technology are prioritized in academic institutions – Scientific and technological developments are the basis of agricultural development – Government expenditures for agricultural research is high	– Agricultural R&D is knowledge-development oriented, rather than diffusion-oriented – University-industry collaboration requires further attention – There is no agricultural technology concentration in academia – Agricultural studies and university departments are not sufficient – Field practices acquired from family business or other greenhouses are more valuable – University curriculums need an update
The Netherlands	– Knowledge diffusion is high – University-industry collaboration activities and commercialization concerns play an important role – Trade and business contributions matter in agricultural studies	

Knowledge generation is at a higher rate compared to knowledge diffusion in Turkey. Comparing knowledge diffusion factors with the Netherlands, not being a member of EU might be a reason. Alongside of trade flows, EU member states have high collaboration rates to strengthen the unity. Having an enabling environment creates a difference in terms of knowledge diffusion.

In parallel to low level of knowledge diffusion rates, policies are designed to promote knowledge development. Even though knowledge development is a crucial baseline to put everything on top, existing resources are misused because of not diffusing it.

To exemplify, without university-industry collaboration, it is not possible to adopt scientific and technologic development in agricultural works. Hence, having high number of agricultural researchers with low amount of government budget on agricultural R&D is also indicates a low priority of agricultural development in Turkey.

Additionally, university education and existing curriculums are said to be outdated in terms of new methods and tools of production. If academic institutions and national education policies prioritize other fields, agricultural workers are left by themselves to discover operational aspects. Seeking tacit knowledge and experience-based advisory services are highly common for greenhouse owners.

There are two side-effects of this issue. First, greenhouse owners tend to lock in traditional or outdated methods to conduct their businesses. Such lock-in prevents them to develop their businesses and increases the gap between small and large size greenhouse operations.

At some point, it also creates a hesitation towards technological or engineering solutions as well. Second, because of difficulties faced by current greenhouse owners, children of those families are pushed away to follow other career paths. This career shifts fastens the loss of tacit knowledge because children of greenhouse owners might never know the technical specialties and tacit knowledge acquired from decades of production.

To proceed, Entrepreneurial Activities (F2) is summarized in below Table 15.

Table 15: Summary of Entrepreneurial Activities (F2) Findings

Findings for Japan and the Netherlands		**Findings for Turkey**
Japan	– Entrepreneurship remains limited because of risk averting culture and steady life trends	– Entrepreneurial activities are motivated by financial concerns

Table 15 (continued)

The Netherlands	– Agricultural entrepreneurship is not entirely preferable, but academic entrepreneurship and lab experiments are – Entrepreneurial activities are made for development purposes – Agricultural export has a positive impact on agricultural entrepreneurship – Farmers are acting as entrepreneurs in their businesses through non-farm activities – Government regulations promote risk-taking actions when business opportunities arise	– Agricultural entrepreneurship depends on individual efforts – Multiple stakeholders and variety of responsibilities create managerial problems in greenhouses – Financial and technical capabilities create a gap in entrepreneurial activities among greenhouses – Greenhouses require financial support, guidance, and training opportunities for entrepreneurial activities – Interdisciplinary studies are lacking for agricultural entrepreneurship and development

Entrepreneurship depends on numerous dynamics in a system. Within that framework, agricultural entrepreneurship has even a more distinctive characteristics. Yet, one common point found among different systems is the promotional incentives for entrepreneurs (greenhouse owners). In Turkey, agricultural investment is mainly depending on the farmer's vision and financial capabilities. By meaning of financial capabilities, greenhouse size also plays an important role in actualizing entrepreneurial activities. Due to unavailability of financial resources, improving greenhouse cultivation through entrepreneurship and investment is not always a preferred choice, especially by small farmers.

There are several factors affecting entrepreneurial activities as migration to urban cities, different roles of greenhouse owners, numerous stakeholders for the same arable land, and aging demographics. Adding all constraint together, families also motivated to push away their children to other sectors. Yet, these greenhouses involve high level of traditional knowledge and value-add for the market. It is therefore up most important to consider small-sized greenhouse needs and possible problems in the future business. The reason is, once traditional knowledge disappears, entrepreneurship and innovation also lose an important complementary source of knowledge.

Next, Guidance of Research (F3) is summarized in below Table 16.

Table 16: Summary of Guidance of Research (F3) Findings

Findings for Japan and the Netherlands		**Findings for Turkey**
Japan	– Government’s agricultural support aims to ensure self-sufficiency against natural disasters and limited resources – Total unit of farm machines and machinery capital are high – Government has a leading role in reinsurance, regulation and design of agricultural systems and insurance schemes – Food prices and food expenditure rates are at the highest – Greenhouse infrastructure and equipment are outsourced, but updated with location-based needs – As part of Society 5.0 objective, SPA is part of Japan’s national agenda and innovation trends in agriculture	– Agricultural machinery resources are covering around 20% of total agricultural workers – Food consumption rates and food expenditures are at the highest, while the food price is at lowest – Engineering and manufacturing skills of greenhouse construction sector are strong – Greenhouse manufacturing firms are at the highest in number – Only limited number of firms are providing a technical service for growers after the construction and manufacturing works are done – Digitalization policies are not directly addressing greenhouse cultivation – Majority of farmers have only basic and outdated technologies on hand – Business cultures are not always ensuring plant health – Systematic and controlled authority for price regulations is not present
The Netherlands	– Total unit of farm machines and machinery capital are lowest, however machinery capital per worker is at highest – Private institutions are active in providing greenhouse systems and insurances – Greenhouse insurances are – covering technological risks as much as natural risks, specifically addressing high-tech cultivation equipment installation – Greenhouse constructions are based on scientific solutions and location- based requirements – Training, coaching, mentorship and education programs are available in addition to tools and equipment of greenhouses – Dutch Digitalization Strategy and agricultural research strategies od EC emphasize sustainable agriculture	

First issue under F3 is the perception towards food health and security. Looking at GDP, food consumption, food price rates, and cultural dynamics, Japan might be more sensitive towards the quality, nutrition, and health concerns. On the other hand, food safety and health concerns are still underdeveloped at production level in Turkey. Lack of a transparent tracking system also affecting food health concerns at production level.

Second issue is the inability to adopt engineering and technology solutions. While there is a competitive engineering infrastructure and knowledge for constructing modern greenhouses, the majority of greenhouses are still using traditional methods. One of the barrier against adopting technological l solutions is the lack of support services. Even though Turkey has necessary infrastructure to develop a technology, it might not be properly introduced to end user. At this point, knowledge creation is again at higher rate than diffusion. Once the end user (greenhouse owner) experiences a negative issue with the tool or equipment, it is harder to convince them to adopt technological solutions. Simply because, producers feel lonely when they experience challenging conditions, which also feeds the unthrusting environment.

Third issue is the lack of digitalization policies in greenhouse sector. Even though there are policies and steps towards digitalization, they are not directly linked to greenhouse cultivation. Non-prioritization of greenhouse cultivation is observed under numerous issues. Relatedly, public policies are not addressing specifically to this sector neither. This issue is also one of the reasons why this thesis tries to propose policy instruments.

Fourth issue is the financial constraints influencing business decisions. Financial concerns are the most frequently mentioned issue in greenhouse operations. In fact, many business decisions are depending on minimizing inputs costs. These decisions include but not limited with the place of greenhouse, market to sale products, business relationship to establish, and complementary products to buy. In simple words, greenhouse owners are avoiding as many risks as possible because the sector has great financial risks. Within this framework, producers are caught in the middle of paying too much to foreign brands to ensure product safety and being crushed by local dealers' monopoly.

Passing on the functional analyses, Market Formation (F4) is summarized in below Table 17.

Table 17: Summary of Market Formation (F4) Findings

Findings for Japan and the Netherlands		**Findings for Turkey**
Japan	– Greenhouse market is an important source of crop supply especially for vegetables and fruits Government promotes next generation greenhouse cultivation models to adopt controlling systems Large greenhouses joint their experience to empower their technologies – Greenhouse associations focus on interlinking academic expertise and technical improvement of existing businesses – Production is desired to address in-country businesses, rather than serving to export-oriented objectives – Growing service sectors (hotels, restaurants, and food service industries) increase the demand of high quality and safe food	– Heating and cooling technologies are increasing; however, traditional production systems are still in use – Share of modern greenhouses remains between 1-2% – Financial barriers seem to prevent overall market growth – Value of agricultural production and value add for agricultural activities are highest – Greenhouse associations address to construction and equipment relevant concerns – Rather than observing a collaborative work or scientific contribution, there is more a division of work and services – Tomato is the most export-oriented product – Political sensitivities influencing agricultural trade – Medium and large greenhouses are dependent on foreign subsidiary products – Small greenhouses are dependent on non-regulated pricing of local dealers to obtain subsidiary products – There is a high trust concern in overall sector – Small and medium sized greenhouses are dependent on intermediary businesses to reach end user – New entrants are not quite familiar with the technical aspects of managing greenhouse cultivation – Relationship between chambers of agriculture and producers are limited
The Netherlands	– Merge of large local growers is observed as a response to sectoral troubles – Greenhouses apply market-oriented concepts – Quality audits, food safety, and pesticide residues are among major concerns – There are centralized and structural dynamics in the market thanks to mergers and joint works – Integrating technological solutions to modernize greenhouse systems is part of government objectives – Greenhouse associations emphasize a collaborative work environment, involving counterparts as academia, public institutions and private sector – Agricultural export carries high importance	

Greenhouse market in Turkey has two major dependencies: one on exports and other on intermediary businesses. Export dependency is one of the upmost crucial and sensitive issue for greenhouse cultivation. Greenhouse products are mainly exporting to Russia, rather than domestic market or a group of international buyers. While such trade relationship is observed in other countries, agricultural trade is more sensitive to political relations in Turkey.

Dependency on intermediary businesses is observed by producers' trust issues in the sector. Large size greenhouses are eliminating such dependency by establishing their own marketing and sale channels. Yet, smaller greenhouses are settled down to conditions proposed by local traders and dealers. Without these intermediary actors, producers are not capable of reaching out the end user. Visa-versa, end users (consumers) are also dependent on charges and self-assigned profit shares of intermediary businesses.

At that point, greenhouse workers are seeking advice on how to react against those dependencies. In theory, Chambers of Agriculture and cooperatives should play a guiding role. Nevertheless, all interviewed greenhouse owners indicated that civil servants working in Chambers of Agriculture do not anything to address producer needs. On the side of agricultural engineers and advisors working in Chambers of Agriculture, bureaucratic procedures are blamed for not being able to go on field and assist producers. It is not possible to link this collaboration problem entirely to bureaucracy, however; small changes to save paper works might lead to greater results. Continuing to next function, Creation of Legitimacy (F5) is summarized in below Table 18.

Table 18: Summary of Creation of Legitimacy (F5) Findings

Findings for Japan and the Netherlands		Findings for Turkey
Japan	– Technology policies are comprehensive for each sector, including agriculture Food education system, environmentally friendly farming against agricultural chemicals and farmer income stabilization were among the actions taken by policy makers and regulative powers	– Fragile lands, climate change, and environmental degradation are addressed by government policy and programs – Agricultural initiatives are dependent to international donor support – Good agriculture practices have started to take part in regulations as of 2004 and keep updated with more specific targets

Table 18 (continued)

The Netherlands	– Technological tools, equipment, and knowledge are addressed through automated system adoptions – Precision agriculture is among the most observable areas along with reducing the greenhouse operation costs, promotion of climate resistance, and facilitating factors for better farm management – Government interventions in agricultural policies involve scientific and technological inputs – CAP has a flexible and result oriented context – Government supports agricultural research, education, and training along with financial supports – Ecological, climatic, and welfare problems are among policy concerns – Innovative breeding and optimization of pesticide usage are addressed in government policy and plans	– There is no direct indication of precision agriculture on legislative level – Regulations on vegetables, fruit, and flowers are appearing via protection of soil, decreasing dependence on agricultural medicines, applying right treatment based on soil and plant requirements, obligation to optimize fertilizers, water resource management – Safe food and quality of foods are encouraged by government strategies – 11th Development Plan involves supportive measures to modernize existing greenhouses – There are numerous indirect but effective plans and programs to disseminate precision agriculture practices – Strategies specifically targeting precision agriculture remain on the research and development level – Government supports and policies are mainly finance and energy saving focused

Trust issues in greenhouse sector is once again observed in F5. There is a reciprocal issue in existing and non-existing regulations to support greenhouse owners. From producers' side, current supports and incentives are not addressing their exact needs. Yet, some producers are taking advantage of existing supports for their own desire. In other words, some producers are found to apply and get government support for personal usage, rather than improving their business. To address this issue, necessity of a standardized, transparent and auditable system is mentioned. A systematic process to monitor and regulate greenhouse operations and relevant value chain would also eliminate negative effects of ministerial changes. Meaning that, people would always change in government system, however establishing a strong system prevents negative influences of any transition.

Next, Mobilization of Resources (F6) is summarized in below Table 19.

Table 19: Summary of Mobilization of Resources (F6) Findings

Findings for Japan and the Netherlands		Findings for Turkey
Japan	– Agricultural sciences have a structured share in R&D expenditures, regardless of sectoral shifts – Decline in newly born rates and increase in life expectancy encouraged the capital accumulation, especially in favor for non-agricultural businesses – Agricultural field graduates are high, in parallel with the highest population rate	– R&D expenditures in agricultural sciences are fluctuating – Budgetary decisions changing according to national focuses – Due to unpopularity of agricultural departments, young labor force prefers non-agricultural businesses as career – Due to aging labor force, greenhouse operations are becoming more dependent on seasonal agricultural labor force – Main problem of seasonal labor force is the availability of workers during harvest period – Instead of being a source of economic development, agriculture is mainly addressed by needy groups – Producers' main target is to optimize input costs
The Netherlands	– The Netherlands has fluctuating R&D expenditures in agricultural sciences – Budgetary decisions are changing according to national focuses and prioritizations – There is a young population, whereas aging started – Contribution to agricultural labor force is moderate	

Aging agricultural labor force creates several risks for greenhouse cultivation. These are: (1) risk of losing tacit knowledge, (2) damage in future innovative activities in to greenhouse operations, and (3) negative perception towards agricultural works.

The fact that younger generation coming from greenhouse businesses are shifting to other careers, tacit knowledge acquired since generations are started to get lost. Without having an experience-based knowledge, new entrants might act wrongly in their own operations. Doing mistakes in a new business is common for all sectors. Yet, the investment and risk of losing financial inputs are higher in greenhouse operation without a strong knowledge base.

Relatedly, people are getting afraid of taking new risks in greenhouse sector. Majority of small and medium-size greenhouses are just trying to survive in the market with short-term objectives. Since it is challenging to maintain a sustainable growth and financial gain, these greenhouses are not considering to improve daily operation. As a result, innovation in those greenhouses, which are at highest in number compared to large greenhouses, remains limited or fall short.

Hence, perception towards agricultural works is linked to a way of survival, rather than a career opportunity. Meaning that, part of agricultural labor is feeling obligated to continue their operations because they do not have another choice. Within such worrywart environment, these people are also trying to push away their children from agricultural labor force. Therefore, existing works are handled by other minority groups as women in need and Syrian migrants. Coupling with those perceptions, government prioritizations and supports are not enlarging their concept to technological improvement. They are focusing mainly on energy saving solutions rather than operational technology support.

At last, Public Awareness and Information Network (F7) is summarized in below Table 20.

Table 20: Summary of Public Awareness and Information Network (F7) Findings

Findings for Japan and the Netherlands		**Findings for Turkey**
Japan	– There is a technical and information-focused research dynamic for precision agriculture – Precision agriculture is among the top searched keywords	– Online searching effort on "agriculture", in terms of number of searches, is at highest – Online searching for agricultural practices is trade oriented
The Netherlands	– Importance of virtual network is recognized by farmers as "imperfect but necessary – Online searches indicate the importance of commercialization of agricultural practices – Social media awareness level for precision agriculture is highest – Awareness raising events for greenhouses are targeting children and general public in addition to government bodies, agricultural businesses, and trading organizations	– Ministry website provides the best context and detail of information – Facebook is actively used to share experiences and ask for further assistance from other farmers – Producers select mentors in the same location to discuss production methods – Agricultural workers also use network hubs as coffee houses to observe other producers and discuss their own business problems – Small and medium sized greenhouses do not always have the human resource to manage social media and website channels

While there are good and rich sources of information, given by government bodies, greenhouse owners tend to engage with other producer either through social media or face-to-face gatherings. In general, greenhouses have closed information networks, because being open to potential customers and other actors require additional operation costs. As a result, it is hard to reach out this target audience (current and future greenhouse owners), especially those working in small greenhouses. Within such mistrustful environment, personal perceptions are also staying within network limits.

CHAPTER 6

CONCLUSION and POLICY RECOMMENDATIONS

There are four sections in this chapter. First section refreshes the precision agriculture and SPA concepts to understand advanced production methods and Turkey's stand on this topic. Second section comes after with details of challenges of greenhouses in Turkey. Additionally, the potential of applying technological solutions is emphasized in this section. Third section summarizes policy recommendations to show ways of diffusing advanced tools and equipment for greenhouse production. Fourth section briefly introduces limitations of the study.

6.1 Greenhouse Cultivation in Turkey and Advanced Production Methods

Turkey is among the top producer countries using protected cultivation. Being located in Mediterranean region and having large arable land area are important factors for Turkey's position as producer. Greenhouse cultivation is among the manufacturing-like field in agricultural production due to its closed and controlled environment. Yet, there are several difficulties in managing these controlled environment. Heating problems come at first in greenhouse cultivation difficulties.

According to existing producers, there are several additional issues to survive in this field. Along with financial barriers, catching up with product expiration dates, disinfection issues, insufficient safety precautions and product safety concerns are the most common ones. For fragile products as fruits and vegetables, these issues are having even more attention.

Greenhouse operations and production facilities have moved across the history of agricultural production towards advanced technologies. Beside of engineering solutions, increasing human capacities in technical know-how and supporting interdisciplinary aspects are compulsory to improve the overall production method. Accordingly, existing producers consider technology as the solution for all expressed problems. Starting from reaching out financial opportunities to increasing food and production quality, advanced tools and methods in greenhouse cultivation return the investment costs.

Scientific literature suggests SPA as one of the advanced production approach in controlled environments. With the aim of establishing a transparent and 7/24 controlled production system, SPA makes producers confident on the product safety and quality. Like so, SPA has a positive value-add on productivity, time saving, optimization, promotion, and increased safety measures.

6.2 Challenging Issues observed in Greenhouse Cultivation in Turkey

While SPA is not fully-adopted by greenhouses in Turkey, it surely addresses to all producer concerns through a standardized and business-level tailoring options. There are several challenges against adopting such advanced production method and relevant technologies. Yet, there is one common word to describe them all: dependency. Businesses are dependent on international trade, import of complementary products, individual effort to improve production methods, financial support, interdisciplinary studies, skilled labor, and politically neutral environment. These dependencies are applicable for different scale and located greenhouses, yet they all need the government to act as the entrepreneur in the market. To have a comprehensive and all-applied policies, dependencies in different functions must be regarded by decision-making bodies. Only by doing that, a sustainable productivity is ensured and maximum profit is gained from minimum inputs.

Dependency issues under different functions are elaborated under seven categories: Knowledge Development and Diffusion (F1), Entrepreneurial Activities (F2), Guidance of Research (F3), Market Formation (F4), Creation of Legitimacy (F5), Mobilization of Resources (F6), and Public Awareness and Information Network (F7).

Main dependency under F1 is to traditional knowledge. Due to missing or insufficient academic concentration towards advancing production methods, students are not capable of applying theoretical information into practice. There are numerous agricultural departments in Turkey, yet only one is ranked in top 1000 universities in the world. Ankara University, in that framework, provides a good theoretical background but lacks technology interlinked curriculums and on-filed demonstrations.

Additionally, existing businesses and scientific researches cannot meet due to financial or infrastructural barriers. As result, scientific knowledge does not diffuse on the business level. That creates a misusage of existing academic resources. Thus, researchers recruited by government institutions seem to have a larger number compared to spending on agricultural R&D. Altogether, producers remain dependent on traditional production methods and tacit knowledge transferred across generations, especially acquired from family-owned businesses. Additionally, improving existing knowledge remains dependent on individual effort, rather than collaborative works between university and industry.

F2 have different dependencies within the overall entrepreneurship ecosystem. Financial motivations and barriers come at first before taking any step towards entrepreneurship. There are further concerns in agricultural entrepreneurship, due to high investment costs and dependency on external factors. Thus, divided arable lands and high number of small and medium sized greenhouses make the investment decision even harder. While this was not directly indicated, human skills might not be competent to take entrepreneurial activities in existing greenhouses. Therefore, new entrants and youth should be supported in the level of selling and promoting new technologies and methods. At this point, government support plays crucial role to boost agricultural entrepreneurship. Different from F1, entrepreneurship in greenhouses is dependent on government initiatives, supports and promotions, along with personal effort to take an action.

Dependencies under F3 are interlinked with human labor skills and inefficient university education. Main focus of this function is the level of technology usage among producers. Machinery resources are not allocated enough to reach out all agricultural labor force. Instead of the ways to promote advanced machineries and technological tools, perception towards them is examined. As result, impact of technical services is found important in technology adoption. After purchasing a technology, producers seek for a technical service in case there is any technical issue. If producers are not satisfied with the available technical service, they tend to quit using. This might be one of the reasons why greenhouse technologies are outdated.

Similarly, work flows and business cultures are not flexible to adopt new technologies. Once again, an authority is required to control and intervene technical issues according to producer needs.

F4 shows the characteristics of overall greenhouse market. There are different operation scales and different needs of greenhouses. Yet, overall market seems to be centering business development and trade, regardless of size of business. Within this concentration, adoption to advanced technologies is lagging behind. Existing infrastructural and engineering solutions are sale to other countries, rather than local buyers. Respectively, share of modern greenhouses remain lower than 2%. Existing associations also acting as intermediate sources to promote businesses and international trade. Nevertheless, agricultural trade – especially fruits and vegetables – is influenced by international relations and political sensitivity. On the other side, subsidiary products are found more trustworthy if imported. Adding up the non-trusting business environment, overall market remains closed to collaborate with local sources and dependent on foreign trade. Finally, limited collaboration between producers and public consultants are examined under F4. The main reason of non-collaborative environment is said to be high number of bureaucratic work that Chambers of Agriculture are required to do. Due to such amount of paper work, agricultural consultants cannot find time to go on field to support producers, which makes them unfamiliar with the actual field work.

F5 has no direct dependency issues to be examined. Instead, the context of existing public laws, rules, regulations and policies are examined. There are indirect indications of advanced methods as precision agriculture and applicable technologies. Yet, legitimacy remains mainly on research and development level, instead of centering production of businesses. There is, once again, a gap between research-oriented and business-oriented approaches. Regulations and policies for businesses are rather generic and financial. The fact that greenhouse technologies and precision agriculture are not specifically addressed, target producers are missed by existing regulative measures. Thus, financial support mechanisms are depending on international donors, more than government supports. In a nutshell, public policies need more specified sectoral targets, while addressing different objects in addition to financial support.

F6 is examined through financial and human resources. There are limited data on to analyze the allocation of financial resources. Main observation is made through sectoral budget allocations in government. Agricultural R&D spending is fluctuating depending on national priority sectors. While financial resources are not providing sufficient data on resource mobilization, human resources do. A shift from agricultural employment is recorded, especially throughout urban to rural migration. Even low-qualified job opportunities seem more preferable for youth, who has the chance to work in agricultural production. As a result of this shift, agricultural labor force involves seasonal workers and vulnerable groups including women and migrants. Accordingly, greenhouse operations are becoming more dependent on seasonal workers during harvest periods. Since the availability of needed workers are not guaranteed, greenhouses are facing operational risks because of this dependency.

F7 reflects overall findings in terms of how to share information, increase knowledge and establish a network. Online searches, at first, are found to be focusing on trade and international relations. Technical knowledge sharing, on the other hand, seem to be handled through face-to-face mentorships and social gatherings. Such knowledge sharing preferences boost the traditional production methods and outdated technology usage for existing producers. Then again, the main issue relates with the problems identified F1. In terms of business promotion, social media and website usage are recorded as additional operational costs, which producers try to eliminate. Greenhouse owners, in that sense, try to cope with daily challenges and sell their product to the best offer. Value-adding steps are remaining as a cost, rather than investment. As a consequence, awareness level becomes dependent on individual curiosity and information networks on individual connections.

6.3 Performance Measurement and Policy Recommendations

Technology adoption to address existing greenhouse cultivation problems is quite compelling. To adopt advanced greenhouse technologies, compatible with SPA, Turkey is evaluated under seven functions. Analyses presented under each function are persuasive to suggest policies for diffusing advanced greenhouse technology.

Bearing in mind most problematic areas and Turkey's overall performance against best practices, prioritized factors in policy development are detailed in this section.

Compared to the Netherlands and Japan, Turkish greenhouse sector is concentrated and shaped by trade-relevant dynamics. Such concentration comes with benefits and weaknesses towards greenhouse cultivation. As emphasized several times, each system has its own dynamic and motivations toward greenhouse cultivation. Coupling with strengths of Turkish greenhouse market, each comparative country is briefly summarized and evaluated based on functional performance.

Japanese greenhouse market involves high level of academic and scientific contribution. In that sense, greenhouse cultivation is supported by the scientific approach and new technologies to increase the productivity. Therefore, F1 has the highest performance level for Japan. While the main objective is to address national self-sufficiency, advancing in cultivation methods makes Japan a competitive market.

In addition to academic contribution, government is the main supporter of greenhouse cultivation. Heading off private sector actors, government support depends on one major factor. History of extreme natural catastrophes pushes the government to promote agricultural production to ensure enough food stocks. Since the overall arable land is less than the Netherlands and Turkey, greenhouse cultivation is promoted as an important mean of agricultural production.

Integration of advanced technologies in agriculture is one of the Japan's strongest sides. Nevertheless, labor force is quite risk averse by culture. This prevents small businesses to take entrepreneurial activities and to apply innovative solutions in greenhouse cultivation. As a result, the market is oriented by large-scale firms and academic institutions. Yet, ICT prioritization in all existing sectors enables greenhouse market to act at highest productivity level. In the sense that SPA involves adoption of advanced technologies, Creation of Legitimacy function is also among best performing functions for Japan.

