



Establishing drone technology to agriculture as a service provider

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Abstract

Drones have opened a broad range of opportunities for agriculture and businesses working with drones. However, there is not much research done in Finland and the whole business model is new. Drones have been used around the world to help with tasks done manually by humans. Global markets have shown the advantages of drones for farming and also financial potential for businesses. This business possibility was examined to gain valuable information. Implementing the drones in agriculture in Finland faces many problems including the lack of knowledge and professional pilots. Also, the climate in Finland affects all parties of drone operators, including pilots/businesses and farms. Study was not executed to give direct answers on questions, but to give base for the future studies and projects. The objective of this study was to examine market opportunities for drone service providers and to work as a benchmark for future studies.

Topic was examined with a survey. Methods used to collect data were qualitative and quantitative. Quantitative data was used to build general guidelines for the research. The qualitative study complemented the findings of the quantitative study. Respondents answered multiple-choice questions and open-ended questions from which qualitative data were collected. Survey gathered primary data. Secondary data were collected from US based sources to give reference on financial side. The primary data of the study was collected with a Google Forms survey tool. The conducted survey gathered 23 responses from the professionals working in agriculture. The collected data was then analyzed and compared to secondary data and potential of market and information introduced.

The market research identified an opportunity for business to build profitable business. Despite the small amount of responses, the data show the potential to create business by providing drone piloting services to farms in Finland. Awareness was at a good level and therefore the study also recommends deeper research based on the research work done. Research in the field has been very limited and the best benchmarks can be found in other markets outside Finland. The application of other markets operating models in Finland is a good starting point until more comprehensive regional research has been done. Without companies in the industry, accurate calculations were difficult to implement. It confirms the view that the data from this study cannot be directly applied in practice but can be used as a benchmark.

Keywords/tags (subjects)

Market research, Drone, Agriculture, Business opportunity, DJI

Miscellaneous (Confidential information)

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1 Introduction

This thesis will be a research for using modern drone technology in agriculture. Thesis will focus on using drones as a machine for inspections, spread seeds, spray and fertilize the fields and plants. Thesis introduces the drones, agriculture and ways drones are used at the time and how they can be more adapted in the future. Thesis will look into if there is a market cap for outsourcing these operations. Technology used in today's agriculture is mainly old innovations with modern technological improvements. Lately, some companies have developed new tools for agriculture to make it more efficient and advanced. This thesis will look into this new technology as well as agriculture today and how these two can be combined in a profitable way.

Similar research has been conducted in 2020 by Santeri Karte. The research however was more towards forest industries in Finland, where this thesis will focus on agriculture. Thesis made by Karte, is still a good benchmark for this research since the technology is almost the same used in agriculture and forest industry. Also, in both industries drones can be used to take photos and do measurements. In Karte's research the common phenomenon was that outsourcing drone operations is too expensive and too time consuming with too long delivery time from order to final analyzed data. This research will discuss the similar questions in agriculture and if possible, find a market opportunity for outsourcing drone operations.

Context

Thesis will introduce the basics of drones and agriculture. After the basic information thesis introduces more specific information on modern technology of drones. DJI Agras t20 example drone is used to showcase the possibilities the drones can bring to modernize agriculture. Data from the US market will be used to build a basic understanding of financial side of the drone piloting. Research examines research questions and builds an analyzed data package around these questions. Research examining these topics is executed to provide data for future studies and businesses. Thesis will also look into new rules and regulations in Finland set by Traficom 2020-2021. New rules and regulations are taken in use in 2021-2022 with transition time for some operators and drones.

Motivation for the research

The motivation for this research comes from the need of improvements in agriculture to make farming more efficient to provide enough clean healthy food for future generations. Studies show that more than 820 million people are suffering from hunger (WHO, World hunger is still not going down after three years and obesity is still growing – UN report, 2019). Even modern technology and drones cannot make world hunger disappear, but it is an effective way to provide food for people who need. In countries like Finland, we have to be first ones to implement these possibilities to show their effectiveness. The researcher has been working with drones for several years in real estate and commercial videography and therefore uses this base knowledge in this thesis. Author also has a background in agriculture and can use its own knowledge to fill the lack of information available.

1.1 Research Objective and questions

Objective is to recognize market opportunity for drone usage in agriculture to partly replace heavy polluting machinery with modern technology. Study will start by introducing current state of drone usage and finally answer if the farmers are willing to outsource some of its operations for third party service provider and therefore create a business opportunity for drone service providers. The research is generated to seek the basic information and therefore the questions asked in the survey had to be in basic level, not in small details. At present, the author did not have comparable material at his disposal, and it supported the idea of simplicity of research. Therefore, the other objective of the research is to create a picture of the market, but above all to create a background for future research. The research questions were also kept clear and simple, so the survey is able to generate answers to the questions.

- RQ1 Are farmers and people working in agriculture familiar with drones?
- RQ2 How is drone technology currently used and are farmers willing to use drones?
- RQ3 How much financial resources farms are ready to invest into drones and outsourcing?
Does these indicate market potential?

This study takes first steps on examining three main things that are important when finding new market opportunities (Chehtman, 2017). First thing the thesis examines is the indicators if the farmers and their employees are familiar with these kinds of technological possibilities and if they are considering using them. Secondly, this research explores how drones are used currently in

Finnish agriculture and does farmers know the possibilities drones can offer. Last question tries to find indications on how much financial resources farms are ready to use and are they ready to use this technology by themselves or do they consider outsourcing the services for third party operator. These three main categories build a shallow picture if there is a market opportunity. Research is built to recognize general guidelines that can be followed in future studies. This thesis does not try to give in-depth analysis of the whole market, but the introduce theory and possibilities.

1.2 Glossary of key terms

UAS	Unmanned aircraft system includes the drone, operator and devices to operate the drone.
ICAO	International Civil Aviation Organization changes the principles and techniques of international air navigation.
EASA	European Union Aviation Safety Agency provides studies and methods for safe operating of aerial vehicles.
BVLOS	Beyond Visual Line of Sight means operating drone or other aerial vehicle without visual contact into it.
FPV	First Person View is the onboard view the drone operator is able to see with a screen or glasses.
GPS	Global Positioning System that drones use to locate themselves.
UAV	Unmanned Aerial Vehicle is a vehicle able to execute autonomous operations airborne.
VTOL	Vertical Take-off and Landing is when Aerial vehicle produces lift while remaining in place. Therefore, no runway is needed.

2 Literature Review

2.1 Drones

An unmanned aerial vehicle (UAV), commonly known as a drone is an aircraft without human operator(pilot) on board (Howell, 2018). Drones are widely used across industries all the way from military use to agriculture and photography. Even though drones were originally designed for military applications, they are used in many more applications today for example in agriculture, aerial photography and even product deliveries. Hobbyists are using drones even for racing as an FPV vehicle to compete against each other's. In the last few years drones have taken enormous leap to become more advanced than ever before. (Maddocks, 2020)

The ways UAVs can be used these days are numerous. UAV is a part of UAS (unmanned aircraft system). UAS includes a UAV, ground-based controller and a communication system between them. The ways drones fly can vary between different degrees of autonomy. They can be flown by the human operator with remote control unit or fully autonomously with its onboard computer also known as autopilot. Originally drones were designed for missions that were too simple, dirty or dangerous for humans when compared to manned aircrafts. These days, as said, there are many more applications than those specific missions. (Maddocks, 2020)

In January 2019, there were 2,416 commercial operators using drones in Finland, with 3,073 drones at their disposal. From the year 2021 a drone pilot must complete an online aviation course and exam after that to qualified as a drone operator in Finland. The requirements are based on new regulations set by EU. (droneinfo.fi, 2020) Research of this thesis will focus on professional use of drones in agriculture. Technology introduced later will be part of the big picture of drones in agriculture.

History of drones

In 1916, Archibald Low developed radio control for airplanes. In March 1917 he developed the unmanned, remotely piloted aircraft Ruston Proctor Aerial Target, which was to be further devel-

oped for use against zeppelins. (Taylor, 1977) This, and neither the American "air torpedo" Kettering Bug, which was successfully tested in October 1918, had time to be used in military operations. (Stamp, 2013) These were the first steps in the process of development of the modern drones.

Between the wars from the 20th century, but especially in the 30s, the English developed radio-controlled drones. In the 1940s, these early drones were used as training targets for military personnel. In the 1960s, Ryan Aeronautics also developed the Model 147 aircraft, which was sent from a transport plane and parachuted. It was used for intelligence. A fiberglass drone was able to carry camera or signal intelligence equipment as a payload to be used in military purposes. On the basis of information obtained by aircraft during the Vietnam War, an interference system was developed that effectively prevented the impact of the radar-guided SA 2 missile. (Isoniemi, 2020) In the 1950s, the U.S. Navy were able to develop a drone capable of carrying a torpedo. It became obsolete as early as the late 1960s. The Air Force then began developing an airplane that would destroy the enemy air defenses. Drones developed carried either missiles or TV-controlled bombs. (The First UAV Squadron, 2018)