The Netherlands, on the other hand, is oriented by business and trade concerns rather than scientific development and self-sufficiency concerns. Main performance difference of the Netherlands comes into light under Entrepreneurial Activities, Creation of Legitimacy and Public Awareness. While agricultural academic studies are involving interdisciplinary subjects and technology-focused approaches, overall sectoral performance depends on producers on field. Farmers are considered as entrepreneurs and innovative business risks are taken with development-motivations. This creates the best enabling environment for agricultural entrepreneurship.

Government and private institutions seem to be involved in greenhouse market for further development. Digitalization strategies and Common Agricultural Policy promotes advanced production methods for greenhouse cultivation. Trade relationship with other EU countries (especially Germany) boost this development.

High level of collaborative development is also observed for Dutch greenhouse market. While private firms combine their experience to have a larger share in market, small-sized greenhouses are also promoted by government supports and initiatives. These supports are not necessarily financial. Awareness raising, training, complementary services and mentorships take great part of Dutch greenhouse sector. Policies and private sector involvement, therefore, carry greatly of capacity development in greenhouse cultivation.

Bearing all in mind, Turkish greenhouse sector could be defined simply by “dependency”. Existing businesses are dependent on international trade and import of complementary products to maintain their business. Thus, businesses are dependent on individual effort to catch up with international competitors. While natural resources and climate conditions are in favor for existing greenhouse cultivations, there is a high level of sensitivity of overall sector towards international relationships, government supports, unavailability of skilled labor force in agriculture and mis-usage of existing human resources.

Turkish greenhouse market has different necessities and capabilities. Based on the interviewed businesses, technological improvement can solve the majority of main cultivation concerns. Yet, only a minority of greenhouses is able to cope with financial burdens. Therefore, Turkish government needs to act as the entrepreneur in this ecosystem. Meaning that, government policies must take different concerns in mind and promote greenhouse cultivation to ensure sustainable development and to avoid dependency. To do such, policies should be structured to address all in together. Only then, advantages of Turkish greenhouse sector could be used and the problems could be minimized.

Based on the findings presented so far, Turkey’s main strengths are:

- Availability of necessary engineering and manufacturing skills, products, and services

– Young labor force demographic, able to improve agricultural entrepreneurship and to boost innovative approaches on traditional methods
– Enthusiasm of new entrants to make individual effort
– Great knowledge sharing network among individual producers through social media (such as Facebook)
– Benefiting from tacit production methods thanks to transferring family-business knowledge across generations
– Detailed and official data sharing by government sources

To have a comprehensive and applicable technology policies, Table 21 is prepared to link existing problems with relevant policy recommendations.

Table 21: Functional Analysis of Turkey to Diffuse Advanced Greenhouse Technologies

Function	**Main Issues to Consider**	**Policy Recommendations**	**Relevant Policy Instruments**
F1	– Lack of agricultural concentration in universities – Lack of up-datedness of curriculums in universities for agricultural technology applications – Knowledge development oriented agricultural studies and lack of diffusion effort – Academic resources are not allocated at optimum level – Insufficient field knowledge in academic institutions – Dependency to promote agricultural businesses through individual learning efforts – Unavailability of interdisciplinary	– Updating university curriculums for agricultural departments, emphasizing new production methods and technological solutions; – Increasing government R&D expenditure share for agricultural purposes Integrating agricultural studies into interdisciplinary departments Ensuring public servants and advisors are well-equipped with field experience before official assignments	– Establish a research and control system in agricultural education ensuring updated models of production are introduced – Improve R&D allocation in agriculture so that technological inputs are applied – Restructure obligatory trainings and curriculums for public servants so that they have theoretical and practical knowledge on production methods

Table 21 (continued)

	studies in academic institutions to diminish individual effort in agricultural R&D	–	
F2	– Limited enabling ecosystem for agricultural entrepreneurship – Financial motivations as the main driver of entrepreneurial activities – Financial concerns as the top-ranked barrier against agricultural entrepreneurship – Divided lands and different responsibilities in greenhouses, hampering decision making process – Dependency on government support for entrepreneurial activities – Limited presence of other disciplines, contributing to overall agricultural development	– Promoting agricultural entrepreneurship in academia, in order to ensure scientific baseline in entrepreneurial activities – Provision of both financial and capacity building supports to agricultural entrepreneurship – Regulating identification, implementation and evaluation of government support for agricultural entrepreneurship – Supporting not only greenhouse cultivation, but also intermediary businesses taking part in agricultural entrepreneurship	– Introduce agricultural entrepreneurship in relevant university curriculums – Promote trainings for students, business owners, farmers and civil society favoring agricultural entrepreneurship – Establish a monitoring and evaluation mechanisms to track agricultural entrepreneurship projects and their impact
F3	– Limited coverage of machinery resources for agricultural labor force – Limited opportunity on technical services after purchasing or acquiring certain technology tool Limited opportunity on technical services after constructing a modern greenhouse – Inability to diffuse available greenhouse engineering and	– Regular tracking of agricultural machinery usage in order to follow-up necessary updates and to optimize existing machinery resources – Offering 7/24 technical services of agricultural technologies and modern greenhouse equipment –	– Establish auditing and quality control mechanisms for agricultural machineries – Create an intermediary communication agency for farmers and greenhouse owners when they cannot reach out any technical support on their machinery – Adopt a traceable and transparent value chain audit

Table 21 (continued)

	manufacturing solutions – Lack of government policies promoting agricultural or greenhouse technologies – Out-dated technologies in use for agricultural operations – Greenhouse business cultures and work flows are not always adaptable for technological automation – Need for price regulations by a systematic / controlled authority	– Promoting locally produced greenhouse manufacturing and engineering solutions – Ensuring transparent and equitable price regulations – Regulating health and safety measures in greenhouses, both for producer and for plant – Promoting transparent and traceable equipment usage to acquire necessary certifications	mechanism between producer and end user
F4	– While available technologies are improving, production systems lagging behind – Low percentage of modern greenhouses existing in market – Greenhouse associations are business-oriented, rather than research-oriented Collaborative works are for trade, commercial activities and infrastructural development – Fruit and vegetable production address to domestic demand rather to export objectives – High level of political sensitivity in agricultural trade, especially for	– Ensuring neutral trade relationship to minimize political sensitivity in agricultural trade – Promoting locally produced subsidiary products and services for existing greenhouse operations – Ensuring protective and systematic business partnerships through rules and regulations – Supporting both large and small level investments – Ensuring necessary advisory services for the new entrants in	– Announce a neutral and separate trade regulations to ensure agricultural exports are not sensitive towards political instabilities – Regulate pricing and distribution policies of local subsidiary products for greenhouse operations – Introduce differentiated financial supports to attract both large and small greenhouses – Redesign bureaucratic procedures or introduce new public agencies so that public consultants become more effective in responding producer needs

Table 21 (continued)

F4	greenhouse cultivation – Dependency on foreign subsidiary products and services in greenhouse cultivation – Non-trusting environment in establishing business relationship, which creates rather closed market – Divided lands diminish the investment opportunity New entrants are not always familiar with the technical aspects of managing greenhouse cultivation Limited collaboration between producers and public consultants due to bureaucratic tasks and unfamiliarity of field work	– greenhouse management Establishing better communication and advisory services between producers and public servants	
F5	– Initiatives depend on international donor support – Lack of greenhouse or agricultural technology policies – Limited precision agriculture indication on legislative level – Legitimacy targeting precision agriculture remains on the research and development level rather than presenting comprehensive	– Addressing sub-specific sectors in agricultural and greenhouse operations in public policies – Emphasizing technology inputs in agricultural policies – Eliminating dependency on international donor support and ensuring government support on	– Introduce technology-oriented policies to reduce input costs for producers – Control intermediary businesses on price regulations so that international donor support diminishes – Address greenhouse technologies, beside of energy saving technologies, in public policies

Table 21 (continued)

	policies and programs – Regulations and policies are rather generic and not specifically addressing greenhouse technologies – Government supports and policies are mainly financial, not directly technology-oriented	agricultural development	
F6	– Financial resources spend on agricultural R&D are changing according to sectoral prioritization – Even though labor force has a young demographic, shift to non-agricultural employment is a growing concern Agricultural labor force mainly involve vulnerable groups (as women) and dependent workers (with family business legacy) – Greenhouse operations are becoming more dependent on seasonal agricultural labor force Operational cost is top concern in greenhouses, against optimizing financial resources for investment	– Promoting qualified and interdisciplinary human resource in agricultural labor force – Supporting youth in agricultural businesses Ensuring regulated and systematic agricultural labor force, both seasonal and full-time – Provision of financial support to reduce operational costs through technological and scientific solutions Prioritizing agricultural R&D in government R&D expenditures at constant level	– Differentiate public servant profile in agricultural bureaus with different academic disciplines – Introduce regulations to mobilize existing human resource (seasonal workers) for greenhouse production – Reduce administrative works of government officials in Chambers of Agriculture to ensure better field experience – Keep a standardized percentage on public expenditures reserved for agricultural R&D
F7	– Public awareness in advanced agricultural practices has commercial focus	– Promoting social media channels and social media users for agricultural	– Introduce public awareness campaigns on greenhouse production

Table 21 (continued)

	rather than research and development focus – Face-to-face and local networks are affecting existing operations and producer perceptions – Corporate websites are not seen as a preferable communication, marketing or sale channel for small and medium-small greenhouses – Social media usage in favor of greenhouse sector remains limited – Lack of target specific or tailored information sharing network or events	information sharing – Organizing more sector specific, technology specific and target audience specific events to increase public awareness – Enabling open information networks to share experiences and news on greenhouse cultivation – Providing support to open and manage corporate websites for greenhouses	– Establish online platforms for greenhouse producers to share and search information according to their needs – Promote official website of Ministry and informative contents in social media

All functions have substantial contribution for adopting advanced agricultural solutions as SPA. To make a prioritization among identified problems, recommendations and relevant policy instruments, respondents from Chambers of Agriculture are asked to rank these functions. 58% respondents prioritized education (F1) for achieving advanced greenhouse operations in Turkey (Figure 22).

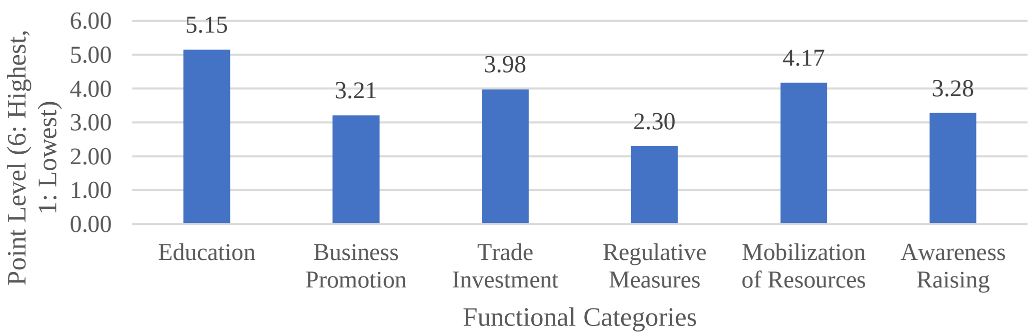


Figure 22: Ranking of Functions to Increase Success of Greenhouse Operations

Based on the findings, education should not be limited with academic institutions. All relevant actors (government bodies, relevant NGOs, entrepreneurs, etc.) must be well-equipped towards agricultural works to emphasize actual needs of producers. In this ranking, education is followed by mobilization of resources and trade investment.

Accordingly, agricultural policies are found most effective, by 47%, when they are designed to promote education and knowledge. By the definition of Knowledge Creation and Diffusion, education relevant initiatives could be considered as a starting point for further adoption functions. The fact that SPA is not specifically addressed in Turkish greenhouse operations, relevant methods and technologies should be linked to this scientific approach.

In addition to given policy instruments, there are interlinked but additional points that is worth highlighting. Based on findings gathered from greenhouse owner interviews, two major concerns are identified: (1) loss of tacit knowledge and (2) dependency on various levels.

Strongly related with lack of updated university curriculums and field-knowledge applied to theoretical courses, greenhouse owners are getting away from academic and scientific knowledge. This results in a lock-in to traditional methods and tacit knowledge passed among generations. This lock-in comes with a negative influence on greenhouse owner perception towards entrepreneurship, innovation, and technological development. Coupling with challenges of the sector itself, young generation is either escaping or being pushed away from greenhouse operations. In future, this issue might result as losing experience-based knowledge, which has been built up since generations.

In that framework, following policy instruments should be prioritized as well, in addition to those proposed under F1:

- Introduce agricultural entrepreneurship in relevant university curriculums
- Promote trainings for students, business owners, farmers and civil society favoring agricultural entrepreneurship
- Establish a monitoring and evaluation mechanisms to track agricultural entrepreneurship projects and their impact
- Create an intermediary communication agency for farmers and greenhouse owners when they cannot reach out any technical support on their machinery

- Announce a neutral and separate trade regulations to ensure agricultural exports are not sensitive towards political instabilities
- Regulate pricing and distribution policies of local subsidiary products for greenhouse operations
- Differentiate public servant profile in agricultural bureaus with different academic disciplines
- Keep a standardized percentage on public expenditures reserved for agricultural R&D

Dependency, on the other hand, comes into surface by different meanings. Yet, at a generic level, it is correlated with non-collaborative environment in Turkey. In other words, greenhouse owners are feeling alone to survive in the market or to take their operations to the next level. Sectoral improvement requires a collaborative work among various actors: universities, public bodies, cooperatives, NGOs, private sector, and producers. There is a network among producers, however, other actors are not contributing enough to boost greenhouse sector as a whole.

Studies suggest that strategic joint-ventures are an important source of business success in uncertainties (Cohn et al., 2005). Only in a respectful and trustworthy environment a successful collaboration is possible against existing dependencies. As exemplified by advantages of constructing ventures between physicians and hospitals, existing actors should also be together as strategic ventures. So that transparent and achievable objectives could be identified and accomplished (Blair et al., 1990). Therefore, proposed policy recommendations should be re-evaluated in further studies with: (i) identified stakeholder relations; (ii) potential problems and conflicts; (iii) diagnosis and classification of collaboration success; (iv) optimization of success with existing resources.

6.4 Limitations of the Study

Functional analyses, especially for technology diffusion purposes, require in-depth understanding of target environment. This includes elaborating existing infrastructure and farmer needs to come up with feasible solutions to existing problems. Given the scope of target system, relevant and available actors and focus of this thesis, three limitations are identified.

First, only greenhouse owners and government representatives are included in primary data collection. Thus, due to COVID-19 pandemic, number of semi structured interviews remained limited. Future studies should take into count larger variety of greenhouse workers, civil society organizations, universities and other government bodies to generate accurate and feasible solutions to existing issues.

Second, comparative data analysis included only publicly available data for all three countries. Main purpose of such selection was to make comparable arguments. While primary data collection enriched the understanding of dynamics in greenhouse cultivation in Turkey, similar qualitative research methods should be integrated in future studies for comparative countries.

Third, while this study investigated preliminary issues against diffusing greenhouse technologies, policy recommendations are mainly resulted to promote knowledge and education. Sub-functions and interview findings under F1 carry substantial importance; however, it is possible that respondents selected an easy answer against problems. Analysis given under functions are given as they are proposed by respondents and interviewees. Yet, their acknowledgment and understanding of functional dynamics should be ensured. To exemplify, importance of F1 is also linked to entrepreneurial activities and awareness level. For that reason, future studies should avoid similar categorization to prioritize functions.

This thesis is now the first academic study on recommending policies to diffuse SPA related greenhouse technologies in Turkey. For that reason, it also guides future studies through highlighting the state of technology usage and comparing functional elements with best practices in the world. That being said, future research is encouraged to focus either a location or product-based greenhouses to eliminate changing input requirements, or specific technological solution (even more specific than SPA) applicable for production development.

REFERENCES

ABOUT GPEC | GPEC 2021. (n.d.). Retrieved February 27, 2021, from https://www.gpec.jp/english/outline/index.html

Ağızhan, K., & Bayramoğlu, Z. (2018). Tarımsal Girişimcilik Ekosistemi. International Congress of Social Science.

Agricultural Reform Implementation Project (ARIP). (n.d.). World Bank. https://projects.worldbank.org/en/projects-operations/project-detail/P070286?lang=en

Agriculture in Japan New developments in Smart Agriculture. (2018). In Science and Technology Office Tokyo. Embassy of Switzerland in Tokyo. https://www.stofficetokyo.ch/about-us/projects/smart-agriculture-in-japan

All eyes on horticulture | GreenTech. (n.d.). Retrieved February 27, 2021, from https://www.greentech.nl/

Anderson, J. L. (2005). Industrializing the Corn Belt: Iowa farmers, technology and the Midwestern landscape, 1945-1972 [Iowa State University]. https://lib.dr.iastate.edu/rtd/1827

Arima, S. (2011). Speaking Plant Approach for Highly Sophisticated Intelligent Greenhouse. Combined Proceedings International Plant Propagators' Society, 61, 251–253. http://admin.ipps.org/uploads/61_051.pdf

Asheim, B. T., & Isaksen, A. (2002). Regional Innovation Systems: The integration of Local "Sticky" and Global "Ubiquitous" Knowledge. Journal of Technology Transfer, 27(1), 77–86. https://doi.org/10.1023/A:1013100704794

AVAG | About us. (n.d.). Retrieved February 18, 2021, from https://www.avag.nl/en/about-avag/

Avouris, N., Tselios, N., Fidas, C., & Papachristos, E. (2003). Website Evaluation: A Usability-Based Perspective. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2563, 217–231. https://doi.org/10.1007/3-540-38076-0_15

Bachev, H., & Ito, F. (2017). *Agricultural impacts of the Great East Japan Earthquake-six years later*. https://mpra.ub.uni-muenchen.de/79469/

Balafoutis, A., Beck, B., Fountas, S., Vangeyte, J., Van Der Wal, T., Soto, I., Gómez-Barbero, M., Barnes, A., & Eory, V. (2017). Precision Agriculture Technologies Positively Contributing to GHG Emissions Mitigation, Farm

Productivity and Economics. *Sustainability*, *9*(1339), 1–28. https://doi.org/10.3390/su9081339

Baltussen, W., & Smit, P. (2013). *Greenhouse Technology Suppliers Conquer The World*.

Baylou, P. (1987). Agricultural Robots. *IFAC Proceedings Volumes*, *20*(5), 111–119. https://doi.org/10.1016/s1474-6670(17)55251-9

Bergek, A., Hekkert, M., & Jacobsson, S. (2008). *Functions in Innovation Systems: A Framework for Analysing Energy System Dynamics and Identifying Goals for System-Building Activities by Entrepreneurs and Policy Makers* (Innovations for a Low Carbon Economy: Economic, Institutional and Management Approaches (Preliminary Title), Issue 84426). https://www.researchgate.net/publication/46678191_Functions_in_Innovation_Systems_a_framework_for_analysing_energy_system_dynamics_and_identifying_goals_for_system_building_activities_by_entrepreneurs_and_policy_makers

Bergek, A., & Jacobsson, S. (2003). The emergence ofa growth industry: a comparative analysis of the German, Dutch and Swedish wind turbine industries. *Change,Transformation and Development*, 197–227. http://www.ecn.nl/docs/library/report/2003/rx03045.pdf%5Cnhttp://space.hgo.se/wpcvi/wp-content/uploads/import/pdf/Kunskapsdatabas samhalle/energipolitik/Forskning/The Emergence of a Growth Industry.pdf

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the Functional Dynamics of Technological Innovation Systems: A Scheme of Analysis. *Research Policy*, *37*(3), 407–429. https://doi.org/10.1016/j.respol.2007.12.003

Bergek, A., Jacobsson, S., Carlsson, B., Lindmarki, S., & Rickne, A. (2005). Analyzing The Dynamics and Functionality of Sectoral Innovation Systems–A Manual. *DRUID Tenth Anniversary Summer Conference 2005*, 1–34. http://www2.druid.dk/conferences/viewpaper.php?id=2687&cf=18

Bergek, A., Jacobsson, S., Hekkert, M., & Keith, S. (2010). Functionality of Innovation Systems as A Rationale for and Guide to Innovation Policy. In *An International Research Handbook*. https://doi.org/10.4337/9781849804424.00013

Berners-Lee, M., Kennelly, C., Watson, R., & Hewitt, C. N. (2018). Current global food production is sufficient to meet human nutritional needs in 2050 provided there is radical societal adaptation. *Elementa*, *6*. https://doi.org/10.1525/elementa.310

Bhattacharjee, S., & Raj, S. (2016). *Social Media: Shaping the Future of Agricultural Extension and Advisory Services*. www.g-fras.org

Bicer, A. (2020). *Turkey launches digital market for agriculture*. Anadolu Agency. https://www.aa.com.tr/en/economy/turkey-launches-digital-market-for-agriculture/1823154

Biermacher, J. T., Brorsen, B. W., Epplin, F. M., Solie, J. B., & Raun, W. R. (2009). The economic potential of precision nitrogen application with wheat based on plant sensing. *Agricultural Economics*, *40*(4), 397–407. https://doi.org/10.1111/j.1574-0862.2009.00387.x

Blair, J. D., Slaton, C. R., & Savage, G. T. (1990). Hospital-physician joint ventures: a strategic approach for both dimensions of success. *Hospital and Health Services Administration*, 35(1), 3-26

Blake, C. (1990). Book Review: American Genesis: A Century of Invention and Technological Enthusiasm 1870-1970 by Thomas Hughes. *Indiana Magazine of History*, 239. https://doi.org/10.2307/3106016

Bleda, M., & Del Río, P. (2013). The market failure and the systemic failure rationales in technological innovation systems. *Research Policy*, *42*(5), 1039–1052. https://doi.org/10.1016/j.respol.2013.02.008

Boata, A. (2016). *Press release Euler Hermes study : The Netherlands more positive than Germany on bilateral trade relations 75 % of Dutch and 50 % of German entrepreneurs want more intensive cooperation*. *September 2015*.

Boersma, M., & Nl, H. (2005). *Evolution of Greenhouse Insurance in the Netherlands*. 1–9.

Bongiovanni, R., & Lowenberg-Deboer, J. (2004). Precision Agriculture and Sustainability. *Precision Agriculture*, *5*, 359–387. https://doi.org/10.1023/B:PRAG.0000040806.39604.aa

Bont, K. De, Berkum, S. Van, & Post, J. (2003). Agricultural and Rural Development and Policies in The Netherlands. In *Policies for agriculture in Poland and the Netherlands - Contributions to a policy dialogue* (pp. 16–30). Agricultural Economics Research Institute (LEI). https://edepot.wur.nl/186470

Boot & Dart. (n.d.). Retrieved February 27, 2021, from https://www.bootendart.co.uk/

Borrás, S. (2004). System of innovation theory and the European Union. *Science and Public Policy*, *31*(6), 425–433.

Borrás, S., & Edquist, C. (2013). The Choice of Innovation Policy Instruments. *Technological Forecasting and Social Change*, *80*(8), 1513–1522. https://doi.org/10.1016/j.techfore.2013.03.002

Borremans, L., Marchand, F., Visser, M., & Wauters, E. (2018). Nurturing Agroforestry Systems in Flanders: Analysis from an Agricultural Innovation Systems Perspective. *Agricultural Systems*, *162*, 205–219.

https://doi.org/10.1016/j.agsy.2018.01.004

Breschi, S., & Malerba, F. (2001). The Geography ofInnovation and Economic Clustering: Some Introductory Notes. *Industrial and Corporate Change*, *10*(4), 817–833.

Breukers, A., Hietbrink, O., & Ruijs, M. N. A. (2008). *The power of Dutch greenhouse vegetable horticulture : an analysis of the private sector and its institutional framework*. https://www.researchgate.net/publication/40096170_The_power_of_Dutch_greenhouse_vegetable_horticulture_an_analysis_of_the_private_sector_and_its_institutional_framework

Brewster Christopher, Jan, E., Raymond, K., Fleur, M., Peter, R., Iver, T., Vangeyte, J., & Astrid, W. (2018). *ICT-AGRI 2: ICT and Robotics for Sustainable Agriculture*.

Buick, R. D. (1997). Precision Agriculture: An Integration of Information Technologies with Farming. *Proceedings of the 50th New Zealand Plant Protection Conference*, 176–184. https://doi.org/10.30843/nzpp.1997.50.11310

Busch, L., & Lacy, W. B. (1983). Science, Agriculture, and the Politics of Research. *Boulder*.

Byerlee, D., de Janvry, A., & Sadoulet, E. (2009). Agriculture for Development: Toward a New Paradigm. *Annual Review of Resource Economics*, *1*, 15–31. https://doi.org/10.1146/annurev.resource.050708.144239

Can, B. A., & Engindeniz, S. (2017). Gençlerin Tarımsal Girişimcilik Eğilimleri: Türkiye'de Örnek Bir Araştırma. In S. Koç, A. Orhan, & M. tÇağrı Gözen (Eds.), *Kayıt Dışı İstihdam ve Ekonomi* (pp. 103–122). Umuttepe Yayınları.

Cantliffe, D. J., & Vansickle, J. J. (2009). Competitiveness of the Spanish and Dutch Greenhouse Industries With the Florida Fresh Vegetable Industry. In *EDIS*. https://doi.org/10.32473/edis-cv284-2003

Carlsson, B, & Stankiewicz, R. (1991). On the nature, function and composition of technological systems. *Journal of Evolutionary Economics*, *1*, 93–118.

Carlsson, Bo, & Jacobsson, S. (1994). Technological systems and economic policy: the diffusion of factory automation in Sweden. *Research Policy*, *23*(3), 235–248. https://doi.org/10.1016/0048-7333(94)90036-1

Carlsson, Bo, Jacobsson, S., Holmen, M., & Rickne, A. (2002). Innovation systems: analytical and methodological issues. *Research Policy*, *31*(2), 233–245. https://doi.org/10.1016/S0048-7333(01)00138-X

Cemek, B., Güler, M., & Arslan, H. (2015). Spatial analysis of climate factors used to determine suitability of greenhouse production in Turkey. *Theoretical and Applied Climatology*, 128(1-2), 1–11. doi:10.1007/s00704-015-1686-5

Chaminade, C. (2010). Book review: Small Country Innovation Systems. Globalization, Change and Policy in Asia and Europe, C. Edquist, L. Hommen. Edward Elgar, Cheltenham (2008). *Research Policy, 39*, 186–187. https://doi.org/10.1016/j.respol.2009.09.010

Chaminade, C., & Edquist, C. (2006). Rationales for public policy intervention from a systems of innovation approach: the case of VINNOVA. In *Centre for Innovation, Research and Competence in the Learning Economy* (No. 04).

Choudhury, S. R. (2018). Japan is changing its views on entrepreneurship, and that could be good for start-ups. *CNBC*. https://www.cnbc.com/2018/03/18/working-in-japan-views-on-entrepreneurship-and-start-ups-are-changing.html

Chris Mosby. (2015, March). The state of Japanese CEA. *Greenhouse Management*. https://www.greenhousemag.com/article/gm0315-controlled-environment-agriculture-japan/#

Christiaensen, L., Demery, L., & Kuhl, J. (2011). The (evolving) role of agriculture in poverty reduction-An empirical perspective. *Journal of Development Economics*, *96*(2), 239–254. https://doi.org/10.1016/j.jdeveco.2010.10.006

Cohn, K. H., Allyn, T. R., Rosenfield, R. H., & Schwartz, R. (2005). Overview of physician-hospital ventures. Th*e American journal of surgery*, 189(1), 4-10

Collen, C. (2015). *Dutch greenhouse alliance formed*. EUROFRUIT. http://www.fruitnet.com/americafruit/article/1474/parts-of-san-diego-quarantined-as-psyllid-count-mounts

Cooke, P., Uranga, M. G., & Etxebarria, G. (1997). Regional innovation systems: Institutional and organisational dimensions. *Research Policy*, *26*, 475–491. https://doi.org/10.5195/jmla.2019.695

Coşgel, M. M., Miceli, T. J., & Rubin, J. (2012). Political Legitimacy and Technology Adoption Author. *Journal of Institutional and Theoretical Economics*, *168*(3), 339–361. https://www.jstor.org/stable/41653664 REFERENCES

Could high-tech Netherlands-style farming feed the world? (2019a). DW. https://www.dw.com/en/could-high-tech-netherlands-style-farming-feed-the-world/a-47105412

Could high-tech Netherlands-style farming feed the world? (2019b). DW. https://www.dw.com/en/could-high-tech-netherlands-style-farming-feed-the-world/a-47105412

Cowan, T. (2000). Precision Agriculture and Site-Specific Management: Current Status and Emerging Policy Issues. In *CRS Report for Congress*.

Daberkow, S. G., & McBride, W. D. (2003). Farm and operator characteristics affecting the awareness and adoption of precision agriculture technologies in the US. *Precision Agriculture*, *4*(2), 163–177. https://doi.org/10.1023/A:1024557205871

Danbom, D. B. (1986). The Agricultural Experiment Station and Professionalization: Scientists' Goals for Agriculture. *Agricultural History*, *60*(2), 246–255. https://www.jstor.org/stable/3743443%0AJSTOR

Davies, J., Maru, Y., Hall, A., Abdourhamane, I. K., Adegbidi, A., Carberry, P., Dorai, K., Ennin, S. A., Etwire, P. M., McMillan, L., Njoya, A., Ouedraogo, S., Traoré, A., Traoré–Gué, N. J., & Watson, I. (2018). Understanding innovation platform effectiveness through experiences from west and central Africa. *Agricultural Systems*, *165*(3), 321–334. https://doi.org/10.1016/j.agsy.2016.12.014

Deborah Fitzgerald, Lisa Onaga, Emily Pawley, Denise Phillips, & Jeremy Vetter. (2018). Roundtable: Agricultural History and the History of Science. *Agricultural History*, *92*(4), 569. https://doi.org/10.3098/ah.2018.092.4.569

Deguchi, A., Hirai, C., Matsuoka, H., Nakano, T., Oshima, K., Tai, M., & Tani, S. (2020). What is society 5.0? In *Society 5.0: A People-centric Super-smart Society* (pp. 1–23). https://doi.org/10.1007/978-981-15-2989-4_1

Devienne, S. (2002). *AGTER - NETHERLANDS: An interventionist agricultural policy intended to reduce regional inequalities*. http://www.agter.org/bdf/en/corpus_chemin/fiche-chemin-458.html

Dewalt, B. R. (1994). Using indigenous knowledge to improve agriculture and natural resource management. *Human Organization*, *53*(2), 123–131. https://doi.org/10.17730/humo.53.2.ku60563817m03n73

Diao, X., Hazell, P., Resnick, D., & Thurlow, J. (2007). The role of agriculture in development: Implications for Sub-Saharan Africa. In *Research Report of the International Food Policy Research Institute* (Issue 153). https://doi.org/10.2499/9780896291614rr153

Diederen, P., van Meijl, H., & Wolters, A. (2002). Innovation and Farm Performance: The Case of Dutch Agriculture. In *Innovation and Firm Performance* (pp. 73–85). Palgrave Macmillan. https://doi.org/10.1057/9780230595880_4

Dryancour, G. (2017). *European Agricultural Machinery Association*. www.cema-agri.org

Dutch agricultural exports worth €94.5 billion in 2019 | News item | Government.nl. (2020). https://www.government.nl/latest/news/2020/01/17/dutch-agricultural-exports-worth-€94.5-billion-in-2019

Dzemydaite, G. (2017). Agriculture’s Impact for the Economy: Inter-Industry Linkages and Multiplier Effects. *Rural Development 2017: Bioeconomy Challenges*. https://doi.org/10.15544/rd.2017.057

EC. (2013). *Agricultural Policy Perspectives Brief N°5: Overview of CAP Reform 2014-2020*. http://ec.europa.eu/agriculture/policy-perspectives/index_en.htm

EC. (2018). *EU Budget: The CAP after 2020*. https://ec.europa.eu/commission/sites/beta-political/files/budget-may2018-modernising-cap_en.pdf

Economy Profile of Netherlands Doing Business 2020. (2020).

Edquist, C. (2013). *Systems of Innovation: Technologies, Institutions and Organizations* (C. Edquist (Ed.)). Routledge. https://books.google.com.tr/books?id=2EVj4bkJ9scC&dq=Edquist,+C.+(Ed.).+(1997).+Systems+of+innovation:+technologies,+institutions,+and+organizations&hl=tr&lr=

Ehret, D., Alsanius, B., Wohanka, W., Menzies, J., & Utkhede, R. (2001). Disinfestation of Recirculating Nutrient Solutions in Greenhouse Horticulture. *Agronomie*, *21*(4), 323–339. https://doi.org/10.1051/agro:2001127

Eklund, L., & Thompson, D. (2017). Differences in resource management affects drought vulnerability across the borders between Iraq, Syria, and Turkey. *Ecology and Society*, *22*(4). https://doi.org/10.5751/ES-09179-220409

Eleventh Development Plan (2019-2023). (2019).

Enright, M. J. (2000). Survey on the Characterization of Regional Clusters: Initial Results. In *Institute of Economic Policy and Business Strategy: Competitiveness Program*.

Enright, M. J. (2003). Regional Clusters: What We Know and What We Should Know. In *Innovation Clusters and Interregional Competition* (pp. 99–129). https://doi.org/10.1007/978-3-540-24760-9_6

Erickson, B., & Widmar, D. A. (2015). Precision Agricultural Services: Dealership Survey Results, Draft. In *Purdue University*.

Erixon, L. (2009). *Development blocks, faulty investment and structural tensions – the Åkerman- Dahmén theory of the business cycle*.

Eryılmaz, G. A., Demiryürek, K., & Murat, E. M. İ. R. (2015). Avrupa Birliği ve Türkiye’de organik tarım ve gıda ürünlerine karşı tüketici davranışları. *Anadolu Tarım Bilimleri Dergisi*, 30(2), 199-206.

Examples of Creating New Value in the Field of Disaster Prevention (Society 5.0). (n.d.). Japan Cabinet Office. https://www8.cao.go.jp/cstp/engl?sh/soc?ety5_0/agr?culture_e.html

Facts and Figures 2010: The Dutch Agricluster in a Global Context. (2010). In *Ministery of Agriculture Nature and Food Quality*. https://www.government.nl/topics/agriculture-and-livestock/documents/leaflets/2010/09/07/facts-and-figures-2010-the-dutch-agricluster-in-a-global-context

FAO. (2018). New Food Balances. *Food Balance Sheet.*

FAO. (2011). *Agricultural insurance in Asia and the Pacific region*.

FAO. (2021). *Japan supports FAO to train Syrian refugees and their host communities in joint agri-food activities*. http://www.fao.org/turkey/news/detail-news/en/c/1370571/

Fields, G. S. (2004). A Guide to Multisector Labor Markets Models. In *World Bank Labor Market Conference*.

Fitzgerald, D. (1991). Beyond Tractors: The History of Technology in American Agriculture. *Technology and Culture*, *32*(1), 114–126. https://doi.org/10.2307/3106015

Food Export Blog Food Export - Country Market Profile: Japan. (2019). Food Export. https://www.foodexport.org/blog/blog/2019/10/31/food-export---country-market-profile-japan#:~:text=Market Overview,the total import market share.&text=Japan is the 3rd,products after Canada and Mexico.

Freebairn, D. K. (1995). Did the Green Revolution Concentrate Incomes? A Quantitative Study of Research Reports. *World Development*, *23*(2), 265–279. https://doi.org/10.1016/0305-750X(94)00116-G

Freeman, C. (1995). The “National System of Innovation” in historical perspective. *Cambridge Journal of Economics*, *19*(19), 5–24.

Fuglie, K. O., & Bosch, D. J. (1995). Economic and Environmental Implications of Soil Nitrogen Testing: A Switching-Regression Analysis. *American Journal of Agricultural Economics*, *77*, 891–900. https://doi.org/10.2307/1243812

Fukuyama, M. (2018). Society 5.0: Aiming for a New Human-Centered Society. *Japan SPOTLIGHT*, 47–50. http://www8.cao.go.jp/cstp/%0Ahttp://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=108487927&site=ehost-live

Gebbers, R., & Adamchuk, V. I. (2010). Precision Agriculture and Food Security. *Science AAAS*, *327*(5967), 828–831. https://doi.org/10.1126/science.1183899

Geroski, P. A. (1998). An Applied Econometrician' s View of Large Company Performance. *Review of Industrial Organization*, *13*(3), 271–293. http://www.jstor.org/stable/41798801 Accessed:

Get into the Greenhouse - Holland.com. (n.d.). Retrieved February 27, 2021, from https://www.holland.com/global/tourism/activities/events/get-into-the-greenhouse.htm

Gielen, I. (2014). *Test results "Social Media & smartphone use in agriculture , horticulture."* HortiDaily. https://www.hort?da?ly.com/art?cle/6011183/test-results-soc?al-med?a-smartphone-use-?n-agr?culture-hort?culture/

Gilmour, B. W., & Gurung, R. (2007). Japan Agriculture Policy Review. *Agriculture and Agri-Food Canada*, *3*(1). https://www.researchgate.net/publication/46472850

Gökçe, O. (2010). *TARIMSAL GİRİŞİMCİLİK VE GELİŞTİRİLMESİ*. http://osmangokce.net/wp/2010/05/16/tarimsal-grmclk-ve-geltrlmes/

Goto, K. (2019). Entrepreneurship and Innovation in Japanese Agriculture. In *The Role of Open Innovation and Platform in Agriculture* (pp. 115–132). https://doi.org/10.1007/978-981-13-8055-6_9

Goumopoulos, C., O'Flynn, B., & Kameas, A. (2014). Automated zone-specific irrigation with wireless sensor/actuator network and adaptable decision support. *Computers and Electronics in Agriculture*, *105*, 20–33. https://doi.org/10.1016/j.compag.2014.03.012

Grabowski, R. (1979). The Implications of an Induced Innovation Model Author. *Economic Development and Cultural Change*, *27*(4), 723–734. https://www.jstor.org/stable/1153567

greenhouse manufacturers Companies and Suppliers serving ... (n.d.). Retrieved February 18, 2021, from https://www.agriculture-xprt.com/companies/serving-japan/page-1/?keyword=greenhouse+manufacturers

Gürkan, N. P. (2015). *Turkish Olive and Olive Oil Sectoral Innovation System: A Functional - Structural Analysis*. Middle East Technical University.

Haga, K. (2018). Innovation in Rural Japan: Entrepreneurs and Residents Meeting the Challenges of Aging and Shrinking Agricultural Communities. *Journal of Innovation Economics and Management*, *25*, 87–117. https://doi.org/10.3917/jie.pr1.0023

Hagelunie : Your partner in risk management How well do you know your greenhouse insurancy policy ? Hagelunie : (2014). Hagelunie. https://www.hort?da?ly.com/art?cle/6008698/how-well-do-you-know-your-greenhouse-?nsurancy-pol?cy/

Half of Dutch production of greenhouse vegetables goes to Germany and the UK. (n.d.). Retrieved February 18, 2021, from https://www.hortidaily.com/article/6043255/half-of-dutch-production-of-greenhouse-vegetables-goes-to-germany-and-the-uk/

Harari, Y. N. (2011). *Sapiens: A brief history of humankind*. https://www.amazon.com/Sapiens-Humankind-Yuval-Noah-Harari/dp/0062316095

Harayama, Y. (2017). Mobilizing Science, Technology, and Innovation to Transform Japanese Agriculture. In *The Global Innovation Index* (pp. 129–134). http://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2017-chapter8.pdf

Havlíček, Z., Lohr, V., Šmejkalová, M., Grosz, J., & Benda, P. (2013). Agritourism Farms - Evaluation of Their Websites Quality and Web 2.0. *Agris On-Line Papers in Economics and Informatics*, *V*, 31–38.

Hekkert, Marko ; Heimeriks, Gaston; Harmsen, R. (2011). Technological Innovation System Analysis. In *Universiteit Utrecht*. http://docplayer.net/25667597-Technological-innovation-system-analysis.html

Hekkert, M. P., Suurs, R. A. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. H. M. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change*, *74*(4), 413–432. https://doi.org/10.1016/j.techfore.2006.03.002

Hekkert, Marko P., & Negro, S. O. (2009). Functions of innovation systems as a framework to understand sustainable technological change: Empirical evidence for earlier claims. *Technological Forecasting and Social Change*, *76*, 584–594. https://doi.org/10.1016/j.techfore.2008.04.013

Hermans, F., Geerling-Eiff, F., Potters, J., & Klerkx, L. (2019). Public-private partnerships as systemic agricultural innovation policy instruments – Assessing their contribution to innovation system function dynamics. *NJAS - Wageningen Journal of Life Sciences*, *88*, 76–95. https://doi.org/10.1016/j.njas.2018.10.001

Hirasawa, A. (2017). Food Security Measures in Japan since World War II. In Z.-Y. Zhou & G. Wan (Eds.), *Food Inseruity in Asia: Why Institutions Matter* (pp. 89–138). ADBI. https://www.researchgate.net/publication/326313711_Food_Security_Measures_in_Japan_since_World_War_II

Hirschman, A. O. (1958). The Strategy of Economic Development. In *New Haven: Yale University Press*. New Haven: Yale University Press. https://www.worldcat.org/title/strategy-of-economic-development/oclc/947224676

Hoffmann, V., Probst, K., & Christinck, A. (2007). Farmers and researchers: How can collaborative advantages be created in participatory research and technology development? *Agriculture and Human Values*, *24*(3), 355–368.

https://doi.org/10.1007/s10460-007-9072-2

Holthuis, J., Burg, P., & Buren, N. V. (2020). *Agricultural law in The Netherlands : overview*. Practical Law Country Q&A. https://uk.practicallaw.thomsonreuters.com/1-603-8746?transitionType=Default&contextData=(sc.Default)&firstPage=true

Holthuis, J., & Velden, M. van der. (2019). Plant variety rights versus plant patents: legal developments and frictions in a regional perspective. In *Business Law International* (Vol. 20, Issue 2, pp. 91–190).

Home | Growtech. (n.d.). Retrieved February 27, 2021, from https://www.growtech.com.tr/en/home.html

Hu, E. (2015). *A Startup Scene That's Not So Hot: Japan's Entrepreneur Shortage*. NPR. https://www.npr.org/sections/alltechconsidered/2015/05/07/404376767/a-startup-scene-thats-not-so-hot-japans-entrepreneur-shortage

Hudson, D., & Hite, D. (2003). Producer willingness to pay for precision application technology: Implications for government and the technology industry. *Canadian Journal of Agricultural Economics*, *51*, 39–53. https://doi.org/10.1111/j.1744-7976.2003.tb00163.x

Innoplex. (2015). *Innovative Greenhouse project in Japan, tomato production of 50kg/m2 in a high-tech greenhouse*. Business/Market. innoplex-agri.org/2015/08/innovative-greenhouse-project/

Innovation in the Netherlands. (2016). In *PWC*.

Innovation Japan | The Government of Japan - JapanGov -. (n.d.). Retrieved February 27, 2021, from https://www.japan.go.jp/technology/innovation/

J. S. Metcalfe. (1994). Evolutionary Economics and Technology Policy. *The Economic Journal*, *104*(425), 931–944. http://www.jstor.org/stable/2234988

Jacobsson, S., Sandén, B. A., & Bångens, L. (2004). Transforming the energy system-the evolution of the German technological system for solar cells. *Technology Analysis and Strategic Management*, *16*(1), 3–30. https://doi.org/10.1080/0953732032000199061

Japan' s food self-sufficiency rate hits lowest level in 25 years due to drop in wheat production. (2019). Japan Times. https://www.japantimes.co.jp/news/2019/08/06/national/japans-food-self-sufficiency-rate-hits-lowest-level-25-years-due-drop-wheat-production/#.XcHMFS-ZNN0

Japan Greenhouse Horticulture Association. (n.d.). https://jgha.com/english-page/

Jetro. (2017). *Market Report: Smart agriculture Content*.

https://www.jetro.go.jp/ext_images/usa/2018/PDF_files/mr_smartagri_en.pdf

Jin, B., & Moon, H. C. (2006). The diamond approach to the competitiveness of Korea's apparel industry: Michael Porter and beyond. *Journal of Fashion Marketing and Management*, *10*(2), 195–208. https://doi.org/10.1108/13612020610667504

Johnson, A., & Jacobsson, S. (2001). Inducement and blocking mechanisms in the development of a new industry: the case of renewable energy technology in Sweden. *Technology and the Market: Demand, Users and Innovation*. https://doi.org/10.4337/9781843762867.00012

Jouanjean, M.-A. (2019). Digital Opportunities for Trade in the Agriculture and Food Sectors. *OECD Working Paper*, *122*, 58. http://dx.doi.org/10.1787/91c40e07-en

JPFA Japan Plant Factory Association. (n.d.). https://npoplantfactory.org/en/

Jun, B., Gerybadze, A., & Kim, T.-Y. (2016). The legacy of Friedrich List: The expansive reproduction system and the Korean history of industrialization. *Hohenheim Discussion Papers in Business, Economics and Social Sciences*, *2*. http://nbn-resolving.de/urn:nbn:de:bsz:100-opus-11894

Kacira, M., Sase, S., Kacira, O., OKUSHIMA, L., ISHII, M., Kowata, H., & Moriyama, H. (2004). Status of greenhouse production in Turkey: Focusing on vegetable and floriculture production. *Journal of Agricultural Meteorology*, 60(2), 115-122.

Kahan, D. (2013). Entrepreneurship in Farming. *FAO Farm Management Extension Guide*, *5*. https://www.cabdirect.org/cabdirect/abstract/19501100562

Kalecki, M. (1966). The difference between crucial economic problems of developed and underdeveloped non-socialist economies. In *Collected works of Michal Kalecki*.

Karakayacı, Z., & Bayramoglu, Z. (2013). Effect of ecological factors on yield and price fuctuations in agricultural products. *Journal of Environmental Protection and Ecology*, *14*(4), 1614–1626. https://www.cabdirect.org/cabdirect/abstract/19501100562

Karaşahin, M., Dündar, Ö., & Samancı, A. (2018). *The Way of Yield Increasing and Cost Reducing in Agriculture : Smart Irrigation and Fertigation*. *6*(10), 1370–1380.

Kavak, S. (2016). *Syrian refugees in seasonal agricultural work: a case of adverse incorporation in Turkey*. https://doi.org/10.1017/npt.2016.7

Kawasaki, N. (2019). *Analysis of Entrepreneurship and Multisectoral Farm Business Development*. Springer, Singapore. https://doi.org/10.1007/978-981-13-8055-6_2

Kaygusuz, K. (2010). Sustainable energy, environmental and agricultural policies in Turkey. *Energy Conversion and Management*, *51*(5), 1075–1084. https://doi.org/10.1016/j.enconman.2009.12.012

Kebebe, E., Duncan, A. J., Klerkx, L., de Boer, I. J. M., & Oosting, S. J. (2015). Understanding socio-economic and policy constraints to dairy development in Ethiopia: A coupled functional-structural innovation systems analysis. *Agricultural Systems*, *141*, 69–78. https://doi.org/10.1016/j.agsy.2015.09.007

Kekkilä-BVB Research - BVB Substrates. (n.d.). Retrieved February 27, 2021, from https://www.bvb-substrates.nl/en/home-2/services/bvb-research/

Kim, E. (2016). Japanese Policy and Programs for the Fostering of Global Entrepreneurs. *STI Policy Review*, *7*(1), 40–65. http://www.jst.go.jp/start/event/20121022/k02.pdf

Kiminami, A. (2019). *Issues on Entrepreneurship and Human Resource Development in Japanese Farm Business* (pp. 1–11). https://doi.org/10.1007/978-981-13-8055-6_1

Klein Woolthuis, R., Lankhuizen, M., & Gilsing, V. (2005). A system failure framework for innovation policy design. *Technovation*, *25*(6), 609–619. https://doi.org/10.1016/j.technovation.2003.11.002

Klerkx, L., Aarts, N., & Leeuwis, C. (2010). Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment. *Agricultural Systems*, *103*(6), 390–400. https://doi.org/10.1016/j.agsy.2010.03.012

Kline, S. J., & Rosenberg, N. (1968). *An overview of innovation*. https://doi.org/10.1142/9789814273596_0009

KOSGEB. (2015). *Turkish Entrepreneurship Strategy and Action Plan (2015-2018)*. http://www.kosgeb.gov.tr/Content/Upload/Dosya/Mali Tablolar/Gisep_2015-2018_EN.pdf

Kristensen, A. R. (1997). European Conference for Information Technology in Agriculture. *The Royal Veterinary and Agricultural University*. https://www.researchgate.net/publication/2827291%0AProceedings:

Kruger, H. (2017a). Creating an enabling environment for industry-driven pest suppression: The case of suppressing Queensland fruit fly through area-wide management. *Agricultural Systems*, *156*, 139–148. https://doi.org/10.1016/j.agsy.2017.05.008

Kruger, H. (2017b). Helping local industries help themselves in a multi-level biosecurity world – Dealing with the impact of horticultural pests in the trade arena. *NJAS - Wageningen Journal of Life Sciences*, *83*, 1–11.

https://doi.org/10.1016/j.njas.2017.11.001

Krutz, G. W. (1983). Intelligent machines for agriculture in 1990. In *SAE Technical Paper*. https://doi.org/10.4271/831269

Kumagai, F. (2015). Family issues on marriage, divorce, and older adults in Japan: With special attention to regional variations. In *Springer Science+Business Media Singapore*. https://doi.org/10.1007/978-981-287-185-5

Kurtaslan, T. (2021). Comparison of Conventional Production and Good Agricultural Practices (GAP) in Greenhouse Grown Strawberry. *Asian Journal of Advances in Agricultural Research*. 15(2): 1-13, 2021; Article no.AJAAR.67704. ISSN: 2456-8864

Kurz, H. D., & Salvadori, N. (2006). Input-output analysis from a wider perspective: A comparison of the early works of Leontief and Sraffa. *Economic Systems Research*, *18*(4), 373–390. https://doi.org/10.1080/09535310601020959

Kushida, K. E. (2018). *Abenomics and Japan's Entrepreneurship and Innovation: Is the Third Arrow Pointed in the Right Direction for Global Competition in the Digital Era of Silicon Valley?*

Kuznets, S. (1961). The role of agriculture in development. *International Journal of Agrarian Affairs*, *3*(2). https://doi.org/10.1093/0195305191.003.0008

Lambert, D., & Lowenberg-DeBoer, J. (2000). *Precision Agriculture Profitability Review*.

Lamprinopoulou, C., Renwick, A., Klerkx, L., Hermans, F., & Roep, D. (2014). Application of an integrated systemic framework for analysing agricultural innovation systems and informing innovation policies: Comparing the Dutch and Scottish agrifood sectors. *Agricultural Systems*, *129*, 40–54. https://doi.org/10.1016/j.agsy.2014.05.001

Larosse, J. (2017). *Analysis of National Initiatives on Digitising European Industry*. https://ec.europa.eu/digital-single-market/en/news/europes-digital-progress-report-2017

Lauwere, C. C. de. (2005). The role of agricultural entrepreneurship in Dutch agriculture of today. *Agricultural Economics*, *33*(2), 229–238. https://www.wur.nl/en/Publication-details.htm?publicationId=publication-way-333536313734

Law Changes 2020: Entrepreneurship. (2019). NL Times. https://nltimes.nl/2019/12/19/law-changes-2020-entrepreneurship

Liaghat, S., & Balasundram, S. K. (2010). A review: The role of remote sensing in precision agriculture. *American Journal of Agricultural and Biological Science*, *5*(1), 50–55. https://doi.org/10.3844/ajabssp.2010.50.55

Liu, X., & White, S. (2001). Comparing innovation systems: a framework and application to China's transitional context. *Research Policy, 30,* 1091–1114.

Long, T. B., Blok, V., & Coninx, I. (2016). Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: Evidence from the Netherlands, France, Switzerland and Italy. *Journal of Cleaner Production*, *112,* 9–21. https://doi.org/10.1016/j.jclepro.2015.06.044

López, J., & Assous, M. (2010). *Michal Kalecki (Great Thinkers in Economics)* (A. P. Thirlwall (Ed.)).