The United States started the development of the Predator aircraft for reconnaissance in 1994. Test flights were flown in 1996. First weapons were installed in the Predator in 2000. After that, the United States developed larger models. The United States has used combat aircraft a lot in the war on terror. On the other hand, terrorists have also started using them. These military technologies have developed into everyday use of drones and now they can be used all the way from toys to professional industrial inspections with high technology thermal cameras. The current popular recreational use of drones has set in motion in the 21st century side, when a large number of ready-made drones have appeared on the civilian market. Drone flying has already been among aircraft enthusiasts before this. Outside military use drones are also used, for example, in border control in rescue missions, in agriculture, in the film industry, and in the construction industry. (Tikkanen, 2020)

2.2 Agriculture

Agriculture is an industry that produces food and feed and other products by growing certain crops and livestock. Agriculture is the most important source of food for mankind alongside fishing. Agriculture includes farming, which produces plant food for humans and fodder for domestic

animals, as well as fiber crops, and animal husbandry, which produces meat, dairy products, leather and wool. Agriculture and animal husbandry are interlinked because the majority of meat is produced with farm-produced feed instead of grazing. (Rutledge et al., 2011)

In agriculture, plants can be divided into food and fiber plants. For example, grains and fruits are plant foods for humans. Food crops can be further subdivided. Significant fibrous plants include hemp and cotton: the best-known use of hemp fiber is hemp rope, but hemp fibers can also be used to make durable fabrics, cellulose as a raw material for paper, and industrial raw material for use as insulation, sheets or furniture material. (Vaarna, 1965) Cotton, on the other hand, is used to make clothes.

Technologies used in agriculture have evolved, and plant and animal species have been bred to be more profitable. Agriculture requires land that is suitable for modern farming. With the help of agriculture, humanity is making a significant difference to the environment and forest areas have been converted for agricultural use, as, for example, Europe was a very forested continent before agriculture. In the 1950s and 1960s, the so-called Green Revolution increased agricultural productivity with fertilizers and pesticides. The link between agricultural production and world population growth is controversial (Zahid et al., 2016)

History of agriculture

The history of agriculture covers the development of agriculture from the birth of agriculture to modern times. Agriculture originated in several places around the globe independently of each other. One of these was the ancient Middle East. In addition, agriculture also developed in China, Central America, South America, the eastern parts of North America, and New Guinea (Vaarna, 1965). Agricultural society spread around the world. After the Industrial Revolution, the development towards an industrial society began. As a result of population growth, agriculture has had to become more efficient and expand enormously. Enhancing efficiency with new technologies is called the green revolution. (Hazell, 2009)

New technology in agriculture

There are a lot of expectations associated with new technologies in agriculture: easier work, better quality of production, cost-effectiveness and competitiveness. So far, little has been said about the benefits of technologies for ecological sustainability and responsibility. There is research data and practical experience on technologies, but overall, the knowledge is scattered.

The goal of the Sustainable Development in Agriculture with New Technologies project (2019-21), coordinated by the TTS Work Efficiency Society, is that by disseminating information and combining know-how, agricultural entrepreneurs find new alternatives to reduce the burden on the environment and develop working methods. Combining different perspectives produces objective information and builds a network between research, education, advice and practice. The association of ProAgria Centers, HAMK and Luke Natural Resources Center are involved in the cooperation.

2.3 Drones in agriculture as imaging device

Photogrammetry or image measurement refers to methods by which the shape of an object and properties are explored by taking photos of the subject and performing measurements from them instead of measuring the object itself directly on site. Traditionally, methods have meant taking photographs of a subject, but thanks to technological advances, photogrammetry can be utilized also with electromagnetic and digital imagery. Photogrammetric measurement does not interfere with even the most fragile measurement object, which is one of its great advantages. (Vinni 2003).

Drone remote sensing using photogrammetry is the most cost-effective method when the target is too large for terrain mapping and too small for helicopter laser scanning and aerial photography. Operators are divided into air service providers, device manufacturers and data processing software developers. Typically, a system consists of description design software, the drone itself, the controller, autopilot and ground station with radio links, and of course camera (s). Take-off and landing systems vary by manufacturer. Both work steps can be performed manually by the pilot or allows the autopilot to automatically steer the device to the air and back to the ground. (Sippo, 2013, 33). This remote mapping method is partly already used in agriculture in Finland, but yet there are not many service providers. The lack of expertise can lead into false results and therefore cause wrong decision when making plans for farming. In conclusion, the lack of knowledge can harm the overall process and in worst case scenario make financial losses. This same goes with upcoming topics on wavelengths. Not understanding them can be harmful.

Wavelengths

Remote sensing is based on measuring electromagnetic radiation reflected back from an object. Continuous scale of electromagnetic radiation is called spectra and different spectra can be utilized in their most characteristic ways. For example, the wavelengths of light visible to the human eye are a very narrow part of the entire spectral range. Remote sensing can be utilizing not only visible light but also other spectra such as UV and infrared radiation. (Eskelinen, 2001).