Lowenberg-DeBoer, J., & Boehlje, M. (1996). Revolution, Evolution or Dead-End: Economic Perspectives on Precision Agriculture. In P.C. Robert, R. H. Rust, & W. E. Larson (Eds.), *Third International Conference on Precision Agriculture*. https://doi.org/10.2134/1996.precisionagproc3.c116

Lowenberg-DeBoer, J., & Swinton, S. M. (1997). *Economics of Site-Specific Management in Agronomic Crops*. 369–396. https://doi.org/10.2134/1997.stateofsitespecific.c16

LTO Netherlands. (n.d.). https://www.lto.nl/over-lto/english/

Lundvall, B.-äke, & Johnson, B. (2006). The Learning Economy. *Journal of Industry Studies*. https://doi.org/10.1080/13662719400000002

Lundvall, B. Å. (1998). Why study national systems and national styles of innovation? *Technology Analysis and Strategic Management*, *10*(4), 407–422. https://doi.org/10.1080/09537329808524324

Lundvall, B. Å. (2010). Innovation system research – Where it came from and where it might go. *National Systems of Innovation: Toward a Theory of Innovation and Interactive Learning*, 317–350. https://doi.org/10.7135/UPO9781843318903.016

Maghabl, R., Naderi Mahdei, K., Yaghoubi Farani, A., & Mohammadi, M. (2018). Institutional mapping of nano-technological innovation system in the agricultural sector of Iran. *Journal of Agricultural Science and Technology, 20*(3), 445–457.

Mahant, M., Shukla, A., Dixit, S., & Patel, D. (2012). Uses of ICT in Agriculture. *International Journal of Advanced Computer Research*, *2*(1), 46.

Malerba, F. (2002). Sectoral systems of innovation and production. *Research Policy*, *31*, 247–264.

Maohua, W. (2001). Possible adoption of precision agriculture for developing countries at the threshold of the new millennium. *Computers and Electronics in Agriculture*, *30,* 45–50. https://doi.org/10.1016/S0168-1699(00)00154-X

Marcus, A. (1985). Agricultural Science and the Quest for Legitimacy: Farmers, Agricultural Colleges and Experiment Stations, 1870-1890. *Iowa State University Press*. http://dx.doi.org/10.1016/j.cirp.2016.06.001%0Ahttp://dx.doi.org/10.1016/j.powtec.2016.12.055%0Ahttps://doi.org/10.1016/j.ijfatigue.2019.02.006%0Ahttps://doi.org/10.1016/j.matlet.2019.04.024%0Ahttps://doi.org/10.1016/j.matlet.2019.127252%0Ahttp://dx.doi.o

Markard, J., Hekkert, M., & Jacobsson, S. (2015). The technological innovation systems framework: Response to six criticisms. *Environmental Innovation and Societal Transitions, 16*, 76–86. https://doi.org/10.1016/j.eist.2015.07.006

Market scan: Japan's modern greenhouse industry. (2018). HortiDaily. https://www.hortidaily.com/article/9052156/market-scan-japan-s-modern-greenhouse-industry/

Marktscan moderne glastuinbouw Japan. (2018). Government of Netherlands. https://www.agroberichtenbuitenland.nl/actueel/nieuws/2018/12/10/market-scan-on-large-scale-modern-greenhouses-in-japan

Masayoshi, H. (1993). Japan's Agricultural Policy and Protection Growth. *Natioanal Bureau of Economic Research, 2*, 95–114. http://www.nber.org/books/ito_93-2

Matlı, Ö. (2019). *Sera paketi Türkiye Tarımı için büyük firsat!* Gıda Hattı. https://www.gidahatti.com/sera-paketi-turkiye-tarimi-icin-buyuk-firsat-141847/

Mazzucato, M. (2011). The entrepreneurial state. *Soundings*, *49*. https://doi.org/10.3898/136266211798411183

Mcbratney, A., Whelan, B., & Ancev, T. (2005). Future Directions of Precision Agriculture. *7th International Conference on Precision Agriculture*, *6*, 7–23. https://doi.org/10.1007/978-981-15-6333-1_9

McElwee, G. (2005). Developing entrepreneurial skills of farmers. In *Commission of the European Community*.

Menary, J., Collier, R., & Seers, K. (2019). Innovation in the UK fresh produce sector: Identifying systemic problems and the move towards systemic facilitation. *Agricultural Systems, 176*. https://doi.org/10.1016/j.agsy.2019.102675

Micaëlli, J.-P., Forest, J., Coatanéa, É., & Medyna, G. (2014). How to improve Kline and Rosenberg's chain-linked model of innovation: building blocks and diagram-based languages. *Journal of Innovation Economics and Management*, *15*(3), 59–77. https://doi.org/10.3917/jie.015.0059

Minh, T. T. (2019). Unpacking the systemic problems and blocking mechanisms of a regional agricultural innovation system: An integrated regional-functional-structural analysis. *Agricultural Systems, 173*, 268–280.

https://doi.org/10.1016/j.agsy.2019.03.009

More Dutch agrarians active on social media | AgriDirect. (n.d.). Retrieved February 18, 2021, from https://www.agridirect.eu/news/more-dutch-agrarians-active-on-social-media

Morimoto, T., Purwanto, W., Suzuki, J., & Hashimoto, Y. (1997). Optimization of heat treatment for fruit during storage using neural networks and genetic algorithms. *Computers and Electronics in Agriculture*, *19*, 87–101. https://doi.org/10.1016/S0168-1699(97)00037-9

Morimoto, Tetsuo, & Hashimoto, Y. (1998). An Intelligent Control Technique Based on Fuzzy Controls, Neural Networks and Genetic Algorithms for Greenhouse Automation. *IFAC Artificial Intelligence in Agriculture*, 61–66. https://doi.org/10.1016/s1474-6670(17)42098-2

Morimoto, Tetsuo, & Hashimoto, Y. (2009). Speaking plant/fruit approach for greenhouses and plant factories. In *Environmental Control in Biology* (Vol. 47, Issue 2, pp. 55–72). https://doi.org/10.2525/ecb.47.55

Mulla, D. J. (2013). Twenty five years of remote sensing in precision agriculture: Key advances and remaining knowledge gaps. *Biosystems Engineering*, *114*, 358–371. https://doi.org/10.1016/j.biosystemseng.2012.08.009

Müller, K., Artner, A., & Knierim, A. (2008). Demographic changes and the demands on agricultural landscapes: Refl ections on a new research topic. *Landscape Online*. https://doi.org/10.3097/LO.200809

Negro, S. O. (2007). Dynamics of Technological Innovation Systems. *Netherlands Geographical Studies 356*.

Nelson, R. R. (1993a). *National Innovation Systems: A Comparative Analysis*. https://books.google.com.tr/books?hl=tr&lr=&id=C3Q8DwAAQBAJ&oi=fnd&pg=PR7&dq=Nelson,+R.+R.+(1993).+National+innovation+systems:+a+comparative+analysis.+Oxford+University+Press+on+Demand.&ots=diI1nPyAlM&sig=WOJUlemLS8XU1KWqissW4G6ec0s&redir_esc=y#v=onepage

Nelson, R. R. (1993b). National Innovation Systems: Italy. In *National Innovation Systems: A Comparative Analysis* (pp. 230–259). https://books.google.com.tr/books?hl=tr&lr=&id=C3Q8DwAAQBAJ&oi=fnd&pg=PA230&dq=Malerba,+F.+(1993).+The+national+system+of+innovation:+Italy.+National+innovation+systems:+A+comparative+analysis,+230-259.&ots=diI1nODDlG&sig=QAIr7HXCtuJKkNBm_JQxyRQxrWs&redir

Netherlands: number of greenhouse horticulture farms 2007-2019 | Statista. (2021). Statista. https://www.statista.com/statistics/647446/total-number-of-greenhouse-horticulture-farms-in-the-netherlands/

Netherlands doubles 2020 green subsidies in rush to hit climate goals. (2020). Reuters. https://www.reuters.com/article/us-climate-change-netherlands-idUSKBN20R2DT

New Dutch greenhouse alliance - Hort News. (2015). Hort News. https://hortnews.com/new-dutch-greenhouse-alliance/

OECD. (2009). Evaluation of agricultural policy reforms in Japan. *Evaluation of Agricultural Policy Reforms in Japan*, *9789264061*, 1–120. https://doi.org/10.1787/9789264061545-en

OECD. (2015). Innovation, Agricultural Productivity and Sustainability in Turkey. In *OECD Food and Agricultural Reviews*. http://www.oecd-ilibrary.org/agriculture-and-food/innovation-agricultural-productivity-and-sustainability-in-brazil/investment-in-the-brazilian-food-and-agriculture-system_9789264237056-7-en%5Cnhttp://www.oecd-ilibrary.org/agriculture-and-food/innovation-

OECD. (2018). *Agricultural Policy Monitoring and Evaluation 2018*. OECD Publishing. https://doi.org/10.1787/b0541836-es

OECD. (2020). *Education at a Glance 2020* (Education at a Glance). OECD. https://doi.org/10.1787/69096873-en

OECD iLibrary | Elderly population. (n.d.). Retrieved February 20, 2021, from https://www.oecd-ilibrary.org/social-issues-migration-health/elderly-population/indicator/english_8d805ea1-en

Oliver, M., Bishop, T., & Marchant, B. (2013). Precision Agriculture for Sustainability and Environmental Protection. In *Earthscan Food and Agriculture*. https://books.google.com.tr/books?hl=tr&lr=&id=ep4lAgAAQBAJ&oi=fnd&pg=PP1&dq=Olivier,+M.+A.+(2013).+Precision+Agriculture+for+Sustainability+and+Evironmental+Protection&ots=KgNDc9nYph&sig=LkvNhxoWc0CqTZGCS5M98Vzp9BY&redir_esc=y#v=onepage&q&f=false

Olson, K. (1998). Precision agriculture: current economic and environmental issues. *Sixth Joint Conference on Food, Agriculture, and the Environment*.

Ondoua, R. N., & Walsh, O. (2017). Precision agriculture advances and limitations: Lessons to the stakeholders. *Crops & Soils*. https://doi.org/10.2134/cs2017.50.0408

Onitsuka, K. (2019). How social media can foster social innovation in disadvantaged rural communities. *Sustainability*, *11*(9). https://doi.org/10.3390/su11092697

Oriade, C. A., King, R. P., Forcella, F., & Gunsolus, J. L. (1996). A Bioeconomic Analysis of Site-Specific Management for Weed Control. *Review of Agricultural Economics*, *18*(4), 523–535. https://doi.org/10.2307/1349587

Oriade, C., & Popp, M. (2000). Precision farming as a risk reducing tool: a whole-farm investigation. In P. C. Robert, R. H. Rust, & W. E. Larson (Eds.), *Proceedings of Fifth International Conference on Precision Agriculture*. American Society of Agronomy. https://www.cabdirect.org/cabdirect/abstract/20023117726

Orji, R. O. (2010). Analysis of Usability and Accessibility Problems of Financial Sectors ' Website using Visitor-based Evaluation Technique. *2nd International Conference on Information and Multimedia Technology*, 252–257. https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwj2t7j_-szYAhVRzaQKHdeuDXsQFggnMAA&url=http%3A%2F%2Fhomepage.usask.ca%2F~roo083%2FPapers%2FAnalysis%2520of%2520Usability%2520and%2520Accessibility%2520Problems%2520

Örtü Altı Yetiştiricilik. (n.d.). Ministry of Agriculture and Forestry. https://www.tarimorman.gov.tr/Konular/Bitkisel-Uretim/Tarla-Ve-Bahce-Bitkileri/Ortu-Alti-Yetistiricilik

Özeke, H. B. (2018). *Turkey Incentivizes the Start-up Ecosystem*. Lexology. https://www.lexology.com/library/detail.aspx?g=a3e8cd0a-1696-4a7b-9ed2-c46ea862a2b8

Panagos, P., Karydas, C. G., Gitas, I. Z., & Montanarella, L. (2012). Monthly soil erosion monitoring based on remotely sensed biophysical parameters: a case study in Strymonas river basin towards a functional pan-European service. *International Journal of Digital Earth*, *5*(6), 461–487. https://doi.org/10.1080/17538947.2011.587897

Park, Y.-T. (1999). Technology diffusion policy: A review and classification of policy practices. *Technology in Society*, *21*(3), 275–286. https://doi.org/10.1016/S0160-791X(99)00015-9

Pawlak, K., & Kołodziejczak, M. (2020). The role of agriculture in ensuring food security in developing countries: Considerations in the context of the problem of sustainable food production. *Sustainability*, *12*. https://doi.org/10.3390/su12135488

Performance Programme for 2018. (2018).

Pitts, M. J., Hummel, J. W., & Butler, B. J. (1986). Sensors Utilizing Light Reflection To Measure Soil Organic Matter. *Transactions of the American Society of Agricultural Engineers*, *29*, 422–428. https://doi.org/10.13031/2013.30166

Porter, M. E. (1998). Clusters and the New Economics of Competition. *Harvard Business Review*. http://marasbiber.com/wp-content/uploads/2018/05/Michael-E.-Porter-Cluster-Reading.pdf

Possas, M. L., Salles-Filho, S., & Da Silveira, J. M. (1996). An evolutionary approach to technological innovation in agriculture: Some preliminary remarks. *Research Policy, 25*(6), 933–945. https://doi.org/10.1016/0048-7333(96)00884-0

Precision Farming Market by Technology (Guidance, VRT, Remote Sensing), Application (Crop Scouting, Field Mapping, Variable Rate Application), Offering (Hardware—Sensors, GPS, Yield Monitors; Software; Services) and Geography - Global Forecast to 2025. (2020). https://www.marketsandmarkets.com/Market-Reports/precision-farming-market-1243.html

Raikar, K., Gawade, S., & Chopade, S. (2017). Usability Evaluation of Agricultural Websites. *Computing for Sustainable Global Development, September,* 136–141.

Rajalahti, R., Janssen, W., & Pehu, E. (2008). Agricultural Innovation Systems : From Diagnostics toward Operational Practices Systems. *Agriculture and Rural Development, 38*. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Agricultural+Innovation+Systems:+From+Diagnostics+toward+Operational+Practices+Systems#0

Relations between Turkey and the Russian Federation. (n.d.). Rep. of Turkey Ministry of Foreign Affairs. http://www.mfa.gov.tr/relations-between-turkey-and-the-russian-federation.en.mfa

Richter, A. (2019). *New loan product announced for greenhouse development in Turkey*. ThinkGeoEnergy - Geothermal Energy News. https://www.thinkgeoenergy.com/new-loan-product-announced-for-greenhouse-development-in-turkey/

Robert, Pierre C. (1999). Precision Agriculture: an Information Revolution in Agriculture. In *Journal of Chemical Information and Modeling*.

Rossler, M. T. (2019). The Impact of Police Technology Adoption on Social Control, Police Accountability, and Police Legitimacy. *Political Authority, Social Control and Public Policy*. https://doi.org/10.1108/s2053-769720190000031014

Rothaermel, F. T., Agung, S. D., & Jiang, L. (2007). University entrepreneurship: A taxonomy of the literature. *Industrial and Corporate Change*, *16*(4), 691–791. https://doi.org/10.1093/icc/dtm023

Rudmann, C. (2008). Entrepreneurial Skills and their Role in Enhancing the Relative Independence of Farmers. In *FiBL*. http://orgprints.org/18064/1/rudmann-etal-2008-esof.pdf

Ruttan, A. V. W., & Hayami, Y. (1973). Technology Transfer and Agricultural Development. *Technology and Culture*, *14*(2), 119–151. https://www.jstor.org/stable/3102398 REFERENCES

Saito, K. (2019). *Issues on Innovation in Japanese Farm Business*. https://doi.org/10.1007/978-981-13-8055-6_6

Sasao, A., & Shibusawa, S. (2000). Prospects and strategies for precision farming in Japan. *Japan Agricultural Research Quarterly*, *34*(4), 233–238.

Schiller, K. J. F., Klerkx, L., Poortvliet, P. M., & Godek, W. (2020). Exploring barriers to the agroecological transition in Nicaragua: A Technological Innovation Systems Approach. *Agroecology and Sustainable Food Systems*, *44*(1), 88–132. https://doi.org/10.1080/21683565.2019.1602097

Schlepers, R. (2016). *International High Tech Greenhouse 2020 in Holland*. HortiDaily. https://www.hortidaily.com/article/6023881/international-high-tech-greenhouse-2020-in-holland/

Schrijver, R., Poppe, K., & Daheim, C. (2016). *Precision agriculture and the future of farming in Europe: Scientific Foresight Study*. https://doi.org/10.2861/020809

Schueller, J. K. (2009). Dynamic accuracy in fruit and vegetable precision agriculture. *Acta Horticulturae*, *824*, 245–250. https://doi.org/10.17660/ActaHortic.2009.824.28

Schumpeter, J. A. (1939). Business cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process Abridged,. In *The Routledge Handbook of Modern Economic History*. https://doi.org/10.4324/9780203075616-20

Schumpeter, J. A. (2000). Entrepreneurship as Innovation. *University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship*. https://papers.ssrn.com/abstract=1512266

Schwab, K., & Zahidi, S. (2020). *Global Competitiveness Report 2020*. https://www.weforum.org/reports/the-global-competitiveness-report-2020

Sebby, K. (2010). *The Green Revolution of the 1960's and Its Impact on Small Farmers in India* [University of Nebraska at Lincoln Follow]. https://digitalcommons.unl.edu/envstudtheses/10

Sener, S., Hacioglu, V., & Akdemir, A. (2017). Invention and innovation in economic change. *Journal of Economics, Finance and Accounting*, *4*(2), 201–206. https://doi.org/10.17261/pressacademia.2017.450

SERA-BİR. (n.d.). https://www.sera-bir.org.tr/

SERKONDER – Sera Konstrüksiyon Donanım ve Ekipman Üreticileri ve İhracatçıları Derneği. (n.d.). https://www.serkonder.org.tr/

Seuneke, P., Lans, T., & Wiskerke, J. S. C. (2013). Moving beyond entrepreneurial skills: Key factors driving entrepreneurial learning in multifunctional agriculture. *Journal of Rural Studies*, *32*, 208–219. https://doi.org/10.1016/j.jrurstud.2013.06.001

Sevgican, A. (1999). PROTECTED CULTIVATION IN TURKEY. Acta Horticulturae, (491), 31–36. doi:10.17660/actahortic.1999.491.3

Sevgican, A., Gül, A., Tüzel, Y., & Eltez, R. Z. (2000). Türkiye'de Örtüaltı Yetiştiriciliği. *Akdeniz Üniversitesi Ziraat Fakültesi Dergisi*.

Shapira, P., & Rosenfeld, S. (1996). An Overview of Technology Diffusion Policies and Programs to Enhance the Technological Absorptive Capabilities of Small and Medium Enterprises. In *Mimeo*.

Shibusawa, S. (2011). New Stage of Agricultural Mechanization Research in Japan. *Agricultural Mechanization in Asia, Africa & Latin America*, *42*(1), 79–82. https://www.researchgate.net/publication/286741921_New_Stage_of_Agricultural_Mechanization_Research_in_Japan

Shinato, T., Kamei, K., & Dana, L. P. (2013). Entrepreneurship education in Japanese universities -how do we train for risk taking in a culture of risk adverseness? *International Journal of Entrepreneurship and Small Business*, *20*(2), 184–204. https://doi.org/10.1504/IJESB.2013.056278

Siegel, D. S., Veugelers, R., & Wright, M. (2007). Technology transfer offices and commercialization of university intellectual property: performance and policy implications. *Oxford Review of Economic Policy*, *23*(4), 640–660. https://doi.org/10.1093/icb/grm036

Sijmonsma, A. (2014). *Kagome to build first Ultra Clima greenhouse in Japan*. HortiDaily. https://www.hortidaily.com/article/6010543/kagome-to-build-first-ultra-clima-greenhouse-in-japan/

Sijmonsma, A. (2016). *Japan: Many opportunities, but growers lack the confidence to invest without subsidies*. HortiDaily. https://www.hortidaily.com/article/6027995/japan-many-opportunities-but-growers-lack-the-confidence-to-invest-without-subsidies/

Silleli, H., Tazegül, Ü., & Yıldırım, E. (2020). SERA MEKANİZASYONUNDA MEVCUT DURUM VE GELECEK. *Türkiye Ziraat Mühendisliği IX. Teknik Kongresi Bildiriler Kitabı*-1, 325

Situation of Greenhouse Horticulture Ministry of Agriculture, Forestry and Fisheries. (2018). Ministry of Agriculture, Forestry and Fisheries. http://www.maff.go.jp/e/policies/agri/attach/pdf/index-16.pdf

Smit, M. J., Van Leeuwen, E. S., Florax, R. J. G. M., & De Groot, H. L. F. (2015). Rural development funding and agricultural labour productivity: A spatial analysis of the European Union at the NUTS2 level. *Ecological Indicators*, *59*, 6–18. https://doi.org/10.1016/j.ecolind.2015.05.061

Smith, A., & Kern, F. (2009). The transitions storyline in Dutch environmental policy. *Environmental Politics, 18*(1), 78–98. https://doi.org/10.1080/09644010802624835

Smithers, J., & Blay-Palmer, A. (2001). Technology innovation as a strategy for climate adaptation in agriculture. *Applied Geography*, *21*(2), 175–197. https://doi.org/10.1016/S0143-6228(01)00004-2

Smits, R., & Kuhlmann, S. (2004). The rise of systemic instruments in innovation policy. *International Journal of Foresight and Innovation Policy*, *1*(1–2), 4–32. https://doi.org/10.1504/ijfip.2004.004621

Soto, I., Barnes, A., Balafoutis, A., Beck, B., Sánchez, B., Vangeyte, J., Fountas, S., Van der Wal, T., Eory, V., & Gómez-Barbero, M. (2019). *The contribution of precision agriculture technologies to farm productivity and the mitigation of greenhouse gas emissions in the EU*. https://doi.org/10.2760/016263

Spielman, D. J., Ekboir, J., & Davis, K. (2009). The art and science of innovation systems inquiry: Applications to Sub-Saharan African agriculture. *Technology in Society, 31*(4), 399–405. https://doi.org/10.1016/j.techsoc.2009.10.004

Strategic Plan 2013-2017. (n.d.).

Strategic Plan 2018-2022. (n.d.).

Structural Changes and Reforms on Turkish Agriculture (2003-2013). (2013).

Summary of the Annual Report on Food, Agriculture and Rural Areas in Japan. (2017). http://www.maff.go.jp/j/wpaper/w_maff/h27/attach/pdf/index-5.pdf

Supporting ambitious entrepreneurs and startups | Enterprise and innovation. (n.d.). Government.Nl. https://www.government.nl/topics/enterprise-and-innovation/supporting-ambitious-entrepreneurs-and-startups

Syrian refugees harvest greenhouse vegetables in Turkey's Osmaniye. (2018). *Hurriyet Daily News*. https://www.hurriyetdailynews.com/syrian-refugees-harvest-greenhouse-vegetables-in-turkeys-osmaniye-139429

Tahir, U., & Mushtaq, A. (2015). Measuring User Satisfaction through Website Evaluation Framework. *International Journal of Knowledge Engineering-IACSIT, 1*(2), 125–128. https://doi.org/10.7763/ijke.2015.v1.21

Takayama, K., Nishina, H., Iyoki, S., Arima, S., Hatou, K., Ueka, Y., & Miyoshi, Y. (2011). Early detection of drought stress in tomato plants with chlorophyll fluorescence imaging - Practical application of the speaking plant approach in a greenhouse. In *18th World Congress The International Federation of Automatic Control*. IFAC. https://doi.org/10.3182/20110828-6-IT-1002.01490

Tani, A. (2018). A Strategic Niche Management approach for shaping bio-based economy in Europe. *Open Agriculture*, *3*(1), 98–109. https://doi.org/10.1515/opag-2018-0010

Tardaguila, J., Baluja, J., Arpon, L., Balda, P., & Oliveira, M. (2011). Variations of soil properties affect the vegetative growth and yield components of “Tempranillo” grapevines. *Precision Agriculture*, *12*(5), 762–773. https://doi.org/10.1007/s11119-011-9219-4

TARSIM. (n.d.). https://web.tarsim.gov.tr/havuz/subpageEng?_key_=6D7415BE31795E0576A7CE18FEDB4F2E32687854HWFTMGFBMMT260IZO224062015

Tataraki, K., Giannini, E., Kavvadias, K., & Maroulis, Z. (2020). Cogeneration economics for greenhouses in Europe. *Energies, 13*. https://doi.org/10.3390/en13133373

Tey, Y. S., & Brindal, M. (2012). Factors influencing the adoption of precision agricultural technologies: A review for policy implications. *Precision Agriculture*, *13*, 713–730. https://doi.org/10.1007/s11119-012-9273-6

The EU Response to the Refugee Crisis in Turkey. (n.d.). EUD. https://www.avrupa.info.tr/en/eu-response-refugee-crisis-turkey-710

The Global Information Technology Report 2016. (2016). https://www.weforum.org/reports/the-global-information-technology-report-2016

The Netherlands Commercial Greenhouse Market Size, Share, Opportunities And Trends By Type (Plastic, Glass), By Component (High-Tech, Medium-Tech And Low-Tech Commercial Greenhouse) And By Application (Fruits And Vegetables, Flowers And Ornamentals, Nurse. (2020). Knowledge Sourcing Intelligence. https://www.knowledge-sourcing.com/report/netherlands-commercial-greenhouse-market

The Netherlands Greenhouse Cultivation Market Outlook to 2019 - Declining Profitability to Hamper Growth. (2015). Ken Research. https://www.kenresearch.com/blog/2015/03/netherlands-greenhouse-cultivation-market-research-report/

Tokyo government eases regulations to attract foreign entrepreneurs. (2016). Japan Today. https://japantoday.com/category/business/tokyo-government-eases-regulations-to-attract-foreign-entrepreneurs

Touzard, J.-M., Temple, L., Faure, G., & Triomphe, B. (2015). Innovation systems and knowledge communities in the agriculture and agrifood sector: a literature review. *Journal of Innovation Economics and Management*, *17*(2), 117–142.

https://doi.org/10.3917/jie.017.0117

TR63 Bölgesi Seracılık (Örtüaltı Bitki Yetiştiriciliği) Sektör Raporu. (2015).

Turkey Emerges as the Largest Producer of Tomatoes in the Middle East. (2020). Global Trade Magazine. https://www.globaltrademag.com/turkey-emerges-as-the-largest-producer-of-tomatoes-in-the-middle-east/#:~:text=Written by IndexBox-,Turkey Emerges as the Largest Producer of Tomatoes in the,84%25 share of total production.

Turkey Exports to Russia: 1992-2020 Data. (n.d.). Trading Economics. https://tradingeconomics.com/turkey/exports-to-russia

Turkish Greenhouse Market is expected to grow USD 136 million annually in next 5 years. (2018). Eurofresh Distribution. https://www.eurofresh-distribution.com/news/turkish-greenhouse-market-expected-grow-usd-136-million-annually-next-5-years

Turner, J. A., Klerkx, L., Rijswijk, K., Williams, T., & Barnard, T. (2016). Systemic problems affecting co-innovation in the New Zealand Agricultural Innovation System: Identification of blocking mechanisms and underlying institutional logics. *NJAS - Wageningen Journal of Life Sciences, 76*, 99–112. https://doi.org/10.1016/j.njas.2015.12.001

Tuzel, Y., & Oztekin, G. B. (2016). Recent developments of vegetables protected cultivation in Turkey. Acta Horticulturae, (1142), 435–442. doi:10.17660/actahortic.2016.1142.66

TÜZEL, Y., GÜL, A., ÖZTEKİN, G. B., ENGİNDENİZ, S., BOYACI, F., DUYAR, H., CEBECİ, E., & DURDU, T. (2020). TÜRKİYE' DE ÖRTÜALTI YETİŞTİRİCİLİĞİ VE YENİ GELİŞMELER. *Türkiye Ziraat Mühendisliği IX.Teknik Kongresi*.

Udink ten Cate, A. J., Bot, G. P. A., & van Dixhoorn, J. J. (1978). COMPUTER CONTROL OF GREENHOUSE CLIMATES. *Acta Horticulturae*. https://doi.org/10.17660/actahortic.1978.87.28

Upscaling of greenhouse vegetable production. (2018). CBS. https://www.cbs.nl/en-gb/news/2018/16/upscaling-of-greenhouse-vegetable-production

Van der Heide, C. M., Silvis, H. J., & Heijman, W. J. M. (2011). Agriculture in the Netherlands: Its recent past, current state and perspectives. *Applied Studies in Agribusiness and Commerce*, 23–28. https://doi.org/10.19041/apstract/2011/1-2/3

van Mierlo, B., Leeuwis, C., Smits, R., & Woolthuis, R. K. (2010). Learning towards system innovation: Evaluating a systemic instrument. *Technological Forecasting and Social Change*, *77*(2), 318–334.

https://doi.org/10.1016/j.techfore.2009.08.004

Viatte, G. (2002). New Policy Challenges: Requirements for Data Collection and Analysis. *Conference on Agricultural and Environmental Statistical Applications in Rome*.

Vishwanath, A. (2009). From belief-importance to intention: The impact of framing on technology adoption. *Communication Monographs*, *76*(2), 177–206. https://doi.org/10.1080/03637750902828438

Von Elsner, B., Briassoulis, D., Waaijenberg, D., Mistriotis, A., Von Zabeltitz, C., Gratraud, J., Russo, G., & Suay-Cortes, R. (2000). Review of structural and functional characteristics of greenhouses in European Union countries, part II: Typical designs. *Journal of Agricultural and Engineering Research*, *75*, 111–126. https://doi.org/10.1006/jaer.1999.0512

Weber, K. M., & Rohracher, H. (2012). Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive "failures" framework. *Research Policy*, *41*(6), 1037–1047. https://doi.org/10.1016/j.respol.2011.10.015

Weppner, B. (2019). The Bioeconomy in the Post-2020 CAP. In *EURACTIV*. http://eurac.tv/9QdP

Wiebold, B., Sudduth, K., Davis, G., Shannon, K., & Kitchen, N. (2015). Determining Barriers to Adoption and Research Needs of Precision Agriculture. In *North Central Soybean Research Program*.

Wieczorek, A. J. (2009). *A systemic innovation policy framework*.

Wieczorek, A. J., & Hekkert, M. P. (2012). Systemic instruments for systemic innovation problems: A framework for policy makers and innovation scholars. *Science and Public Policy*, *39*, 74–87. https://doi.org/10.1093/scipol/scr008

Wilms, R. (2020). *Dutch horticulture: regaining market leadership by using data*. HortiDaily. https://www.hortidaily.com/article/9196712/dutch-horticulture-regaining-market-leadership-by-using-data/

Yalçın Sever, C. (2018). Örtüaltı üretiminde dünyada dördüncü sıradayız. *Türk Tarım Orman Dergisi*. http://www.turktarim.gov.tr/Haber/11/ortualti-uretiminde-dunyada-dorduncu-siradayiz

Yasuda, T. (2009). Programs to Stimulate Startups and Entrepreneurship in Japan: Experiences and Lessons. In *21st Century Innovation Systems for Japan and the United States: Lessons from a Decade of Change: Report of a Symposium*. https://books.google.com.tr/books?hl=tr&lr=&id=o303RrRt1EgC&oi=fnd&pg=PA95&dq=Yasuda,+T.+(2009).+Programs+to+Stimulate+Startups+and+Entrepreneurship+in+Japan:+Experiences+and+Lessons.+21st+Century+Innovation+Systems+for+Japan+and+the+United+States:+Lesson

Yavuz, F. (2005). Türkiye'de tarım. T*arım ve Köyişleri Bakanlığı Yayınları*, Ankara, 1-252.

Yılmaz, H. (2014). An analysis on factors influencing government supported bumble bees use as pollinators by greenhouse producers' in the mediterranean coastal region of Turkey. *Acta scientiarum Polonorum*. Hortorum cultus = Ogrodnictwo 13(6):59-70

Yilmaz, I., Sayin, C., & Ozkan, B. (2005). Turkish greenhouse industry: Past, present, and future. *New Zealand Journal of Crop and Horticultural Science*, *33*(3). https://doi.org/10.1080/01140671.2005.9514355

Yoshida, S., Yagi, H., Kiminami, A., & Garrod, G. (2019). Farm diversification and sustainability of multifunctional peri-urban agriculture: Entrepreneurial attributes of advanced diversification in Japan. *Sustainability*. https://doi.org/10.3390/su11102887

Zhang, N., Wang, M., & Wang, N. (2002). Precision agriculture - A worldwide overview. *Computers and Electronics in Agriculture*, *36*, 113–132. https://doi.org/10.1016/S0168-1699(02)00096-0

Zollet, S. (2018). Towards sustainability transitions in Japanese agri-food systems: the role of new entrant organic farmers in rural areas of Hiroshima Prefecture, Japan. *13th European International Farming Systems Association Symposium*.

APPENDICES

Appendix 1: Number and Details of Top Ranked Universities

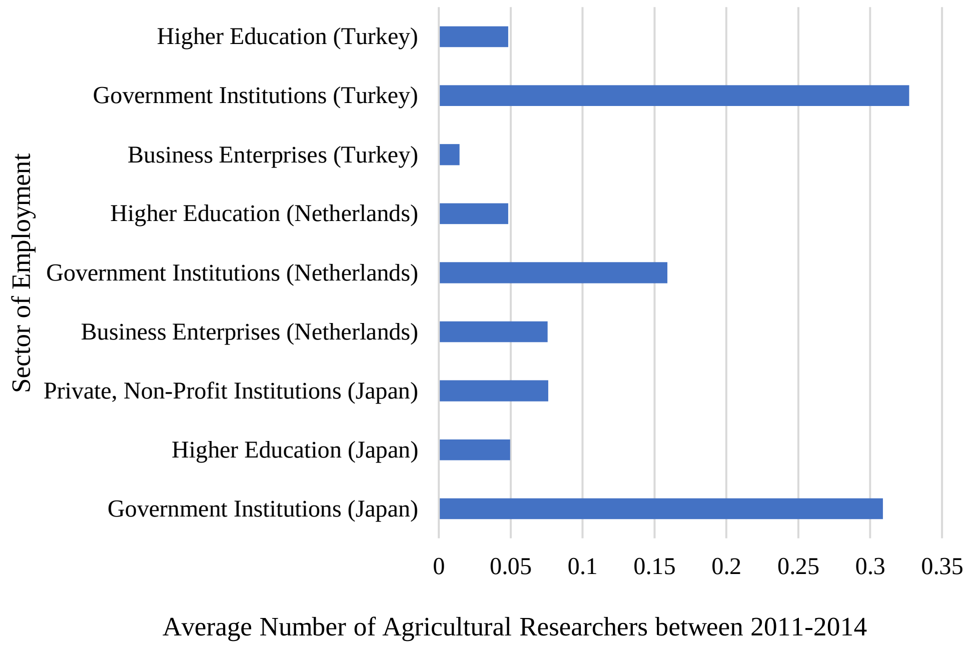
Country	# of Universities	# of Faculties of Agriculture	Universities with Faculty of Agriculture & Number of Students as of May 2020
Japan	41	18	University of Tokyo (27955), Kyoto University (22785), Tohoku University (18460), Nagoya University (16439), Hokkaido University (17909), Kyushu University (18747), University of Tsukuba (16422), Kobe University (16391), Chiba University (14242), Okayama University (13271), Gifu University (7283), Niigata University (12527), Tokyo University of Agriculture and Technology (5742), Kagoshima University (10577), Yamaguchi University (10314), Shinshu University (10944), Yokohama National University (10070), Tokai University (30061)
Netherlands	13	1	Wageningen University & Research (12001 in 2017-2018)
Turkey	9	1	Ankara University (64588 in 2015)

Appendix 2: University & Industry Research Collaboration

	Turkey	Netherlands	Japan
2013	3,57	5,30	5,03
2014	3,86	5,25	4,96
2015	3,70	5,40	5
2016	3,69	5,38	5
2017	3,47	5,50	4,75
2018	3,50	5,60	4,70
2019	3,20	5,50	4,90

Source: Global Innovation Index, 2019

Appendix 3: Share of Agricultural Sciences Researchers in Total Researchers



Source: OECD Data - R-D personnel by sector of employment and field of science, Agricultural Sciences researchers (full time equivalent) divided to Number of full-time researchers (BE: Business Enterprises, G: Government, HE: Higher Education, PNP: Private Non-Profit)

Appendix 4: Number of Patents in Detail

		2010	2011	2012	2013	2014	2015	2016
JPN	All Tech (number)	331953	328056	328754	316947	313973	303945	293083
	% of Tech Relating to Agr.	0,00081	0,00070	0,00073	0,00099	0,00096	0,00080	0,00077
	% Agr. Machinery	0,00031	0,00028	0,00023	0,00036	0,00028	0,00031	0,00027
ND	All Tech (number)	2295	2364	2199	2192	2191	2171	2215
	% of Tech Relating to Agr.	0,00522	0,00592	0,00682	0,00319	0,00547	0,00322	0,00586
	% Agr. Machinery	0,00130	0,00338	0,00181	0,00091	0,00091	0,00046	0,00135
TR	All Tech (number)	2029	2105	1089	974	1202	1475	2519
	% of Tech Relating to Agr.	0,00098	0,00095	0,00183	0,00102	0,00166	0,00135	0,00238
	% Agr. Machinery	0	0	0,00091	0	0,00083	0,00067	0,00119

Source*:* OECD Stat, Patents – Technology Diffusion, 2018

Appendix 5: Codebook

- Generic
  - vegetable production
  - Tomato production ALINTI
  - Climate advantages of Turkey greenhouse-diffused geography

- Knowledge Development and Diffusion
  - Problems
    - resistance in personal knowledge
    - preference in other university departments
    - lost of knowledge
    - insufficient education system
    - low education in chambers of agriculture
    - no science based skills of workers
    - no need for academic knowledge
  - Needs
    - need for technical skills
    - Need for academic knowledge
    - Need for experience based knowledge
  - Sources of knowledge
    - no knowledge sharing among small-large firms
    - knowledge share for money/income
    - knowledge obtained from outside
    - no knowledge asking in local people
    - cooperations (not producers) sharing new tech info
    - knowledge sharing in firm
    - gain of management experience in work
    - experience in other firms
    - knowledge from family business

- Entrepreneurial Activities
  - Large-Size Firm Activities
    - larger firms start with RD
    - large firms as role models
    - branches in other countries
    - tech usage by large firms
    - need for full automacy
    - unavailability of technology
  - Medium-Size Firm Activities
    - application of laboratory technology
    - RD for seed production
    - youth stay in rural
    - application for grant/support
    - not continuing to grant/support implementation
    - tech used for optimization in costs
  - Small-Size Firm Activities
    - small investments are not feasible
    - migration to urban

        - no investment trust
        - more tolerance in human-made mistakes

- Guidance of Research
    - Business culture
        - lack of organizational culture for safety
        - non-systematic work routines
        - No major change in work routines
        - Changes in work routines
        - No major change in technique/equipment
        - Changes in technique/equipment
        - Greenhouse operations - similarities
        - west-admiration
        - decision based on market distance
    - Complementary Services
        - problems - lack of supportive services
        - problems - constant repair need
        - standardized work of machines - disadvantage
    - Competition
        - need for technologic infrastructure for competitiveness
        - trust issues with local actors/service providers
        - weakness of local production material sellers agains large firms
        - competition among intermediary/buyer firms
        - everybody sales - no competition
        - no competitive environment
        - lower quality - due to competition
        - need for scientific development for competitiveness
        - competition on prices
    - Demand
        - no focus on market demand
    - Characteristics of Trade Relationship
        - business relations based on quality and trust
        - importance of timely payment
        - deferred payments in greenhouse production
    - Infrastructure
        - sufficient infrastructure
        - infrastructure problems
        - Available technology
        - need for more technology
    - Pricing
        - chained impacts of prices/payments
        - large firms keeping prices constant - to cope with competition
        - no enough discussion on price regulations

- Market Information
    - Market size
        - unnecessary firms in the market (less is enough)
        - Expanding market in greenhouses
        - matured market for greenhouses

- Relationship characteristics with Foreign Market
    - need for export
    - import on production materials
    - dependence in foreign market
    - preference of large-trusted-quality firms
    - sending tests to other countries
    - government international relations impacting market
- Relationship characteristics within Domestic Market
    - chambers of agriculture only for paper work
    - availability of local production materials
    - unqualify of local production materials
    - no collaboration with intermediary actors
    - no collaboration among producers
    - Collaboration among actors

- Mobilization of Resources
    - Human Resource
        - problems - availability of seasonal labour
        - wish to work in non-agriculture sector
        - Seasonal labour need
        - less worker in modern greenhouse
        - Obligation to work in agricultural sector
        - wish to work in agricultural sector
        - aging labour force
        - Self-development
        - need for collaboration among different disciplines (engineering-agriculture)
    - Social Integration
        - greenhouse operation part of social-integration support
    - Land Resources
        - problems - land division
        - unavailabliy of arable land for greenhouses
        - climate disadvantages due to mismatch of product and environment
    - Technology Resources
        - need to customize foreign tech to our culture
        - local tech companies are more suitable
        - enginerring/construction strong in greenhouse

- Public Awareness and Information Network
    - Society Awareness
        - public awareness through healthy eating habits
    - Greenhouse websites
        - financial opportunities of websites
        - websites not usable for wholesale
        - website requires another labour force
        - tax and other costs of website
    - Greenhouse Information Network
        - Decision based on social network

        - Social media usage
    - New Tech Follow/Search
        - Following new technologies
        - following new tech from websites
        - less interest in following new tech
        - Greenhouse visit to follow new tech
        - Conventions to follow new tech

- Policy, Regulation and Government Support
    - Government support characteristics
        - government support to consumers-not producers
        - Credit support
        - machine support
        - government + academia produced a robotic prototype
        - chambers of agriculture used for politics
        - government support for greenhouse-rare geography
    - Policy needs
        - need for production based on demand
        - need for cooperatives
        - need for systematic routines among small size producers
        - need for policy regulations
        - no need of government support
        - what should chambers of agriculture do
    - Support availability
        - government support
        - Unavailability of government support
        - people taking advantage of supports (negative way)
    - Regulations of Foreign Countries
        - adoption to foreign country criteria
        - foreign policies protecting producers

- Advantages on technology in greenhouse
    - time saving in production with technology
    - advantages in producing high quality product
    - advantages of technology - labour force
    - Food quality with technology
    - Financial opportunities
    - Export high quality products
    - Food safety with technology
    - Productivity with tech
    - Precision agriculture
    - Climate systems in greenhouse
    - solution to disinfection problem

- Problems of greenhouse operations
    - problems - not much time of product life
    - problems - heating
    - problems - disinfection
    - problems - no precautions taken

- Low socio-economic level of producers
- High operation/product cost
- Financial barriers in tech adoption resistance to tech adoption
- problems - product transfer
- no self sufficiency as sector
- high risks in overall sector
- overall inflation in economy

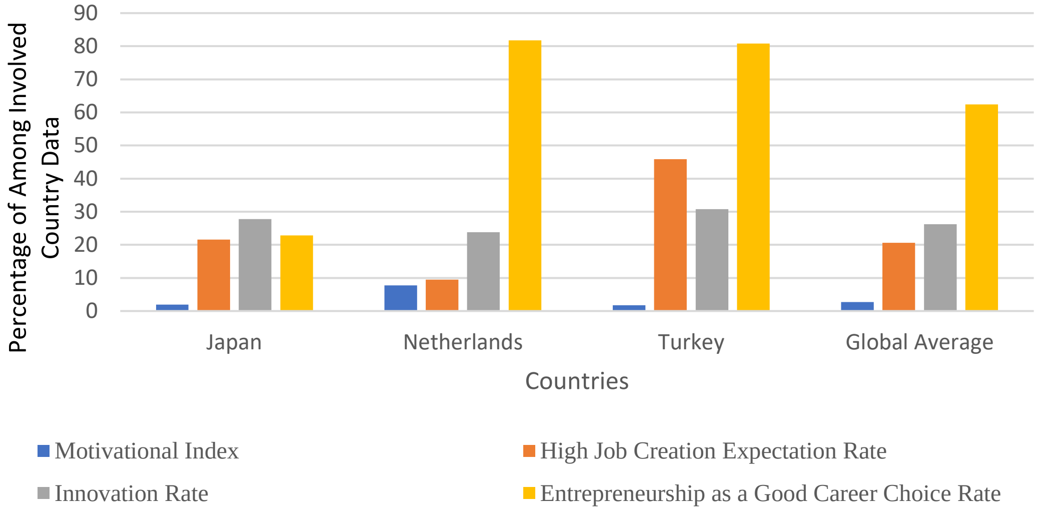
Appendix 6: Entrepreneurship Indicators, 2015-2019

Indicator	Units	Country	2015	2016	2017	2018	2019
Global Enterpreneurship Index, Score	Score=High, *Best Attitude and Potential for Overall Entrepreneurship*	JPN	49,5	50,6	51,7	51,5	53,3
		NL	**66,5**	**65,4**	**67,7**	**68,1**	**72,3**
		TR	54,6	52,7	43,6	44,5	39,8
Opputunity perception	Score=High, *Highest Opportunity Perception for Entrepreneurship*	JPN	0,2	0,2	0,18	0,17	0,18
		NL	**0,6**	**0,73**	**0,86**	**0,89**	**0,80**
		TR	0,66	0,66	0,33	0,35	0,35
Risk Acceptance	Score=High, *Highest Risk Appetite for Entrepreneurship*	JPN	0,68	0,66	0,63	0,64	0,69
		NL	**0,81**	**0,76**	**0,81**	**0,87**	**0,94**
		TR	0,43	0,4	0,24	0,25	0,14
Start up skills	Score=High, *Highest Start-up skill for Entrepreneurship*	JPN	0,12	0,14	0,15	0,17	0,15
		NL	**0,71**	**0,73**	**0,90**	**0,88**	**0,96**
		TR	0,67	0,68	0,64	0,81	0,80
Networking	Score=High, *Best Access to reach each other for Entrepreneurship*	JPN	0,34	0,4	0,32	0,33	0,36
		NL	**0,88**	**0,88**	**0,76**	**0,79**	**0,87**
		TR	0,41	0,43	0,43	0,31	0,32
Cultural Support	Score=High, Best Cultural Support for Entrepreneurship	JPN	0,4	0,4	0,4	0,4	0,3
		NL	**1**	**1**	**1**	**1**	**1**
		TR	0,5	0,41	0,33	0,33	0,32
Entrepreneurial Attitudes, Rank	Rank=1, Highest Entrepreneurial Attitudes Score	JPN	82	N/A	59	N/A	65
		NL	**9**	**7**	**4**	**6**	**2**
		TR	27	N/A	N/A	N/A	56
Entrepreneurial Abilities, Rank	Rank=1, Highest Entrepreneurial Abilities Score	JPN	27	20	16	N/A	19
		NL	**14**	**14**	**14**	**14**	**9**
		TR	37	N/A	N/A	N/A	49
Oppurtunity startup	Score=High, Highest Opportunity Start-up for Entrepreneurship	JPN	0,57	0,57	0,59	0,59	0,73
		NL	**0,94**	**0,9**	**0,96**	**0,93**	**0,97**
		TR	0,37	0,36	0,34	0,36	0,32

Technology Absorption	Score=High, Highest Intensity of Technonology absorption for Entrepreneurship	JPN	**1,00**	**0,88**	**0,97**	**0,90**	**0,74**
		NL	**0,69**	**0,69**	**0,76**	**0,84**	**0,99**
		TR	0,66	0,61	0,62	0,47	0,47
Entrepreneurial Aspirations, Score	Score=High, Best Aspiration for Entrepreneurship	JPN	**61,5**	**60,7**	**63,3**	**62,1**	**67,1**
		NL	**60,3**	**N/A**	**61,0**	**61,7**	**60,2**
		TR	**63,7**	**62,1**	**53,4**	**58,9**	**51,6**
Internationalization	Score=High, Highest Exporting Potential for Entrepreneurship	JPN	**0,55**	**0,40**	**0,60**	**0,61**	**1,00**
		NL	**0,7**	**0,69**	**0,61**	**0,56**	**0,69**
		TR	0,45	0,43	0,39	0,40	0,27
Risk Capital	Score=High, Highest availability of Risk Capital for Entrepreneurship	JPN	**0,59**	**0,60**	**0,55**	**0,55**	**0,72**
		NL	**0,78**	**0,68**	**0,66**	**0,71**	**0,59**
		TR	**0,81**	**0,8**	**0,76**	**0,80**	**0,81**

Source: Global Entrepreneurship Index

Appendix 7: Motivational and Societal Indicators for Entrepreneurship (2018)



Source: Global Entrepreneurship Monitor (GEM)

Appendix 8: Enabling Factors for Agricultural Businesses

Criteria	JPN	NDL	TR
Quality of seed regulation index (0-9)	5,00	9,00	8,00
Time to register a new maize variety (days)	454,00	556,00	646,00
Cost to register a new maize variety (% of income per capita)	1,19	12,90	22,00
Supplying Seed score	**73,93**	**75,78**	**61,49**
Quality of fertilizer regulations index (0-6)	4,00	6,00	4,00
Time to register a new fertilizer product (days)	30,00	0,00	50,00
Cost to register a new fertilizer product (% of income per capita)	1,19	0,00	3,03
Registering Fertilizer score	**88,09**	**100,00**	**87,22**
Securing water index (0-10)	6,00	8,00	5,00
Securing Water score	**60,00**	**80,00**	**50,00**
Time to register a tractor (days)	1,00	1,00	2,00
Cost to register a tractor (% of income per capita)	0,00	0,14	1,58
Registering Machinery score	**100,00**	**99,77**	**94,53**
Quality of manufactured feed index (0-5)	5,00	5,00	5,00
Quality of VMPs index (0-6)	6,00	6,00	6,00
Sustaining Livestock score	**100,00**	**100,00**	**100,00**
Quality of phytosanitary legislation index (0-5)	4,00	5,00	5,00
Protecting Plant Health score	**80,00**	**100,00**	**100,00**
Trading food index (0-7)	6,00	7,00	4,00
Time to obtain mandatory, agriculture-specific documents required to export (hours)	24	0	24
Cost to obtain mandatory, agriculture-specific documents required to export (US$)	0	0	105
Trading Food score	**89,68**	**100,00**	**62,21**
Warehouse receipts index (0-5)	4,00	2,00	5,00
Inclusive finance index (0-5)	4,00	5,00	2,00
Accessing Finance score	**80,00**	**70,00**	**70,00**
Overall Score	**83,96**	**90,69**	**78,18**

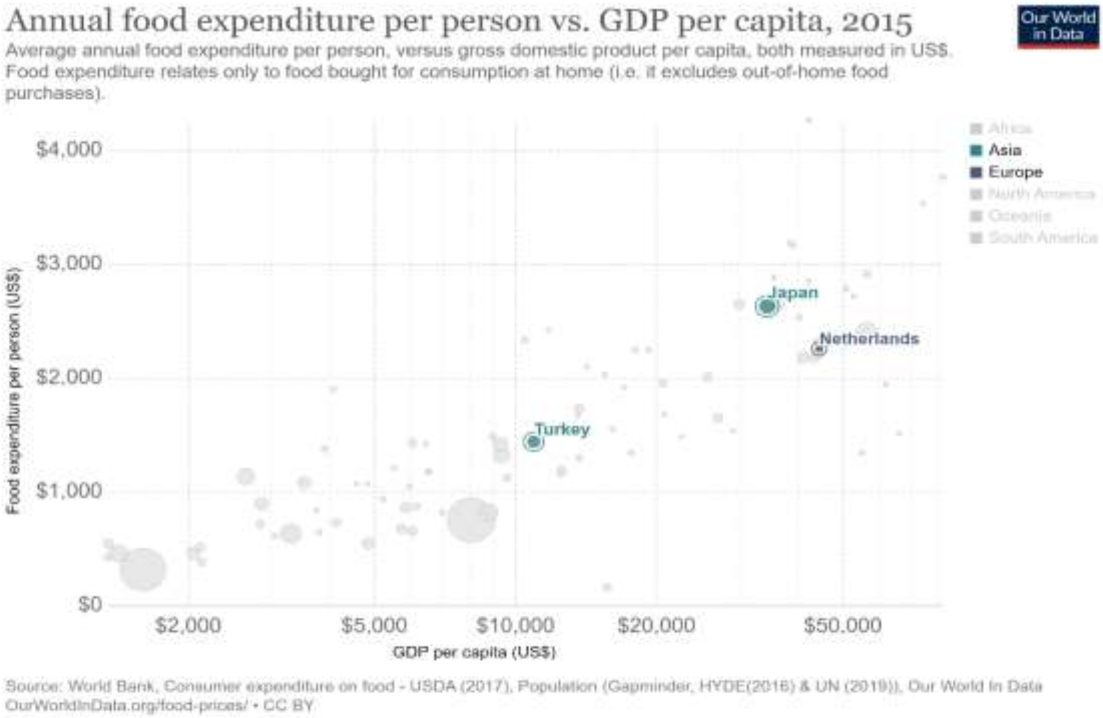
Source: World Bank (2019), Enabling the Business of Agriculture, Current as of June 30, 2018. Available at: https://datacatalog.worldbank.org/dataset/enabling-business-agriculture