Each object reflects radiation back, radiates to the environment and emits some of the radiation. When the radiation reflected back from an object is known, it is called the characteristic spectrum. The characteristic spectrum is utilized in remote sensing. (Kallioinen & Laaksonen, 2016). Radiation is used when analyzing the field for example. Different wavelengths give different information about the stage of the field. These wavelengths help to recognize where the crop is good and where it is not growing in its full potential. There is no difference between water and vegetation in the amount of radiation reflected back large at wavelengths visible to the human eye, but with the transition to near infrared the difference increases significantly.

Leaf green, or chlorophyll, absorbs much of the visible light reflected from the sun for photosynthesis. However, most of the green light is reflected back and therefore humans sees plants green. (Rekola, 2018).

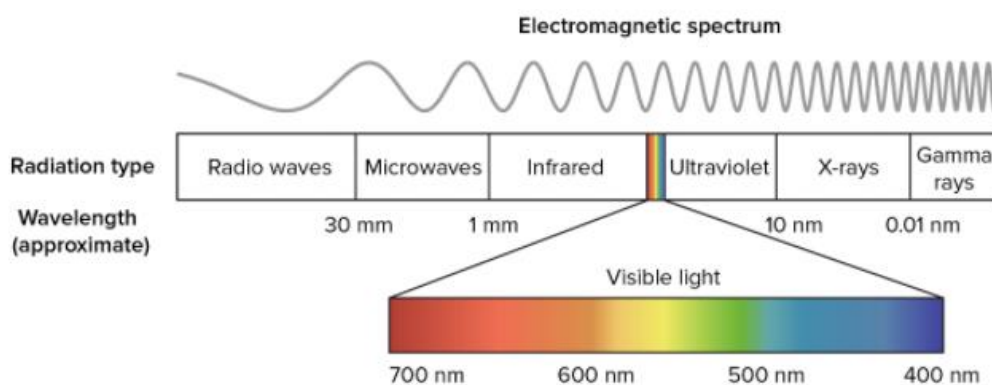


Figure 1 Electromagnetic spectrum (Khanaacademy.org)

As written earlier, not understanding these technologies and methods can cause harm. This knowledge can be helpful in agriculture, but if the big picture of using it is not clear, there is a possibility to read the results wrong. Analyzing the data provided by the drones that use these technologies can help with watering and planting for example, but as the data is read wrong this can cause losses to final amount of harvested crop.

NDVI Index

Normalized Difference Vegetation Index (NDVI) is one of the most common indices in the world to describe green crop size and growth potential. The NDVI index is based on the amount of near-infrared and visible light reflected back from the target. Whole and dense vegetation reflects more near-infrared than the sick and sparse. (Moilanen, 2017)

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

VARI index

The VARI (Visible Atmospherically Resistant Index) is based solely on the utilization of visible light (Gitelson, Kaufman, Stark & Rundquist, 2002). The index does not provide any new information about the crop, only confirms what the human eye could perceive. Roughly speaking, the index only determines how green the image is. (Gitelson et al., 2002)

$$VARI = \frac{Green - Red}{Green + Red - Blue}$$

Ortho aerial view

The ortho aerial image consists of several different photographs that are combined into one large image. There is no perspective distortion in the ortho-aerial image, but each point in the image is photographed directly from above. In this way, areas can be measured with reasonable reliability from the image or interpret surface shapes. (Rekola, 2018)

2.4 Drones beyond imaging

With modern solutions, drones can also be used in many more purposes than only imaging the field for analyzing and making 3d-models. There are some companies providing even more advanced devices to help replace old, heavy and polluting machinery and manual work. This thesis will take a deeper look into industry leading DJI and its new Agras T20 drone (Figure 2). The drone is designed for spraying and seeding. (dji.com) The drone can be combined with different attachable tools. Agras T20 can also share data with other devices to improve its efficiency to better replace other devices.



Figure 2 DJI Agras T20 (dji.com)

Example drone DJI Agras T20

Agras T20 is a ready-to-fly set. The cost of RTF set is around 14 000 euros before taxes. T20 can be upgraded with multiple batteries, tanks and charges for example and these can bring the prices over 20 000€. Unlike the MG series, the T20 always has standard RTK positioning and radar. RTK achieves near-centimeter accuracy in spraying, and the drone's precise radar detects objects about 15 centimeters in size from a distance of 15m. The Agras T20 is an IP67 protected drone designed for agriculture and forestry. The device's 20-liter tank allows the liquid to be effectively applied to an area of up to about 20 hectares at a time. The application takes place on an autopilot, with an accuracy of almost a centimeter. The automation helps the operator to focus on the job itself and not only flying. This allows drone to be used by a single pilot.