Appendix 9: Farm Machinery Capital per Agricultural Worker

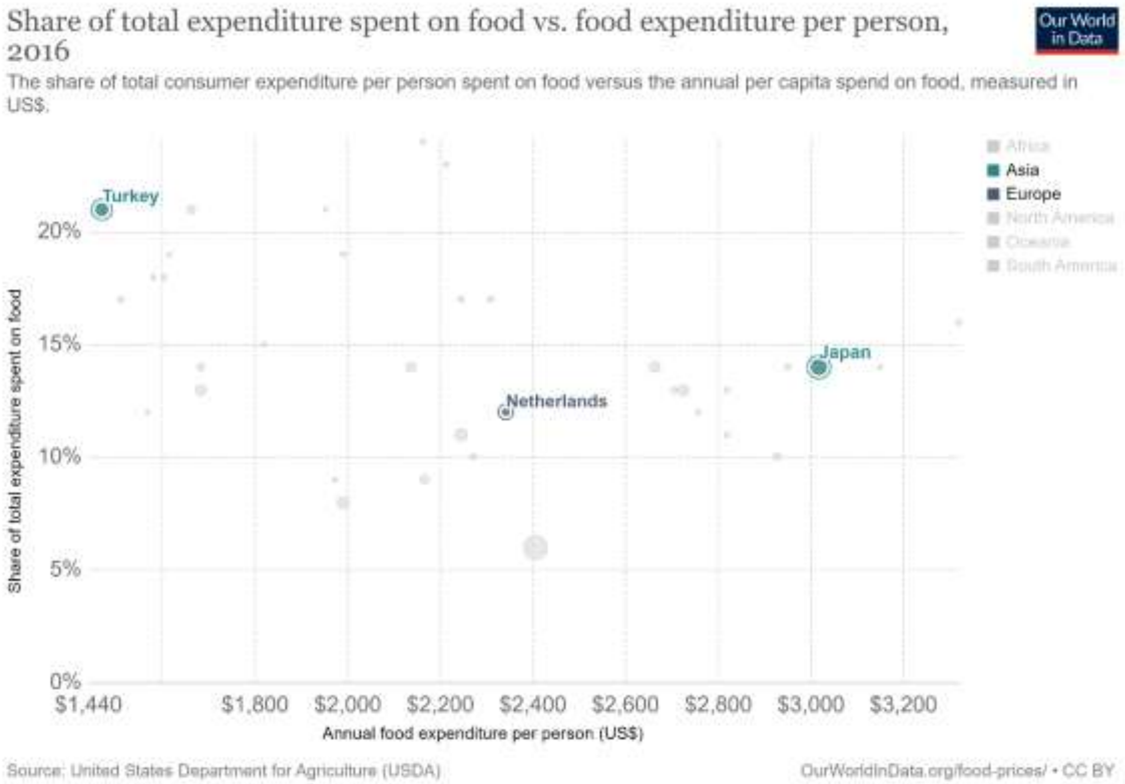
	Turkey	Netherlands	Japan
2010	0,19	0,62	0,88
2011	0,17	0,68	0,93
2012	0,18	0,67	0,92
2013	0,19	0,86	0,90
2014	0,21	0,78	0,90
2015	0,22	0,75	0,87
2016	0,22	0,76	0,92

Source: U.S. Department of Agriculture – International Agricultural Production. Machinery - Farm Machinery Capital (number of units) and OECD Data - Employment by activity, Agriculture, Thousand persons, 2010 – 2018 (Available at: https://data.oecd.org/emp/employment-by-activity.htm#indicator-chart)

Appendix 10-a: Annual Food Expenditure per Person vs GDP per Capita

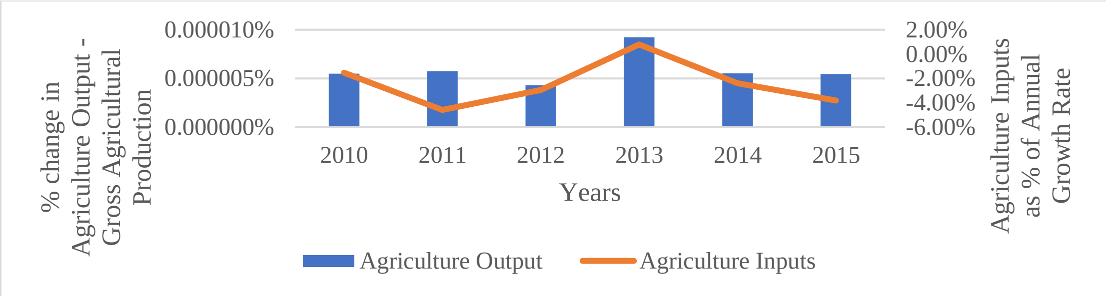


Appendix 10-b: Share of Total Expenditure on Food vs Food Expenditure per Person



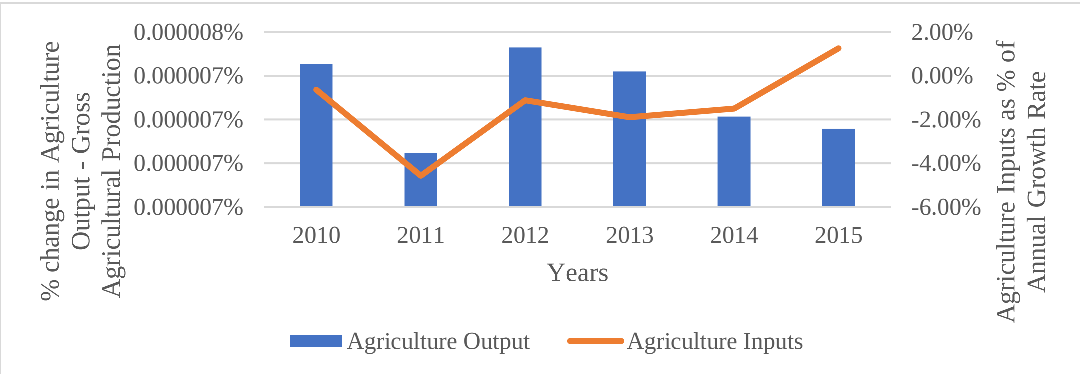
Appendix 11: Agricultural Inputs and Outputs

Agricultural Inputs and Outputs for Japan



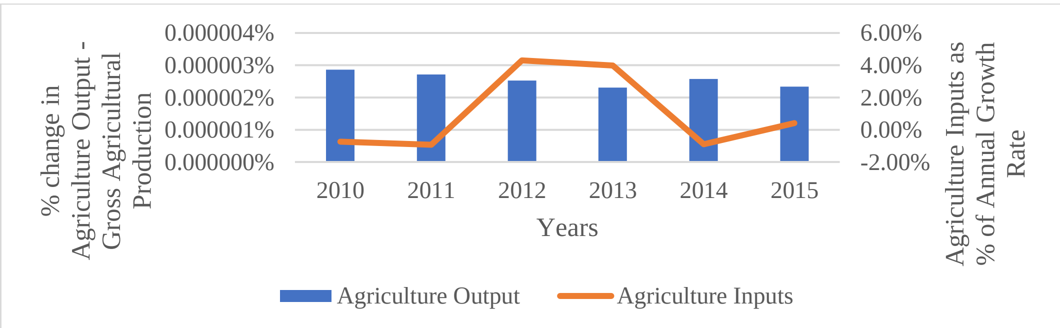
Source: U.S. Department of Agriculture – International Agricultural Production. Agricultural Output - Gross Agricultural Production (Constant 2004-2006 US$1000). Agriculture Inputs - % of Annual Growth Rate

Agricultural Inputs and Outputs for Netherlands



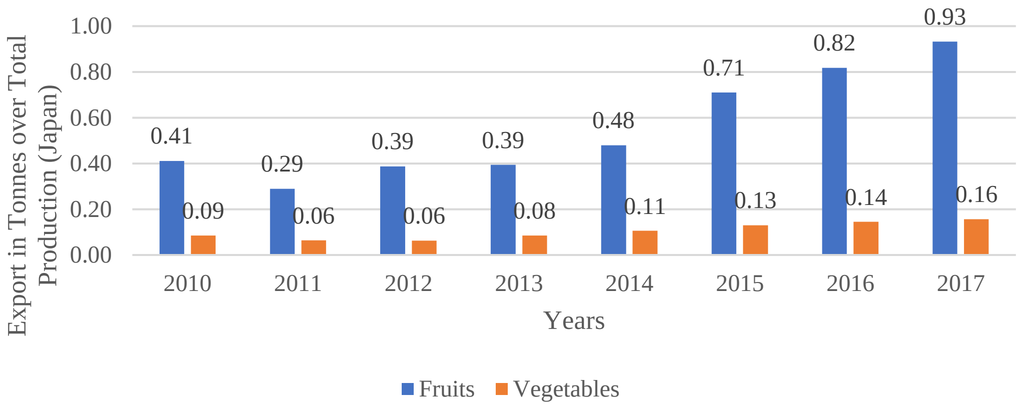
Source: U.S. Department of Agriculture – International Agricultural Production. Agricultural Output - Gross Agricultural Production (Constant 2004-2006 US$1000). Agriculture Inputs - % of Annual Growth Rate

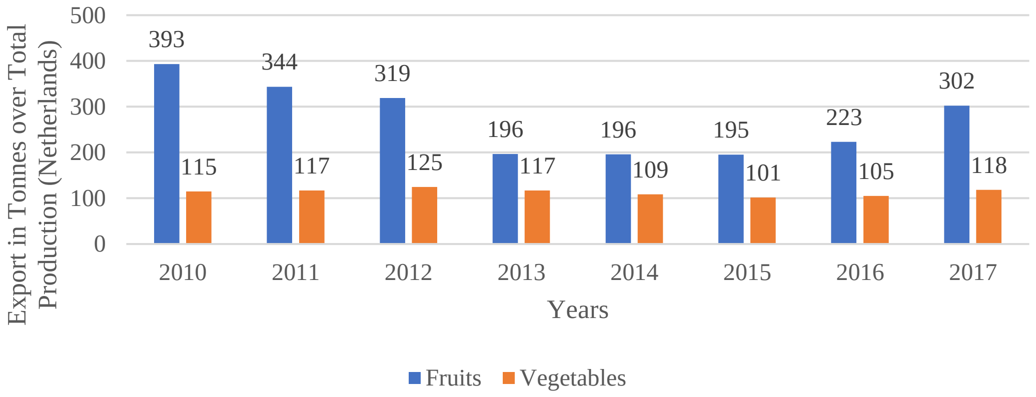
Agricultural Inputs and Outputs for Turkey

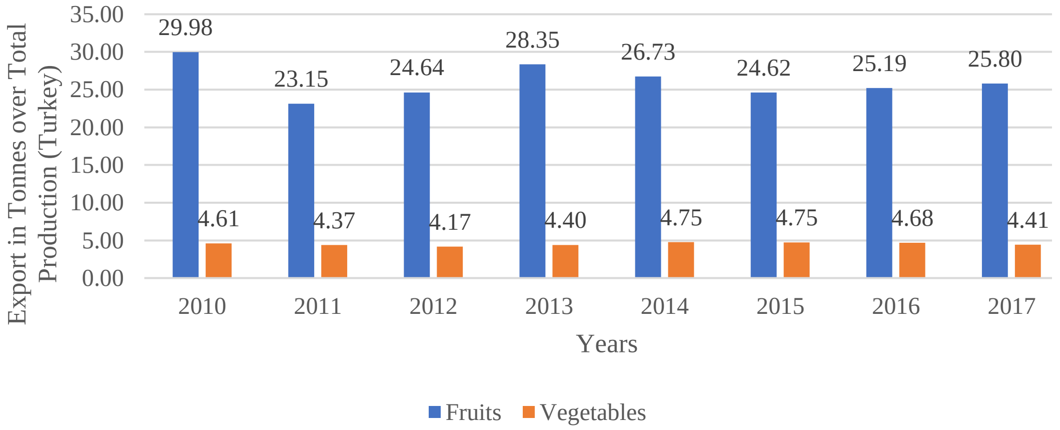


Source: U.S. Department of Agriculture – International Agricultural Production. Agricultural Output - Gross Agricultural Production (Constant 2004-2006 US$1000). Agriculture Inputs - % of Annual Growth Rate

Appendix 12-a: Exports over Total Production of Fruits and Vegetables in Tonnes







Source: Food and Agriculture Organization. Food Balance Sheets

Appendix 12-b: Export of Fruits and Vegetables for Turkey (in USD)

Period	Trade Flow	Reporter	Partner	Commodity Code	Trade Value (US$)
2019	Export	Turkey	World	8	$4,589,511,465
2019	Export	Turkey	World	7	$1,270,838,710
2019	Export	Turkey	Italy	8	$685,088,616
2019	Export	Turkey	Iraq	7	$189,040,547
2018	Export	Turkey	World	8	$3,961,021,572
2018	Export	Turkey	World	7	$1,086,381,715
2018	Export	Turkey	Russian Federation	8	$636,098,917
2018	Export	Turkey	Iraq	7	$100,715,305
2017	Export	Turkey	World	8	$3,940,007,198
2017	Export	Turkey	World	7	$1,001,924,523
2017	Export	Turkey	Russian Federation	8	$637,180,217
2017	Export	Turkey	Iraq	7	$117,489,456
2016	Export	Turkey	World	8	$3,872,708,529
2016	Export	Turkey	World	7	$941,997,339
2016	Export	Turkey	Italy	8	$562,518,492
2016	Export	Turkey	Iraq	7	$113,207,844
2015	Export	Turkey	World	8	$4,355,365,868
2015	Export	Turkey	World	7	$1,040,648,260
2015	Export	Turkey	Italy	8	$647,071,648
2015	Export	Turkey	Russian Federation	7	$336,861,293
2014	Export	Turkey	World	8	$4,327,138,467
2014	Export	Turkey	World	7	$1,082,368,168
2014	Export	Turkey	Italy	8	$662,968,714
2014	Export	Turkey	Russian Federation	7	$384,944,079
2013	Export	Turkey	World	8	$3,969,003,618
2013	Export	Turkey	World	7	$1,039,070,231
2013	Export	Turkey	Russian Federation	8	$614,307,468
2013	Export	Turkey	Russian Federation	7	$347,027,768
2012	Export	Turkey	World	8	$3,806,415,947
2012	Export	Turkey	World	7	$966,062,696
2012	Export	Turkey	Russian Federation	8	$544,654,092
2012	Export	Turkey	Russian Federation	7	$322,608,910
2011	Export	Turkey	World	8	$3,908,880,186
2011	Export	Turkey	World	7	$1,070,414,033
2011	Export	Turkey	Russian Federation	8	$597,368,942
2011	Export	Turkey	Russian Federation	7	$319,248,507
2010	Export	Turkey	World	8	$3,490,879,291

2010	Export	Turkey	World	7	$1,107,483,134
2010	Export	Turkey	Russian Federation	8	$566,142,425
2010	Export	Turkey	Russian Federation	7	$301,161,021

Source: UN Comtrade Database

Appendix 12-c: Import of Fruits and Vegetables for Russia (in USD)

Period	Trade Flow	Reporter	Partner	Commodity Code	Trade Value (US$)
2019	Import	Russian Federation	World	8	$5,113,436,001
2019	Import	Russian Federation	World	7	$1,839,989,359
2019	Import	Russian Federation	Ecuador	8	$1,085,227,853
2019	Import	Russian Federation	Turkey	8	$819,964,164
2019	Import	Russian Federation	China	7	$410,476,750
2019	Import	Russian Federation	Azerbaijan	7	$235,646,370
2019	Import	Russian Federation	Turkey	7	$175,943,456
2018	Import	Russian Federation	World	8	$5,089,703,924
2018	Import	Russian Federation	World	7	$1,845,006,261
2018	Import	Russian Federation	Ecuador	8	$1,109,677,833
2018	Import	Russian Federation	Turkey	8	$801,912,304
2018	Import	Russian Federation	China	7	$412,182,620
2018	Import	Russian Federation	Azerbaijan	7	$224,674,510
2018	Import	Russian Federation	Belarus	7	$187,637,599
2017	Import	Russian Federation	World	8	$4,687,436,793
2017	Import	Russian Federation	World	7	$1,800,651,245
2017	Import	Russian Federation	Ecuador	8	$1,096,297,438
2017	Import	Russian Federation	Turkey	8	$809,097,957
2017	Import	Russian Federation	China	7	$488,130,378
2017	Import	Russian Federation	Azerbaijan	7	$207,462,618
2017	Import	Russian Federation	Israel	7	$181,286,997
2016	Import	Russian Federation	World	8	$3,846,821,644
2016	Import	Russian Federation	World	7	$1,401,436,215
2016	Import	Russian Federation	Ecuador	8	$982,392,295
2016	Import	Russian Federation	Turkey	8	$434,929,459
2016	Import	Russian Federation	China	7	$380,623,472
2016	Import	Russian Federation	Morocco	7	$174,572,255

2016	Import	Russian Federation	Israel	7	$156,397,546
2015	Import	Russian Federation	World	8	$3,944,183,658
2015	Import	Russian Federation	World	7	$1,891,685,019
2015	Import	Russian Federation	Ecuador	8	$905,266,610
2015	Import	Russian Federation	Turkey	8	$757,172,440
2015	Import	Russian Federation	China	7	$445,161,688
2015	Import	Russian Federation	Turkey	7	$441,264,939
2014	Import	Russian Federation	World	8	$5,479,577,428
2014	Import	Russian Federation	World	7	$2,959,077,603
2014	Import	Russian Federation	Ecuador	8	$931,625,894
2014	Import	Russian Federation	Turkey	8	$828,558,494
2014	Import	Russian Federation	Turkey	7	$600,478,536
2013	Import	Russian Federation	World	8	$6,401,898,162
2013	Import	Russian Federation	World	7	$2,881,787,247
2013	Import	Russian Federation	Ecuador	8	$953,246,410
2013	Import	Russian Federation	Turkey	8	$910,732,567
2013	Import	Russian Federation	Turkey	7	$571,651,185
2012	Import	Russian Federation	World	8	$6,279,814,414
2012	Import	Russian Federation	World	7	$2,485,447,611
2012	Import	Russian Federation	Ecuador	8	$830,521,264
2012	Import	Russian Federation	Turkey	8	$822,739,542
2012	Import	Russian Federation	Turkey	7	$474,063,954
2011	Import	Russian Federation	World	8	$6,204,616,964
2011	Import	Russian Federation	World	7	$3,039,948,302
2011	Import	Russian Federation	Ecuador	8	$877,540,942
2011	Import	Russian Federation	Turkey	8	$848,148,583
2011	Import	Russian Federation	Turkey	7	$517,622,111
2010	Import	Russian Federation	World	8	$5,471,168,812
2010	Import	Russian Federation	World	7	$2,223,998,064

2010	Import	Russian Federation	Turkey	8	$825,782,299
2010	Import	Russian Federation	Turkey	7	$470,792,482

Source: UN Comtrade Database

Appendix 12-d: Export of Fruits and Vegetables for Japan (in USD)

Period	Trade Flow	Reporter	Partner	Commodity Code	Trade Value (US$)
2019	Export	Japan	World	8	$228,395,343
2019	Export	Japan	Other Asia, nes	8	$113,293,569
2019	Export	Japan	China, Hong Kong SAR	8	$88,770,757
2019	Export	Japan	World	7	$56,033,281
2019	Export	Japan	Other Asia, nes	7	$16,289,370
2019	Export	Japan	China, Hong Kong SAR	7	$13,732,272
2018	Export	Japan	World	8	$225,898,824
2018	Export	Japan	Other Asia, nes	8	$109,975,008
2018	Export	Japan	China, Hong Kong SAR	8	$91,353,418
2018	Export	Japan	World	7	$51,438,359
2018	Export	Japan	Other Asia, nes	7	$14,055,340
2018	Export	Japan	China, Hong Kong SAR	7	$13,047,168
2017	Export	Japan	World	8	$183,762,721
2017	Export	Japan	Other Asia, nes	8	$89,858,765
2017	Export	Japan	China, Hong Kong SAR	8	$72,487,878
2017	Export	Japan	World	7	$51,745,692
2017	Export	Japan	Other Asia, nes	7	$19,997,996
2017	Export	Japan	China, Hong Kong SAR	7	$10,071,286
2016	Export	Japan	World	8	$190,426,445
2016	Export	Japan	Other Asia, nes	8	$107,679,378
2016	Export	Japan	China, Hong Kong SAR	8	$61,692,866
2016	Export	Japan	World	7	$56,505,168
2016	Export	Japan	Other Asia, nes	7	$22,807,869
2016	Export	Japan	USA	7	$10,486,667
2015	Export	Japan	World	8	$159,774,887
2015	Export	Japan	Other Asia, nes	8	$95,334,264
2015	Export	Japan	China, Hong Kong SAR	8	$47,780,184
2015	Export	Japan	World	7	$45,463,776
2015	Export	Japan	Other Asia, nes	7	$18,237,979
2015	Export	Japan	USA	7	$10,603,026
2014	Export	Japan	World	8	$124,972,524
2014	Export	Japan	Other Asia, nes	8	$76,717,812
2014	Export	Japan	World	7	$40,176,528
2014	Export	Japan	China, Hong Kong SAR	8	$30,381,540
2014	Export	Japan	Other Asia, nes	7	$17,943,740
2014	Export	Japan	USA	7	$8,759,478
2013	Export	Japan	World	8	$109,566,798
2013	Export	Japan	Other Asia, nes	8	$73,593,123

2013	Export	Japan	World	7	$34,156,860
2013	Export	Japan	China, Hong Kong SAR	8	$20,788,009
2013	Export	Japan	Other Asia, nes	7	$15,887,926
2013	Export	Japan	USA	7	$7,051,776
2012	Export	Japan	World	8	$73,661,127
2012	Export	Japan	Other Asia, nes	8	$46,140,974
2012	Export	Japan	World	7	$34,159,112
2012	Export	Japan	Other Asia, nes	7	$18,069,670
2012	Export	Japan	China, Hong Kong SAR	8	$13,818,695
2012	Export	Japan	USA	7	$7,129,161
2011	Export	Japan	World	8	$106,524,351
2011	Export	Japan	Other Asia, nes	8	$80,116,828
2011	Export	Japan	World	7	$29,242,039
2011	Export	Japan	China, Hong Kong SAR	8	$14,147,114
2011	Export	Japan	Other Asia, nes	7	$14,098,097
2011	Export	Japan	USA	7	$6,772,837
2010	Export	Japan	World	8	$105,479,917
2010	Export	Japan	Other Asia, nes	8	$71,917,946
2010	Export	Japan	World	7	$34,583,629
2010	Export	Japan	Other Asia, nes	7	$17,839,230
2010	Export	Japan	China, Hong Kong SAR	8	$14,781,670
2010	Export	Japan	USA	7	$6,228,795

Source: UN Comtrade Database

Appendix 12-e: Import of Fruits and Vegetables for Hong Kong SAR (in USD)

Period	Trade Flow	Reporter	Partner	Commodity Code	Trade Value (US$)
2019	Import	China, Hong Kong SAR	World	8	$4,570,666,090
2019	Import	China, Hong Kong SAR	Chile	8	$1,386,357,947
2019	Import	China, Hong Kong SAR	USA	8	$963,463,703
2019	Import	China, Hong Kong SAR	World	7	$772,507,373
2019	Import	China, Hong Kong SAR	Thailand	8	$601,046,002
2019	Import	China, Hong Kong SAR	China	7	$593,544,138
2019	Import	China, Hong Kong SAR	USA	7	$38,734,395
2019	Import	China, Hong Kong SAR	Japan	7	$34,208,746
2018	Import	China, Hong Kong SAR	World	8	$4,398,274,069
2018	Import	China, Hong Kong SAR	USA	8	$1,334,683,731
2018	Import	China, Hong Kong SAR	Chile	8	$1,064,382,019
2018	Import	China, Hong Kong SAR	World	7	$782,393,170
2018	Import	China, Hong Kong SAR	China	7	$596,359,142
2018	Import	China, Hong Kong SAR	Thailand	8	$483,432,454
2018	Import	China, Hong Kong SAR	USA	7	$57,022,546
2018	Import	China, Hong Kong SAR	Japan	7	$29,008,531
2017	Import	China, Hong Kong SAR	World	8	$4,175,551,647
2017	Import	China, Hong Kong SAR	USA	8	$1,517,489,160
2017	Import	China, Hong Kong SAR	World	7	$685,666,592
2017	Import	China, Hong Kong SAR	Chile	8	$619,094,002
2017	Import	China, Hong Kong SAR	China	7	$505,870,853
2017	Import	China, Hong Kong SAR	Thailand	8	$427,351,963
2017	Import	China, Hong Kong SAR	USA	7	$57,168,238
2017	Import	China, Hong Kong SAR	Japan	7	$26,427,889
2016	Import	China, Hong Kong SAR	World	8	$4,278,649,906
2016	Import	China, Hong Kong SAR	USA	8	$1,547,880,010
2016	Import	China, Hong Kong SAR	Chile	8	$758,554,094

2016	Import	China, Hong Kong SAR	World	7	$661,629,116
2016	Import	China, Hong Kong SAR	Thailand	8	$522,906,575
2016	Import	China, Hong Kong SAR	China	7	$497,510,483
2016	Import	China, Hong Kong SAR	USA	7	$45,920,303
2016	Import	China, Hong Kong SAR	Japan	7	$25,961,060
2015	Import	China, Hong Kong SAR	World	8	$3,760,566,897
2015	Import	China, Hong Kong SAR	USA	8	$1,277,723,239
2015	Import	China, Hong Kong SAR	World	7	$650,350,047
2015	Import	China, Hong Kong SAR	China	7	$507,049,421
2015	Import	China, Hong Kong SAR	Thailand	8	$471,581,766
2015	Import	China, Hong Kong SAR	Chile	8	$452,383,179
2015	Import	China, Hong Kong SAR	USA	7	$48,749,499
2015	Import	China, Hong Kong SAR	Japan	7	$17,021,154
2014	Import	China, Hong Kong SAR	World	8	$3,901,211,260
2014	Import	China, Hong Kong SAR	USA	8	$1,386,286,782
2014	Import	China, Hong Kong SAR	World	7	$613,445,925
2014	Import	China, Hong Kong SAR	Iran	8	$492,975,529
2014	Import	China, Hong Kong SAR	China	7	$473,804,520
2014	Import	China, Hong Kong SAR	Thailand	8	$447,455,687
2014	Import	China, Hong Kong SAR	USA	7	$47,602,414
2014	Import	China, Hong Kong SAR	Japan	7	$15,136,110
2013	Import	China, Hong Kong SAR	World	8	$3,675,317,021
2013	Import	China, Hong Kong SAR	USA	8	$1,861,372,136
2013	Import	China, Hong Kong SAR	World	7	$496,476,642
2013	Import	China, Hong Kong SAR	China	7	$363,947,380
2013	Import	China, Hong Kong SAR	Chile	8	$349,250,711
2013	Import	China, Hong Kong SAR	Thailand	8	$330,051,946
2013	Import	China, Hong Kong SAR	USA	7	$34,203,987
2013	Import	China, Hong Kong SAR	India	7	$15,718,275

2012	Import	China, Hong Kong SAR	World	8	$3,479,781,210
2012	Import	China, Hong Kong SAR	USA	8	$1,662,795,509
2012	Import	China, Hong Kong SAR	World	7	$443,906,063
2012	Import	China, Hong Kong SAR	Chile	8	$339,321,518
2012	Import	China, Hong Kong SAR	China	7	$336,223,893
2012	Import	China, Hong Kong SAR	Thailand	8	$330,583,029
2012	Import	China, Hong Kong SAR	USA	7	$33,274,588
2012	Import	China, Hong Kong SAR	Japan	7	$12,446,711
2011	Import	China, Hong Kong SAR	World	8	$2,892,621,654
2011	Import	China, Hong Kong SAR	USA	8	$1,371,670,330
2011	Import	China, Hong Kong SAR	World	7	$354,493,440
2011	Import	China, Hong Kong SAR	Thailand	8	$299,362,349
2011	Import	China, Hong Kong SAR	Chile	8	$280,749,328
2011	Import	China, Hong Kong SAR	China	7	$251,545,771
2011	Import	China, Hong Kong SAR	USA	7	$31,800,626
2011	Import	China, Hong Kong SAR	Japan	7	$11,849,517
2010	Import	China, Hong Kong SAR	World	8	$2,495,406,258
2010	Import	China, Hong Kong SAR	USA	8	$1,123,465,659
2010	Import	China, Hong Kong SAR	Iran	8	$359,541,672
2010	Import	China, Hong Kong SAR	World	7	$308,215,990
2010	Import	China, Hong Kong SAR	Thailand	8	$268,180,650
2010	Import	China, Hong Kong SAR	China	7	$205,290,555
2010	Import	China, Hong Kong SAR	USA	7	$32,931,299
2010	Import	China, Hong Kong SAR	Japan	7	$13,983,501

Source: UN Comtrade Database

Appendix 12-f: Export of Fruits and Vegetables for Netherlands (in USD)

Period	Trade Flow	Reporter	Partner	Commodity Code	Trade Value (US$)
2019	Export	Netherlands	World	7	$8,121,914,366
2019	Export	Netherlands	World	8	$7,042,478,838
2019	Export	Netherlands	Germany	7	$2,616,564,702
2019	Export	Netherlands	Germany	8	$2,595,354,048
2018	Export	Netherlands	World	7	$7,842,806,641
2018	Export	Netherlands	World	8	$7,009,661,037
2018	Export	Netherlands	Germany	7	$2,602,913,525
2018	Export	Netherlands	Germany	8	$2,571,085,004
2017	Export	Netherlands	World	7	$7,446,554,158
2017	Export	Netherlands	World	8	$6,219,998,727
2017	Export	Netherlands	Germany	7	$2,489,977,036
2017	Export	Netherlands	Germany	8	$2,183,809,552
2016	Export	Netherlands	World	7	$7,143,474,285
2016	Export	Netherlands	World	8	$5,614,821,962
2016	Export	Netherlands	Germany	7	$2,357,783,652
2016	Export	Netherlands	Germany	8	$1,963,528,392
2015	Export	Netherlands	World	7	$7,005,935,017
2015	Export	Netherlands	World	8	$4,783,126,596
2015	Export	Netherlands	Germany	7	$2,342,999,682
2015	Export	Netherlands	Germany	8	$1,609,034,632
2014	Export	Netherlands	World	7	$7,620,154,148
2014	Export	Netherlands	World	8	$5,679,320,453
2014	Export	Netherlands	Germany	7	$2,535,506,151
2014	Export	Netherlands	Germany	8	$2,005,402,933
2013	Export	Netherlands	World	7	$7,906,306,133
2013	Export	Netherlands	World	8	$5,360,299,955
2013	Export	Netherlands	Germany	7	$2,669,883,279
2013	Export	Netherlands	Germany	8	$2,012,213,416
2012	Export	Netherlands	World	7	$7,001,062,748
2012	Export	Netherlands	World	8	$4,649,245,061
2012	Export	Netherlands	Germany	7	$2,434,841,357
2012	Export	Netherlands	Germany	8	$1,645,022,495
2011	Export	Netherlands	World	7	$7,461,511,104
2011	Export	Netherlands	World	8	$4,660,657,660
2011	Export	Netherlands	Germany	7	$2,444,110,594
2011	Export	Netherlands	Germany	8	$1,648,692,796
2010	Export	Netherlands	World	7	$6,779,204,971
2010	Export	Netherlands	World	8	$3,801,082,138
2010	Export	Netherlands	Germany	7	$2,302,306,135
2010	Export	Netherlands	Germany	8	$1,297,468,056

Source: UN Comtrade Database

Appendix 12-g: Import of Fruits and Vegetables for Germany (in USD)

Period	Trade Flow	Reporter	Partner	Commodity Code	Trade Value (US$)
2019	Import	Germany	World	8	$11,242,275,787
2019	Import	Germany	World	7	$7,148,723,767
2019	Import	Germany	Spain	8	$2,426,953,121
2019	Import	Germany	Netherlands	7	$2,393,863,615
2019	Import	Germany	Spain	7	$1,995,539,262
2019	Import	Germany	Italy	8	$1,104,368,126
2019	Import	Germany	USA	8	$1,056,349,939
2019	Import	Germany	Italy	7	$536,604,272
2018	Import	Germany	World	8	$11,874,179,945
2018	Import	Germany	World	7	$7,176,237,192
2018	Import	Germany	Spain	8	$2,577,555,364
2018	Import	Germany	Netherlands	7	$2,410,832,412
2018	Import	Germany	Spain	7	$1,945,033,247
2018	Import	Germany	Italy	8	$1,311,119,286
2018	Import	Germany	USA	8	$1,002,821,480
2018	Import	Germany	Italy	7	$572,773,748
2017	Import	Germany	World	8	$11,215,449,666
2017	Import	Germany	World	7	$6,992,675,540
2017	Import	Germany	Spain	8	$2,347,384,622
2017	Import	Germany	Netherlands	7	$2,274,097,971
2017	Import	Germany	Spain	7	$1,930,232,871
2017	Import	Germany	Italy	8	$1,384,032,352
2017	Import	Germany	USA	8	$952,775,076
2017	Import	Germany	Italy	7	$574,202,537
2016	Import	Germany	World	8	$10,254,168,656
2016	Import	Germany	World	7	$6,507,885,135
2016	Import	Germany	Spain	8	$2,189,302,097
2016	Import	Germany	Netherlands	7	$2,065,150,221
2016	Import	Germany	Spain	7	$1,759,238,854
2016	Import	Germany	Italy	8	$1,253,697,356
2016	Import	Germany	USA	8	$885,104,086
2016	Import	Germany	Italy	7	$526,010,183
2015	Import	Germany	World	8	$10,046,104,257
2015	Import	Germany	World	7	$6,164,534,683
2015	Import	Germany	Spain	8	$2,118,304,672
2015	Import	Germany	Netherlands	7	$2,045,606,630
2015	Import	Germany	Spain	7	$1,599,374,852
2015	Import	Germany	Italy	8	$1,196,977,267
2015	Import	Germany	USA	8	$1,037,555,442
2015	Import	Germany	Italy	7	$480,589,125
2014	Import	Germany	World	8	$10,142,480,119
2014	Import	Germany	World	7	$6,697,689,687

2014	Import	Germany	Netherlands	7	$2,179,729,421
2014	Import	Germany	Spain	8	$2,129,936,464
2014	Import	Germany	Spain	7	$1,640,078,420
2014	Import	Germany	Italy	8	$1,239,013,007
2014	Import	Germany	USA	8	$944,511,008
2014	Import	Germany	Italy	7	$535,125,515
2013	Import	Germany	World	8	$10,119,319,519
2013	Import	Germany	World	7	$6,918,631,851
2013	Import	Germany	Netherlands	7	$2,247,742,189
2013	Import	Germany	Spain	8	$2,233,862,646
2013	Import	Germany	Spain	7	$1,635,923,235
2013	Import	Germany	Italy	8	$1,319,135,015
2013	Import	Germany	USA	8	$793,163,711
2013	Import	Germany	Italy	7	$585,498,665
2012	Import	Germany	World	8	$8,774,770,801
2012	Import	Germany	World	7	$6,162,338,492
2012	Import	Germany	Netherlands	7	$2,018,177,943
2012	Import	Germany	Spain	8	$1,847,024,457
2012	Import	Germany	Spain	7	$1,420,108,164
2012	Import	Germany	Italy	8	$1,154,405,282
2012	Import	Germany	USA	8	$640,364,768
2012	Import	Germany	Italy	7	$507,419,345
2011	Import	Germany	World	8	$9,019,318,067
2011	Import	Germany	World	7	$6,337,345,721
2011	Import	Germany	Netherlands	7	$2,025,960,075
2011	Import	Germany	Spain	8	$1,767,842,840
2011	Import	Germany	Spain	7	$1,409,125,897
2011	Import	Germany	Italy	8	$1,151,170,683
2011	Import	Germany	Turkey	8	$659,881,249
2011	Import	Germany	Italy	7	$514,432,382
2010	Import	Germany	World	8	$8,239,828,272
2010	Import	Germany	World	7	$6,346,020,062
2010	Import	Germany	Netherlands	7	$2,132,255,862
2010	Import	Germany	Spain	8	$1,645,280,725
2010	Import	Germany	Spain	7	$1,404,296,944
2010	Import	Germany	Italy	8	$1,115,785,662
2010	Import	Germany	Turkey	8	$556,345,905
2010	Import	Germany	Italy	7	$533,302,958

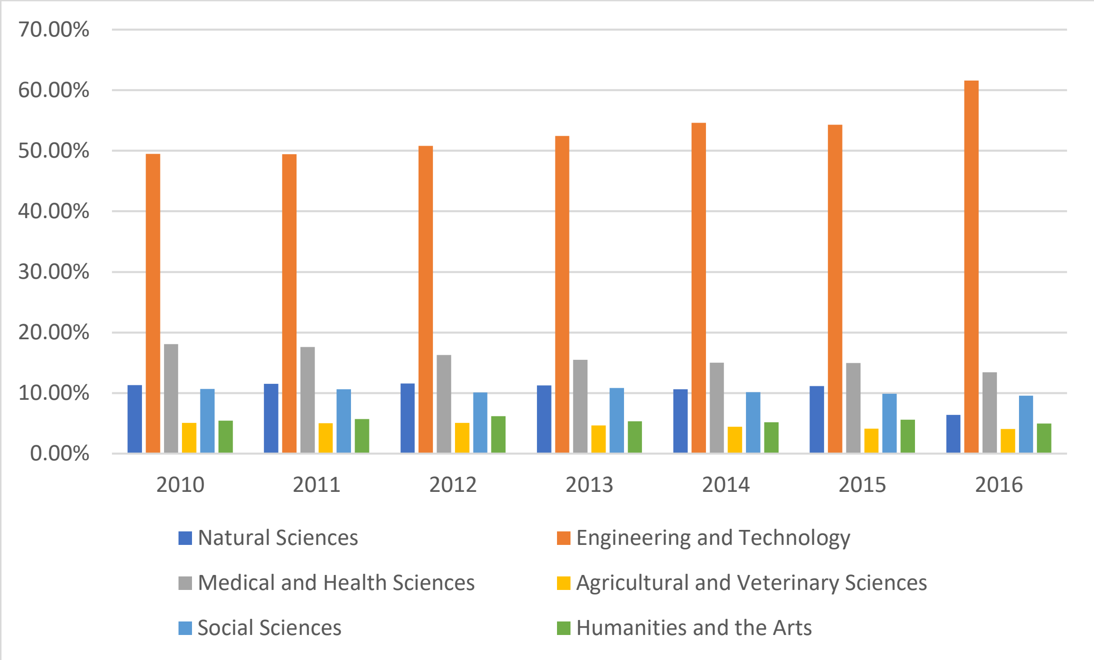
Source: UN Comtrade Database

Appendix 13: Summary of Dutch and German Trade and Bilateral Relations

Export Partnership	In 2018, 22,7% of Dutch exports were for Germany and 17,6% of Dutch imports were from Germany
Provision of Services	Netherlands is the largest service supplier to Germany and Germany is the 2nd largest service supplier to Netherlands
Share of Earning	In 2018, exports to Germany covered 19% of export earnings in Netherlands, which is around 6,5% of GDP while direct and indirect exports to Netherlands adds up to 1,1% of GDP in Germany
Share of Agricultural Earning	In 2018, agricultural earning is recorded at second largest sector following wholesale trade
Labour Force Allocated for Exports	In 2018, 20% of export-related full-time employment were covering exports between Netherlands and Germany
Foreign Direct Investment	Germany is the 5th largest investor in Netherlands, while Netherlands is the 4th largest investor in Germany
Multinational Businesses	In 2017, more than 15% of foreign-owned multinational businesses located in Netherlands were from German
Migration and Residency	In 2018, more than 17 thousand of people moved from Germany to Netherlands while 14 thousand of people moved in the opposite direction for settlement. As result, in the beginning of 2019, 77 thousand people with German nationality were residents of Netherlands and 151 thousand of people with Dutch nationality were in Germany

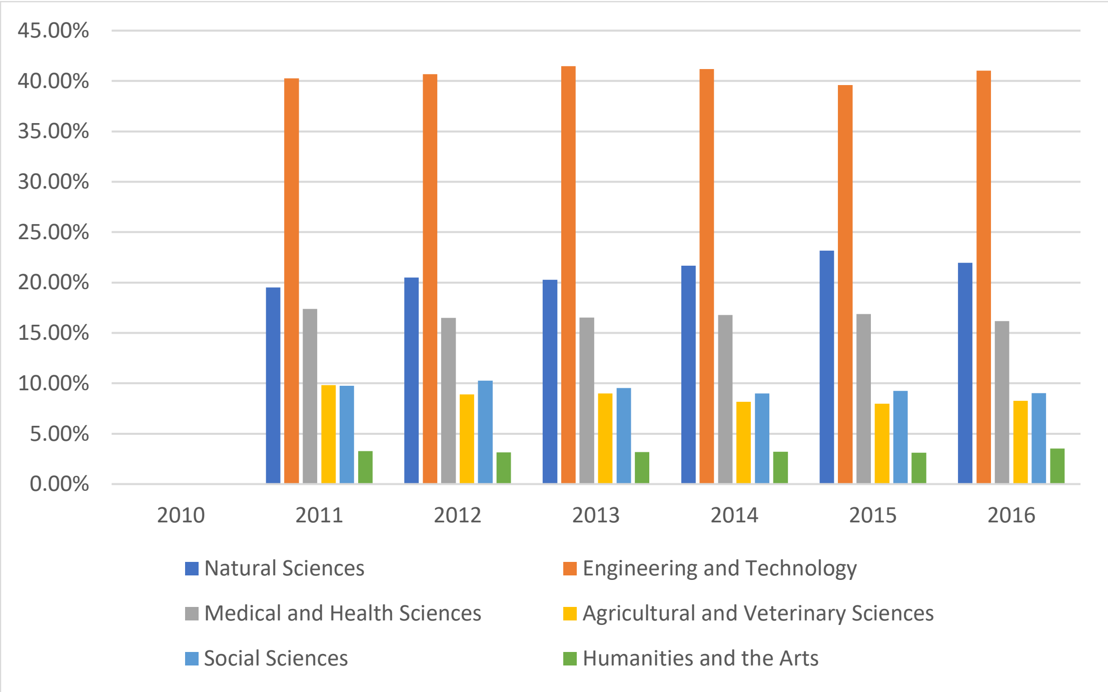
Source: *https://www.cbs.nl/en-gb/publication/2020/13/internationalisation-monitor-2020-first-quarter*

Appendix 14: Percentage of GERD in Turkey by scientific field



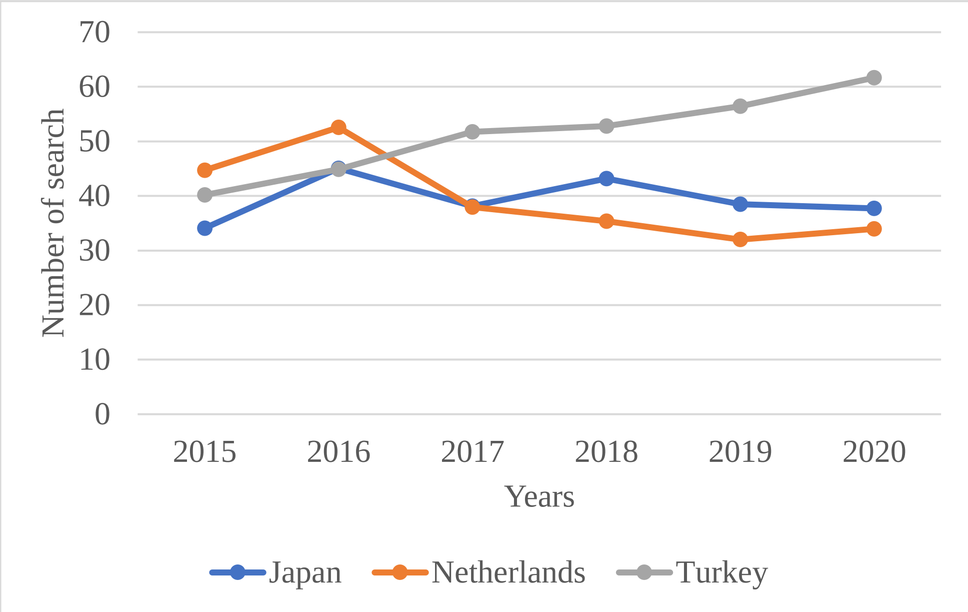
Source: UNESCO: Science, Technology and Innovation Statistics Data

Appendix 15: Percentage of GERD in Netherlands by scientific field



Source: UNESCO: Science, Technology and Innovation Statistics Data

Appendix 16: Number of searches for “agriculture”



Source: Google Analytics

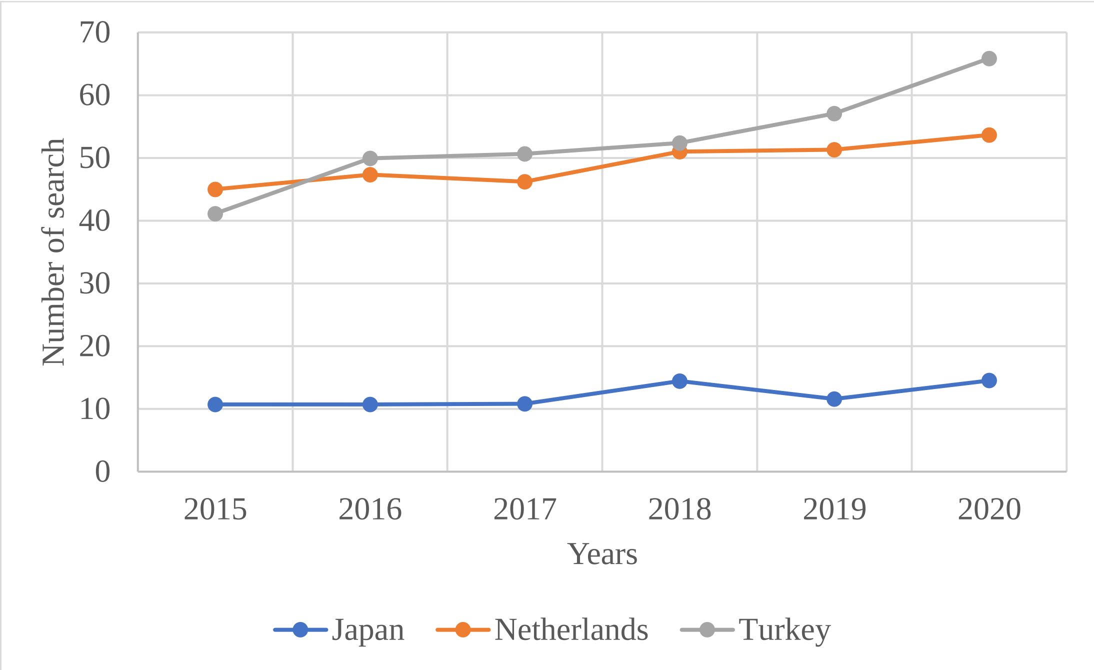
Appendix 17: Website Evaluation – Visitor Based Evaluation (Detailed)

			JPN	NDR	TUR
Identity	*Corporate logo available*		YES	YES	YES
	Organisational chart available		YES	YES	YES
	Contact information available		YES	YES	YES
	Site map available		YES	YES	YES
	Mission and vision available		YES	YES	YES
	Website aids, tools, help sources available		No	No	No
	Website domain available		YES	YES	YES
Loading & Viewing	*Page size*	Website Grader	462 KM	534 KB	3.3 MB
	Page requests	Website Grader	55	20	133
	Page speed	Website Grader	7.6 sec	4.5 sec	20.6 sec
	Minimal page redirection	Website Grader	YES	YES	YES
	Standardized page formats are present		YES	YES	YES
	Image Sizes are not taking time to download	Website Grader	No	YES	NO
	Text is downloadable		YES	YES	YES
Navigation	*Menu structure is present*		YES	YES	YES
	Vertical/horizontal scrolling minimised		3	2	1
	Standard navigation options available		YES	YES	YES
	Keyword and advanced search available		No	YES	No
	Descriptive link texts are available	Website Grader	YES	YES	YES
	Links are not broken		YES	YES	YES

	Permission to Index available	Website Grader	YES	YES	YES
	Clear site organization in home page		YES	YES	YES
Interactivity	*Printer-friendly version available*		YES	YES	YES
	Access to data is possible		YES	NO	YES
	E-mail communication is present		YES	YES	YES
	Forum/comments are available		NO	YES	NO
	FAQ page is available		YES	NO	NO
Comprehensibility	*Forms are self-explanatory*		YES	YES	YES
	Local language and English options are available		Yes but only in homepage	YES	YES
	Font sizes are appropriate (at least 12px)	Website Grader	YES	YES	YES
	Mobile friendly tap targets (at least 8px apart from each other, and at least 48px wide and 48px tall)	Website Grader	No	No	YES
	Presentations are eye-catching		YES	No	YES
Personalization & Content	*User specific services are available*		No	No	Yes
	Subscription is possible		No	No	No
	Information well-guides users		YES	YES	YES
	No pages under construction		YES	YES	YES
	User-friendly for diasbled users		No	No	YES
	E-library is available		YES	YES	YES

Information Quality & Up-to-dateness	*No incorrect information available*		YES	YE S	YES
	Information is up-to-date		YES	YE S	YES
	Date of information is given		YES	YE S	YES
	Links to related sources present		YES	YE S	YES
	Information on planned updates given		No	No	YES
Security & Miscellaneo us	*Includes privacy statement*		No	No	No
	Secured/Updat ed Javascript Libraries are available	Website Grader	NO	YE S	No
	Https is secured	Website Grader	YES	YE S	YES

Appendix 18: Number of searches for “農業”, “Landbouw” and “Tarım”



Source : Google

A. QUESTIONNAIRE QUESTIONS

Soru 1: Yaş aralığınız nedir?
Soru 2: Bakanlığın veya kurumunuzun hangi bölümünde çalışmaktasınız?
Soru 3: Ünvanınız nedir?
Soru 4: Kaç yıldır şu anda bağlı olduğunuz bölümde/kurumda çalışıyorsunuz?
Soru 5: Aldığınız son diploma seviyesi nedir?
Soru 6: Kurumunuzda yüksek öğretime verilen değer/olanakları nasıl değerlendirirsiniz (1: Çok iyi, 5: Çok Yetersiz)
Soru 7: Kurumunuzda tarımsal alandaki AR-GE çalışmalarına ne kadar yer veriliyor? (1: Sıkça, 5: Çok Yetersiz)
Soru 8: Kurum içerisinde daha önce Ar-Ge çalışmalarında yer aldınız mı?
Soru 9: Kurumunuzda akıllı tarım kavramı için kullanılan resmi bir tanım/kapsam var mı?
Soru 10: Kurumunuzda akıllı tarım uygulamalarına yönelik farkındalık veya devam eden / planlanan uygulamalar bulunuyor mu?
Soru 11: "Evet" cevabı için: Kurumunuzda akıllı tarımı desteklemek için ne ölçüde çalışmalar yapılıyor? (1: Sıkça, 5: Çok Yetersiz)
Soru 12: Hassas Tarım kavramını ve uygulama örneklerini biliyor musunuz?
Soru 13: Sizce tarım arazilerinden ayrı olarak seralarda tarımsal üretim Türkiye'de etkili olarak uygulanıyor mu?
Soru 14: Sera üretiminin, uygun finansal/teknolojik yatırım ve kontrol araçlarını kullanması koşulu sonrasındaki potansiyel başarısını değerlendirir misiniz? (1: Çok başarılı, 5: Yetersiz)
Soru 15: Seralardaki tarımsal üretimin başarı oranını artırmak size göre hangi yola bağlıdır? Önem sırasına göre kategorileri sıralayabilir misiniz? (1: En önemlisi, 6: En Önemsizi)
Soru 16: Tarım alanlarındaki teknoloji kullanımını (iletişim ve sosyal medya haricinde) nasıl değerlendirirsiniz? (1: Çok etkili, 5: Çok Yetersiz)
Soru 17: Tarımda Teknoloji kullanımının artırılması sizce gerekli midir?
Soru 18: "Evet" cevabı için: Bu artırım hangi alanda destekleme yaparak en etkili biçimde sağlanabilir? Önem sırasına göre kategorileri sıralayabilir misiniz? (1: En önemlisi, 6: En Önemsizi)
Soru 19: Tarımda ileri teknolojilerin kullanımını artırmak sizce bakanlıklar ve devlet politikaları tarafından önceliklendirilmeli midir?
Soru 20: Tarımda dijitalleşme ve teknoloji kullanımının artırılması adına tarım politikalarının ne kadar etkili olduğunu düşünüyorsunuz? (1: Çok etkili, 5: Çok Yetersiz)

Soru 21: Tarım politikalarının teknoloji ve dijital çözümlere yönelik uygulamalamaları ne ölçüde desteklediğini düşünüyorsunuz? (1: Sıkça, 5: Neredeyse hiç)
Soru 22: Sizce tarım politikalarının güncellenme süresi/içeriği maksimum faydayı sağlıyor mu?
Sou 23: Tarım politikalarının uygulanabirliğini artırmada aşağıdaki hususları en önemliden önemsize doğru sıralayabilir misiniz? (1: en önemli, 6: en önemsiz)
Soru 24: Tarım politikalarının, tarımda ileri teknoloji kullanmayı teşvik etmesi ile nasıl bir sonuç elde edebiliriz? Günümüz koşullarında bunun gerekliliği ve potansiyel sonuçlarına dair yorumlarınız nelerdir?
Soru 25: Siz politika yapıcı olsanız, güncel olanlardan farklı olarak akıllı tarım uygulamalarını yaygınlaştıracak nasıl bir politika tasarlardınız?