If there are roundabouts on the route, they must be marked on the map. You can also use the controller to rotate around the object to be rotated to determine the area where the drone will not fly. The marked areas are automatically stored in the device's memory and cloud service. This helps when the drone is needed next time. The previous route can be used, and no more setup is needed. You can later view flight routes on a computer, change settings, and improve the outcome. If you lose sight of the drone during a flight, you will see its location on the map and you can also view the image of the drone's FPV camera. If in doubt you can stop the flight and if necessary, you can call the drone back to the starting point with the push of a button.

The T20 also works in pairs with the DJI Phantom 4 RTK drone. In this case, P4 RTK makes the area a point cloud curve that takes into account the edges and obstacles of the area to the nearest centimeter. The T20 uses this data for spraying (Figure 3). This results in a very low spray height, resulting in high accuracy and small losses. Automation has made these effective tools available for everyone. With some training most people are able to make a safe and effective flight.

Agras T20 information is based on the marketing material and research done by DJI



Figure 3, T20 agras and Phantom 4 in field example image (dji.com)

Adopting technology

With this type of new technology, there is always people who are waiting longer than others. As the figure 4 below shows, adaptation of new technology can be divided into five cycles. Innovators, early adopters, early majority, late majority and laggards. All these steps are common when new technology is introduced for the audience. This generates a lag for new innovations. It always takes time to hit the market and become well know and commonly used. Geoffrey Moore in his book: "Crossing the Chasm" introduces the technology adoption lifecycle and what separates successful technology companies from the others. "Every truly innovative high-tech product starts as a fad" (Moore, 2002, 5). Figure 4 introduces the technology adoption life cycle by Moore. It shows how the emerging technology affects the different customer groups in different ways. Moore (2002) describes each group briefly:

Innovators pursue new technology aggressively. Sometimes they try to get to product even before the proper marketing has started. This is because technology is a central interest in their life, regardless of the function it is performing. Early adopters buy into new product concepts early in their lifecycle just like innovators. These people however want to see the product been tested by the innovators first and them selves can jump into technology. The early majority have an ability to relate to technology, but ultimately, they are practical people and therefore are not buying first. They know that many of these new inventions end up being a short time thing, so they wait until they see how other people are making out before they buy in themselves. The late majority shares same concerns and worries with the early majority, plus one major additional one: Late majority likes to wait a bit longer and these people are most likely not that comfortable with new technology. Last group of people are the laggards. These people do not want to have the latest technology. There can be many reasons from economic reasons to preconceptions.

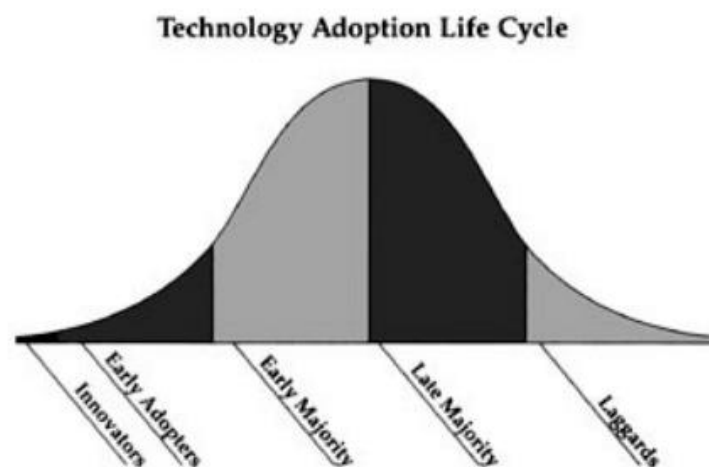


Figure 4 Technology Adoption Life Cycle (Moore, 2002)

2.5 Rules and regulations for drones

The European Union regulation on the use of drones will apply from 31.12.2020. The new drone law will harmonize drone regulations throughout the EU. For Finnish drone users, the reform introduces an obligation to register in the register of drone operators, previously the notification obligation has only applied to professionals. (EU: n dronesäännöt, 2021) At the same time, drone operations are organized into different categories with different requirements. These categories are

the open class, to which most enthusiasts belong, and the specific and certified classes, which are subject to stricter requirements.

Categorized drones

In the Open category, the action always takes place in line of sight, at a height of less than 120 meters, on a drone weighing less than 25 kg. As a general rule, the user of the drone must register and pass an online exam. Subcategory A1 allows individual people to fly on light equipment. Category A2 allows the use of slightly heavier drones, but the activity must take place on the sidelines of people. In category A3, activities always take place away from settlements and people. In this case, operation is also possible with heavier drones. (EU: n dronesäännöt, 2021) If the operation is not possible with open category rules, it should be implemented in special or certified categories. In the Special category, the operator must apply for a separate operating license. The permit can be obtained either in accordance with the standard scenario published by EASA by notification or by applying for a license from the Finnish Transport and Communications Agency Traficom. A risk assessment of the operation is required for the permit. If the activity involves flying over crowds, transporting people or transporting dangerous goods, the activity must be carried out in the certified category, for which preparations are still unfinished. Standards related to the certified category have not yet been published, so it is not yet practically possible to obtain permission for this category. (EU: n dronesäännöt, 2021)

The drones used for spraying and seeding are mainly over 25 kg and therefore the operator needs an operating license to fly the device. Also, some of the liquids that are sprayed are counted as a dangerous good and might require license to fly at the certified category. Therefore, these rules can affect drone usage in agriculture and all the required steps must be taken before using drone. In general, the new drone law will harmonize drone regulations throughout the EU. For Finnish drone users, the reform introduces an obligation to register in the register of drone operators, previously the registration obligation has only applied to professionals. Only drone users who fly unmanned drones weighing less than 250g or defined as toys are excluded from registration. All drone users flying camera drones are covered by the registration. Traficom also introduced specific pricing for drone operators to fly as a registered drone pilot. Registration costs 30 euros for

one year. There are also options to pay 75 euros for three-year license or 100 euros for 5-year license. (Rekisteröityminen ja teoriakoe, 2021) In the future, all drone users should also be familiar with the rules for flying drones and, as a general rule, take the test. For ordinary drone enthusiasts, it is usually enough to take an online exam. For more advantaged use like studied in this thesis more training might be required specially in the future.

2.6 Airspace limits

Due the aircrafts operating in the same airspace as drones, there are many limits when it comes to flying. Some places are completely restricted, and some are limited with altitude limit for example. These limits may lead into situation where all regular drone services cannot be done at the certain locations. For example, near the airfields there are heavy restrictions and limitations and without special permits flying is not allowed. In Finland, Jyväskylä and Utti are heavily restricted, and no drones are allowed in their airports CTR (Control zone), without special permission from the air traffic control. These restrictions can affect some of the local farms. (ais.fi) In the photo of the Jyväskylä CTR, it is clear that large are of Jyväskylä, Uurainen and Äänekoski for example are covered of the CTR. Therefore, no drone should be operated without special permission. The permission must be applied at latest 2 days prior of flying the drone. (Aeronautical information service, ais.fi) These rules apply also in other areas around Finland and all piloting should always be planned before hand to make sure none of the rules and limits are broken.