B. INTERVIEW QUESTIONS

1. Mesleğinizden ve mesleğinizin dinamiklerinden bahseder misiniz?
2. Ne kadar zamandır bu alanda çalışıyorsunuz?
3. Şu an çalıştığınız serada çalışan kaç kişi var?
4. Pandemi süresince işlerinizde nasıl değişiklikler oldu?
5. Seranızda kullandığınız ekipman ve yöntemlerden bahseder misiniz (iklimleme, sulama, izleme vb. sistemler öncelikli olmak üzere)
6. Siz bu mesleğe başladığınızdan beri kullandığınız ekipman veya yöntemlerde değişiklik yapıldı mı?
7. Sizce seracılıkla uğraşanlar bir aile işletmesi olduğu için mi zirai eğitime yöneliyor? Yoksa bu alanda okuyup sonrasında bu sektöre girenler de oluyor mu?
8. Sizin yararlandığınız veya takipte olduğunuz bu sektöre dair haber kaynakları var mı?
9. Bu kaynaklara ek olarak teknolojik ve teknik gelişmeleri takip ettiğiniz kaynaklar var mı?
10. Takip ettiğiniz teknik ve teknolojik çözümlerin herhangi bir açıdan uygulanabilir veya uygulanamaz dediğiniz açıları var mı?
11. Çevrenizde olan diğer seraları daha önce ziyaret ettiniz mi? Ettiyseniz bu seralarda kültür, çalışanlar ve iş süreçleri ile alakalı gözlemleriniz oldu mu?
12. İş ekipmanlarınızı nereden alıyorsunuz?
13. Bu ekipmanların ayar ve kontrolleri kimler tarafından sağlanıyor?
14. Bu ekipmanları ve araçları alabilmek için yararlandığınız teşvik ya da var olduğunu bildiğiniz yatırım teşvikleri var mı?
15. Seracılık sektöründeki piyasa ve rekabeti nasıl anlatabilirsiniz?
16. Sizin üretim anlamındaki operasyonunuz için bulunduğunuz yerdeki altyapı yeterli mi?
17. Sizin ağırlıklı olarak ürün sattığınız ülke veya bölgeler neresi?
18. Şu anda oluşturduğunuz ticari ilişkileri kurarken nelere dikkat ediyorsunuz?
19. Şu anda ürettiğiniz ürünleri tercih etmenizin sebepleri neler?
20. Şu an kullandığınız gübre, ilaç, tohum veya ekipman nereden ağırlıklı olarak tedarik ediliyor?
21. Sizin şu an bağlı olduğunuz ziraat odasının işleyişi nasıl? Ziraat odalarından nasıl faydalar sağlıyorsunuz?
22. Şu an seracılık üzerine, Türkiye çapında bir farkındalık veya oluşmuş bir bilinç var mı? Veya ne yöne doğru gidiyor sizce?

23. Sizin şu an çalıştığınız seranın bir web sitesi veya online bir sayfası var mı?
24. Bugüne kadar aldığınız bir devlet desteği veya teşviki oldu mu?
25. Özel yatırımcılar bu sektöre yatırım yapıyor mu?
26. Siz tecrübelerinizi, seranızda çalışanlar haricindeki kişilerle paylaşıyor musunuz? Evet ise hangi kanallar üzerinden paylaşıyorsunuz?
27. Seracılık sektöründeki rekabeti anlatabilir misiniz?
28. Sizce bu sektörde etkili bir firma olmak için seracıların ne yapması lazım?
29. Siz bu sektörün Türkiye'deki geleceğini nasıl görüyorsunuz?
30. Sizce bu alandaki politikalar ne yönde geliştirilmeli?

C. APPROVAL OF ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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29 OCAK 2021

Konu : Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi : İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Arsev Umur AYDINOĞLU

Danışmanlığını yaptığınız Serra BAYKAL'ın "Akıllı Tarım Uygulamalarında Türkiye'nin Hazırlık Seviyesi ve Politika Değerlendirmeleri" başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **033-ODTU-2021** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof. Dr. Mine MISIRLISOY
İAEK Başkanı

D. TURKISH SUMMARY / TÜRKÇE ÖZET

Türkiye korumalı tarımı en çok uygulayan ülkeler arasında yer almaktadır. Akdeniz iklimine sahip geniş tarım arazilerine sahip olması ve uygun iklim koşulları, Türkiye'nin tarım alanında önemli üretici ülkelerden biri olmasında başlıca faktörlerdendir. Örtü altı yetiştiriciliği, kapalı ve kontrollü ortamların üretimde sağladığı avantajların yanı sıra korumalı tarım aktivitelerinin çeşitli zorlukları da mevcuttur. Mevcut üreticiler finansal problemlerin yanı sıra ürünlerin son kullanma tarihlerine kadar saklanması, ısıtma zorlukları, dezenfeksiyon problemleri ve yetersiz gıda güvenliği önlemleri bu zorlukların başında gelmektedir. Meyve ve sebze gibi hassas ürünler için bu konular çok daha büyük önem taşımaktadır.

Sera işletmeleri ve korumalı tarım üretim tesisleri, tarımsal gelişmenin tarihi boyunca ileri teknolojilere doğru ilerlemiştir. Üretimde karşılaşılan sorunlara sürdürülebilir çözümler sağlayan en büyük faktör de teknoloji olmaya devam etmektedir. Bu kapsamda mühendislik çözümlerinin yanı sıra, teknik bilgi birikimine sahip insan kapasitesinin artırılması ve disiplinler arası çalışmaların desteklenmesi, ileri üretim yöntemlerinin yaygınlaştırılması için gerekli temel unsurlardır.

Korumalı tarım faaliyetlerinin altında literatürde geçen yaygın yöntemlerden biri de hassas tarım başlığı altında yer alan Konuşan Bitki Yaklaşımıdır. Şeffaf ve 7/24 kontrollü bir üretim sistemi kurmak amacı ile uygulanan Konuşan Bitki Yaklaşımı, her bir ürün ihtiyacına göre belirlenen girdiler sayesinde üreticilerin ürün güvenliği ve kalitesi konusunda güven duymasını sağlar.

Bu kapsamda değerlendirilen tam otomatik ve modern seraların sayısı Türkiye'de oldukça azdır. Bunun yerine, büyük ve orta ölçekli seralar içerisinde yarı otomatik üretim sistemleri ve hassas tarım uygulamaları daha yaygın olarak kullanılmaktadır. Örnek vermek gerekirse, orta ölçekli seralarda ağırlıklı olarak tarımsal Ar-Ge kapsamında uygulanan iklim çözümleri, tohum ve fide üreticiliği de dahil olmak üzere çeşitli laboratuvar uygulamaları kullanılmaktadır. Büyük ölçekli seralar tam otomasyon sistemine uygun teknolojik ve teknik alt yapıya sahip olsa da Konuşan Bitki Yaklaşımı'nın tanımı ve uygulanma şekilleri göz önünde bulundurulduğunda orta ölçekli seraların bu üretim yönteminden alacağı fayda diğer seralara göre oldukça fazladır.

Büyük ölçekli seralar geniş bir ticaret ağına sahiptir. Uluslararası deneyim ve bilgi paylaşımı da bu ticaret ağına eklendiğinde, büyük ölçekli sera şubeleri arasında yoğun bir bilgi aktarımına olanak sağlanır. Bu seraların satış ve ihracat büyüklüğüne paralel olarak, tam otomatik operasyonlara geçme istekleri de açıkça görülmektedir. Şu anda Türkiye'deki büyük seralarda uygulanan tohum geliştirme ve insan-makine izleme sistemlerinin bir adım ötesine gitmek için, geliştirilmiş izleme sistemleri, robotik iş gücü ve algoritmaya dayalı veri entegrasyonları günlük üretim operasyonlarına entegre edilmelidir. Orta-büyük ölçekli seralarda ise tohum ıslahı için kurum içi ya da dış kaynaklı Ar-Ge faaliyetleri yürütülmektedir. Bu seraların daha büyük ölçekli seralara yetişebilmek için mevcut bitki durumu sürekli izlenmeye dayalı stratejiler izlediği gözlemlenmiştir.

Bu iki boyutlu işletmelerden farklı olarak, orta ve küçük-orta ölçekli seralar piyasada ayakta kalmakta zorlanmaktadır. Bu sebeple bu işletmeler girdi maliyetlerini düşük tutmak için çeşitli stratejiler izlemektedir. Nakliye maliyetini azaltmak için pazara yakın bir alanda işletmelerin kurulması, bu tür stratejilere bir örnektir. Buna rağmen orta ve küçük-orta ölçekli seralarda ürün kalitesini ve sağlık güvencesini geliştirmek adına yoğun istekler de mevcuttur. Ürünlerin ihracat değeri konuda üreticilerin en büyük motivasyonlarından biridir. Konuşan Bitki Yaklaşımı ve ilgili teknolojik çözümler, bu alanda üretimin geliştirilmesi ve daha geniş bir müşteri ağına ulaşmada önem arz eden unsurlardır.

Farkı ölçekli seraların üretimde karşılaştıkları sorunlar ve işletmelerinin gelişme alanları göz önünde bulundurulduğunda, seracılıkta kullanılan teknolojilerin yaygınlaştırılması adına devlet destekleri ve politikalarının yadsınamaz bir önemi vardır. Her ne kadar mühendislik alanında yeterli altyapı ve insan kapasitesi olsa da bu teknolojiler Türkiye'de yaygınlaşamamaktadır. Bu durumun altında yatan sebepler göz önünde bulundurulduğunda devletin girişimci rolünü üstlenmesi gerektiği anlaşılmaktadır.

Bu çalışmada, gerekli politikaların tasarlanması ve önerilmesi konusunda Teknolojik İnovasyon Sistemleri kapsamında sistematik bir metot izlenmiştir. Teknolojik İnovasyon Sistemi, bir bölge veya endüstriden ziyade sadece belirli teknoloji dinamiklerine odaklanılarak tanımlanabilir. Sektörel ve Ulusal İnovasyon Sistemi ile pek çok ortak yönü olan Teknolojik İnovasyon Sistemi, inovatif çalışmalar kapsamında bilgi üretmek, yaymak ve depolamak için çeşitli kurumları dikkate almaktadır. Ancak olgunlaşmış piyasa sistemlerine ek olarak gelişen piyasalara da uygulanabilirliği nedeniyle diğerlerinden farklıdır. Bu bağlamda tarımsal yenilik ve Konuşan Bitki Yaklaşımı da seralarda sürdürülebilir ve yenilikçi üretim metotları için çeşitli teknoloji ve teknik beceri gerektirmektedir. Konuşan Bitki Yaklaşımı'nın Teknolojik İnovasyon Sistemi kapsamında değerlendirilmesinin en büyük nedeni odak noktasının geleneksel üretim yöntemlerini teknoloji ile dönüştürmek olmasıdır. Bu nedenle, seracılık sektöründe sürdürülebilir bir gelişme için teknoloji odaklı politika tasarımına ihtiyaç vardır.

Türkiye seralarının mevcut durumu araştırılırken, seçilen iki inovasyon sisteminden öğrenilen teknoloji yayılım yaklaşımları yol gösterici olarak dikkate alınmaktadır. Japonya ve Hollanda, Konuşan Bitki Yaklaşımı kapsamında teknolojileri benimseme konusundaki adımlarını takip edecek en iyi uygulama ülkeleri olarak seçilmiştir.

Japonya'da gelişmiş bitki yönetim sistemleri ile farklı ölçeklerde çiftçilik yapılmaktadır. Bu nedenle, hassas tarım ve Konuşan Bitki Yaklaşımı, Japonya'daki çeşitli aktörler için oldukça büyük önem arz eder. Bu aktörler arasında üreticilere ek olarak, devlet memurları, özel sektör üyeleri, politika tasarlayıcılar ve akademik kurumlar yer almaktadır. Bu kapsamda, Japonya'daki devlet politikaları, ileri teknolojileri farklı iş alanlarına entegre etmek için üzerine çalışmaktadır. Tarımsal faaliyetlerin bir parçası olan seracılık da bu politikalar arasında yer almaktadır. Çok sayıda aktör katılımı ve kapsamlı politika tasarımları sayesinde Japonya, Konuşan Bitki Yaklaşımı'nın uygulamalarını ve teknolojilerini benimseme konusunda gereklilikleri ve adımları anlamak için en iyi örneklerden birini temsil etmektedir.

Hollanda seracılık sektöründe tüm üreticiler arasında ilk sıralarda gelen ülkeler arasında yer almaktadır. Modern seracılık, özellikle Avrupa ülkeleri arasında, en çok Hollandalı işletmeler tarafından temsil edilmektedir. Bilimsel ve teknolojik yayılımın yanı sıra Hollanda'da bulunan seralar, ulusal ekonomi ve ticaretteki rolleri açısından da incelenmiştir. Bu kapsamda ticarileştirme ve başarılı iş uygulamaları, Hollanda'yı ikinci en iyi uygulama örneği olarak belirlemede etkili olmuştur.

Mevcut seracılık sorunlarını anlamak ve bu konuda adım atabilmek için benimsenmesi teknolojik yayılımın gerekliliği anlaşılsa da bu alanda yapılan uygulamalar oldukça sınırlı ve zorlayıcıdır. Konuşan Bitki Yaklaşımı ile uyumlu teknolojilerin benimsenmesi, Türkiye gibi henüz gelişmekte olan bir sistem içerisinde çeşitli açılardan değerlendirilmelidir. Bu kapsamda yedi fonksiyon belirlenmiştir. Her bir fonksiyon altında sunulan analizler, gelişmiş sera teknolojisinin yaygınlaştırılmasına yönelik politikalar önermek gerekli çeşitli açıları ele almaktadır. En büyük problem taşıyan konular ve Türkiye'nin en iyi uygulamalar karşısındaki genel performansı göz önünde bulundurularak, politika geliştirmede öncelikli faktörler, hem farklı ölçeklerde çalışan sera sahipleri hem de Ziraat Odaları çalışanları tarafından ele alınarak belirlenmiştir.

Japonya’da mevcut olan sera pazarı, yüksek düzeyde akademik ve bilimsel katkı ile minimum alandan maksimum verim elde etmeye odaklanmaktadır. Bu anlamda seracılık, verimliliği artırmak için bilimsel yaklaşım ve yeni teknolojilerle desteklenmektedir. Temel amaç kendi kendine yeterliliği ele almak olsa da, yetiştirme yöntemlerinde görülen ilerleme Japonya'yı rekabetçi bir pazar haline getirmektedir.

Akademik katkının yanı sıra devlet, örtü altı yetiştiriciliğinin ana destekçisidir. Özel sektör aktörlerini geride bırakan devlet desteği, ülkenin doğal afet geçmişi ile de oldukça ilgilidir. Aşırı doğa felaketlerin tarihi, hükümeti yeterli gıda stoku sağlamak için tarımsal üretimi teşvik etmeye zorlamıştır. Toplam ekilebilir arazi Hollanda ve Türkiye'den daha az olduğu için, örtü altı yetiştiriciliği önemli bir tarımsal üretim aracı olarak halen teşvik edilmektedir.

Hollanda’daki seracılık sektörü ise, kendi kendine yeterlilik kaygılarından ziyade iş ve ticaret kaygıları tarafından yönlendirilmektedir. Hollanda'nın temel performans farkı, Girişimci Faaliyetler, Meşruiyet Yaratma ve Kamuoyu Bilinçlendirme başlıkları altında ortaya çıkmaktadır. Tarımsal akademik çalışmalar disiplinler arası konuları ve teknoloji odaklı yaklaşımları içerirken, genel performans sahadaki üreticilerin aldıkları kararlara ve risklere bağlıdır. Çiftçiler girişimci olarak kabul edilir ve geliştirme-motivasyonları ile yenilikçi adımları atmaktadır. Buna paralel olarak devlet, bu üretici-girişimciler için en uygun ortamı yaratmaya odaklanmaktadır. Diğer AB ülkeleri (özellikle Almanya) ile kurulan ticari ilişkiler seracılıktaki gelişmeyi hızlandırmaktadır.

Hollanda sera pazarı içinde yüksek düzeyde iş birliğine bağlı gelişme gözlemlenmektedir. Özel firmalar pazarda daha büyük bir paya sahip olmak için deneyimlerini birleştirirken, küçük ölçekli seralar da devlet destekleri ve girişimleri ile teşvik edilmektedir. Bu destekler maddi olmanın yanı sıra bilinçlendirme, eğitim ve tamamlayıcı hizmetler alanında da verilmektedir.

Hollanda ve Japonya ile karşılaştırıldığında, Türkiye'deki seracılık sektörü ticaretle ilgili dinamiklere yoğunlaşmakta ve ihracat değerine bağlı olarak şekillenmektedir. Bu tür bir konsantrasyon, sera yetiştiriciliğine yönelik faydalar ve zayıflıklar ile birlikte gelir. Sektörün geneline bakıldığında görülen zayıflıkların tamamı "bağımlılık" başlığı altında ele alınabilir.

Birinci fonksiyon kapsamındaki temel bağımlılık geleneksel bilgiye yöneliktir. İlerleyen üretim yöntemlerine yönelik akademik konsantrasyon eksikliği nedeniyle öğrenciler teorik bilgileri pratiğe dökememektedir. Türkiye'de çok sayıda tarım bölümü olsa da, yalnızca bir tanesi dünyanın en iyi 1000 üniversitesinde yer almaktadır. Ankara Üniversitesi bu kapsamda iyi bir teorik altyapı sağlasa da teknolojik çözümler ile pekiştirilmiş müfredat konusunda Hollanda ve Japonya'ya kıyasla geride kalmaktadır. Buna ek olarak mevcut işletmeler ve bilimsel araştırmalar, finansal veya altyapısal engellerden dolayı kendilerini geliştirememektedir. Sonuç olarak, bilimsel bilgi işletme düzeyinde yayılmakta oldukça yavaştır. Bu durum üreticilerin, özellikle aile şirketlerinden edinilen geleneksel üretim yöntemlerine ve nesiller boyunca aktarılan bilgiye bağımlı kalmasına yol açmaktadır.

İkinci fonksiyon altında açıklanan genel girişimcilik ekosistemi içinde farklı bağımlılıkları mevcuttur. Girişimcilik yolunda herhangi bir adım atılmadan önce öne çıkan finansal motivasyonlar ve engeller bu bağımlılıkların başında gelir. Yüksek yatırım maliyetleri ve dış etkenlere bağımlılık nedeniyle tarımsal girişimcilikte oldukça zorlu ve bireysel çabaya bağlı bir ortam bulunmaktadır. Bu nedenle bölünmüş ekilebilir alanlar ve çok sayıda küçük ve orta ölçekli seralar, üreticinin yatırım kararını daha da zorlaştırmaktadır.

Üçüncü fonksiyon kapsamındaki bağımlılıklar, iş gücü kapasitesi ve mevcut hizmet alt yapısı ile bağlantılıdır. Bu fonksiyonun ana odağı, üreticiler arasındaki teknoloji kullanım düzeyidir. Tarımda kullanılan teknoloji ve ekipmanların, tarımsal işgücünün tamamına ulaşmasında eksiklikler gözlemlenmektedir. Örnek vermek gerekirse, teknik servislerin yetersizliği veya yokluğu, tarımsal teknolojilerin benimsenmesinde önemli bir etkendir. Üreticiler bir teknolojiyi satın aldıktan sonra teknik bir sorun olması durumunda teknik servise baş vurmaktadır. Üreticiler mevcut teknik servisten memnun kalmazlarsa, teknolojik çözüm ne kadar faydalı olursa olsun, kullanmayı bırakma eğilimi gözlemlenmiştir.

Dördüncü fonksiyon altında elde edilen bulgulara göre seraların farklı işletme ölçekleri ve farklı ihtiyaçları vardır. Buna rağmen genel pazar, işletmenin büyüklüğünden bağımsız olarak, ihracat ve ticareti merkeze almaktadır. Bu yoğunlaşma içinde, ileri teknolojilere geçiş geride kalmaktadır. Mevcut altyapı ve mühendislik çözümleri, yerel alıcılardan ziyade diğer ülkelere satılmaktadır. Bununla birlikte, tarımsal ticaret- özellikle meyve ve sebzeler- uluslararası ilişkilerden ve siyasi hassasiyetten etkilenmektedir. Sektördeki güvensiz ortama ek olarak, genel pazar yerel kaynaklarla iş birliğine kapalı ve dış ticarete bağımlıdır.

Beşinci fonksiyon kapsamında incelenen belirli bağımlılık başlıkları yoktur. Bunun yerine mevcut kamu yasaları, düzenlemeler ve politikalar gözden geçirilmiştir. Bu çerçevede seracılık sektörünün ilerlemesinde atılan adımlar gözlemlense de devlet teşviklerinin finansal destek ve enerji tasarrufu alanlarında kısıtlı kaldığı görülmüştür.

Altıncı fonksiyon finansal ve insan kaynakları üzerinden analiz edilmiştir. Bu başlık altında göze çarpan en büyük bulgu tarımsal iş gücünden ayrılan kişilerin yarattığı ve yaratacağı etkilerdir. Aile işletmelerinde dahil genç nüfusun tarım dışı iş kollarına kaydığı veya yönlendirildiği anlaşılmaktadır. Sonuç olarak mevsimlik işçilerin katkısı artmakta ve sera sahiplerinin karşılaştığı riskler daha da büyümektedir.

Yedinci ve son fonksiyon, tarımsal verimlilik ve teknolojik gelişmeler aşığında bilginin ve tecrübenin nasıl yayıldığı ile ilgilenmektedir. Türkiye'de teknik bilgiye erişimde yerel bölgelerde bulunan akıl hocaları ve diğer üreticilerin deneyimlerinin esas alındığı anlaşılmaktadır.

Fonksiyonlar altında elde edilen bulgular; hükümet politikalarının sürdürülebilir kalkınmayı sağlamak ve bağımlılıktan kaçınmak için farklı endişeleri göz önünde bulundurmasını ve seracılık sektörünü bu yaklaşım ile teşvik etmesini göstermektedir. Bu kapsamda, Türkiye'de henüz teknolojik yayılımın başlangıç dönemlerini gözlemlediğimiz seracılık sektöründe, ilk adımın bilgi üretimi ve yayılımı üzerine olması uygun bulunmuştur.

Öncelikli olarak üzerinde durulması gereken konular iki ana başlığa ayrılmıştır: (i) üniversitelerde pratik ve teknolojik adaptasyonu güçlendirecek müfredatların eksikliği ve (ii) bilgi yayılımına yönelik atılan adımların yetersizliği. Bu önceliklendirme başlıklarının belirlenmesinde tüm fonksiyonlarda ortak olarak görülen deneyime ve uygulamaya dayalı bilginin kaybolma riski göz önünde bulundurulmaktadır. Ziraat alanında çalışacak öğrenci ve gençlerin bilimsel ve akademik bilgiden uzaklaşarak deneyime dayalı bilgi ağına büyük önem vermesi tarımsal gelişmelerin ilerleyememesinde bir sorun teşkil etmektedir. Genç iş gücünün farklı meslek kollarına olan yönelimi ise bu ortam içerisinde akademik bilginin yayılımına ek olarak tecrübeye dayalı bilginin de kaybolma riskini beraberinde getirmektedir.

Bu çerçevede bilimsel bilginin geliştirilmesi ve yayılması alanında atılması gereken adımlara ek olarak aşağıdaki unsurların da öncelikli olarak ele alınması gerektiği anlaşılmıştır:

- Tarımsal girişimciliğin ilgili üniversite müfredatlarına dahil edilmesi
- Tarımsal girişimciliği destekleyen öğrenciler, işletme sahipleri, çiftçiler ve sivil toplum örgütleri için eğitimlerin teşvik edilmesi
- Tarımsal girişimcilik projelerini ve etkilerini takip etmek için izleme ve değerlendirme mekanizmalarının oluşturulması
- Üreticilerin satın aldıkları her türlü ekipmanın teknik destek servislerinin güçlendirilmesi
- Tarımsal ihracatın siyasi ilişkilerden etkilenmemesi için tarafsız bir ticaret düzenlemesinin sağlanması
- Seracıların kullandığı yan ürünlerin fiyatlandırma ve dağıtım politikalarının düzenlenmesi
- Seracılık sektöründe etkili olan aktörlerin disiplinler arası bir profile sahip olması
- Tarımsal Ar-Ge için ayrılan kamu harcamalarında standart bir yüzdenin ayrılması

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TEZİN ADI / TITLE OF THE THESIS (**İngilizce** / English): Design and Proposition of Technology Policies to Diffuse Greenhouse Technologies in Turkey: A Case for Speaking Plant Approach

TEZİN TÜRÜ / DEGREE: **Yüksek Lisans** / Master ☒ **Doktora** / PhD ☐

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