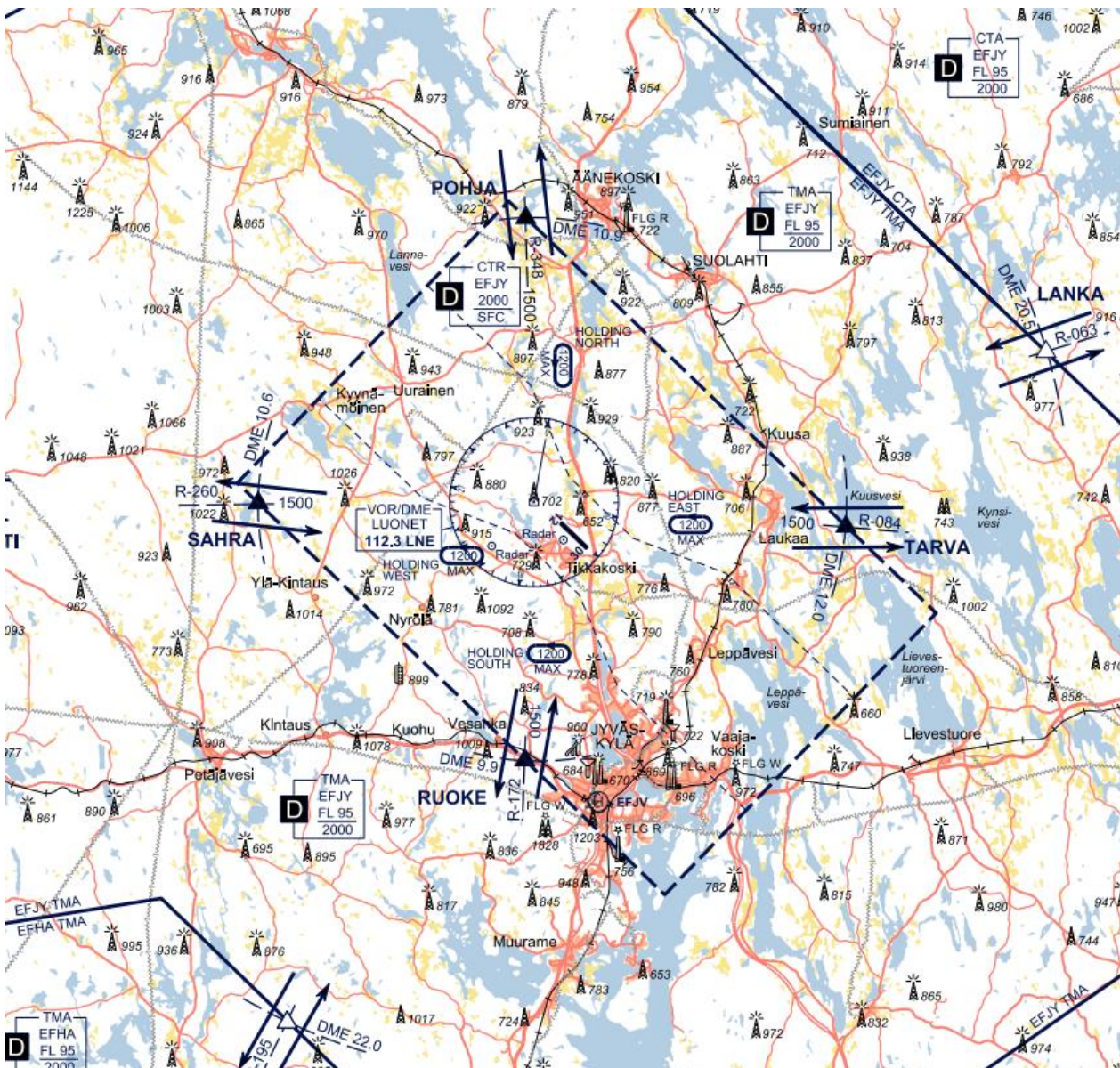


Figure 5 Jyväskylä CTR (ais.fi)

2018 at Gatwick airport, the unauthorized usage of drone was reported, and all flights were suspended in few minutes. Unauthorized drone activity is a major danger to aircraft and passengers because they create a risk of collision. By midnight, 58 flights were diverted or cancelled leaving huge impact in the operations as a drone. (Shackle, 2020) These cases have shown the dangers of drones for aviation and now there has been new anti-drone systems installed. In UK for example, new legislation was introduced to make drone no-fly zone wider around the major airports like Heathrow. Worlds first Counter Drone system (CDS) was designed for Heathrow Airport by Operational Solutions Ltd. They try to detect and track unauthorized drones. The system will also locate the pilots of these drones. These pilots can face up to five years in prison if they fly in a UK's Flight

Restriction Zone without permission. (Fischer, 2020) As these new rules and introduced around the world, similar penalties are most likely adapted in EU. For legal commercial activities this should not be making a big difference, but for single private operator the costs for example might grow and therefore build a barrier for new operators.

2.7 Commercial drone operating as business

Drones are commercially operated around the world in different purposes at the time. For few years also agriculture have gained professionals to provide reliable service to help farmers in their daily tasks. In Finland, at the time there is no major well know operator who provides these types of services. Service providers are mainly focusing on photography, filmmaking, and commercial inspections at factories and other facilities. This generates an opportunity for existing businesses as well as for new companies starting in drone industry as a service provider.

Fortune Business Insights (2020) estimates that agriculture drone market will hit 3.7 billion dollars across the globe by 2027, exhibiting a CAGR of 18.14% during the forecast period. They also estimate that the emergence of new startups worldwide specializing in developing unmanned aerial vehicles for agriculture, will have significant effect to the potential market. Fortune Business Insights writes that agriculture drones have proved to be very successful increasing farm yields around the world. Given the lucrative opportunities, many startups have started developing UAV solutions focusing on the different aspects of farming operations. For example a Swiss startup, Gamaya, is focused on developing productivity and scalability of small farms by using advanced mapping and diagnostic systems. This enables farmers to efficiently manage their farms. Another example HummingBird Technologies from UK. This startup develops drones with customized sensors, machine learning algorithms and computer vision to collect accurate data and imagery to help with precision farming. Startups like these will provide solid development of future drones to be establish drones into farms.

In 2017, Agweb.com released an Farm Journal Pulse where they executed a research for farmers asking their drone usage. In that results 31% said they are considering using drones in 2018. The fact that almost third of farmers were considering using unmanned aerial vehicles back in 2018 shows the clear interest in the technology and its potential for agriculture. Also, 33% said they are already using drones either themselves or through a third party provider in the year of 2017 when

the research was done. In total this makes 64% of farmers already using or willing to use drones as a tool for executing their daily tasks done at the farms. These numbers give good base for research done in this thesis to compare the results and recognizing possible changes in either direction. There were 1092 responses to the research done by Agweb who as a Farm Journal, “delivers the most widely used, trusted and relevant business information throughout American agriculture.” as written in their mission. Same research also shows that third of who are considering using drones are giving the responsibility of it to third party service provider, where two thirds say they will be doing it by themselves. At this time, the knowledge of drones is not considered high yet, and most farmers are not fully familiar with the technical aspects and problems. Thinking of data and the research, need for third party operators might grow in future when devices and procedures get more complicated and technologically advantaged. On the other hand, automation might make these complex devices easy to use for everyone and tractors and drones might be easy to connect in future to work together. In this case the need for services might fall from what it is these days.

The main reason for farms to use drones with third party service provider is to save time and money. Therefore, the company providing drone services needs to make an actual difference when it comes to business. Two well known drone experts Paul Alexander and Rob Burdick were answering to this topic in the interview held back in 2017. The service must be high quality to match up with the need of farmers. At the time, they feel there is a slight oversaturation of the service providers in specific area of operations. The barrier for new small business to step in is low and therefore almost anyone with a “toy” drone can start providing imaging for farmers. This may affect the industry in general, because by them, some farmers are not happy with constant connections from low quality agricultural drone service providers. The data provided can cause heavy crop losses and drive into wrong decisions made by farmers when relying on low quality data. Paul and Rob also points out it is hard to see the difference between low and high quality data because there is no reference for the information that the images are showing.

This generates a big opportunity for well-trained experts that are offering wide services from imaging to spraying. With proved high quality data, good results can be achieved with small financial investments. This gives and slight edge for companies that are already in the drone business, but also shows that for experts there is still room and no oversaturation is seen among true professionals in the industry. The lack of professional at that time also might build up for future, where

the business and the need is constantly growing. Referring to Paul and Rob the drone businesses face often a trouble with giving data to customers. Those who find ways to easily deliver the simple, yet informative data to customers are in good bases as a business. Therefore, every business giving drone services needs to create end to end system, where they can handle all the processes of the operation. Referring to professionals Paul and Rob: “It is a big hill for new operators and not easy for existing ones”.

Economical possibilities

As the field of industry is new, the pricing is still settling, and many operators work with very different pricing. As Karte wrote in his thesis, many possible drone service customers thought that the service is too expensive at this time and they hope the pricing would change in the future. Below the data shows hourly rates of 700 US-based commercial drone pilots. The data is provided by DroneDeploy, which is the leading cloud software platform for commercial drones. They provide service from fleet management to site documentation and analysis of data. DroneDeploy used its own wide database to collect data from operators using their cloud services. The graph takes a look at the industry as a whole. Left side shows percentage of service providers and lower side shows the price in US dollars/hour.

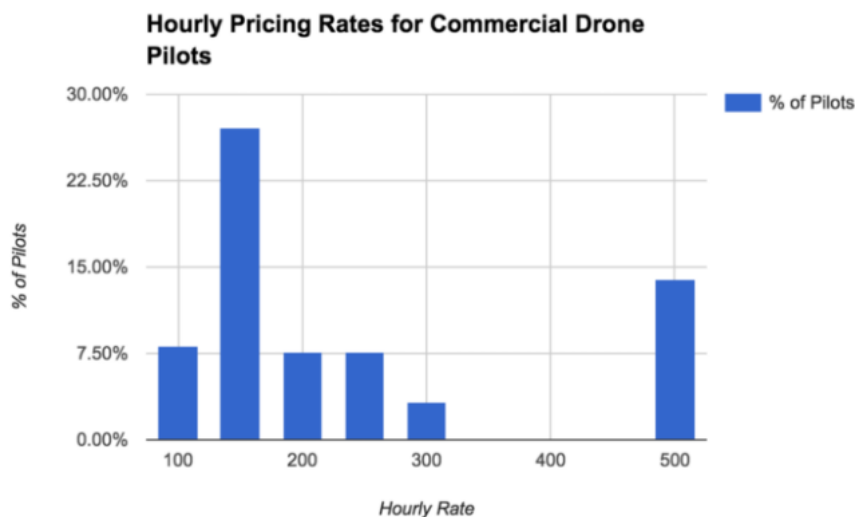


Figure 6 Hourly Pricing Rates (DroneDeploy.com)

The data shows that around 27,5% of service providers hourly rate is 150 USD. The second highest rate is 500 USD/hour, which shows that there is a need for high end service as well. The lowest

price being 100 USD/hour, shows that the service is ranging a lot at this stage. This also makes it accessible for many operators as well as for potential customers due the fact that there is big price range to choose from. Yet, it is hard to analyze only from this graph, what service are provided at which price range. DroneDeploy also examined hourly rates of commercial drone service providers who do mapping. This graph is closest to service this thesis is introducing. Graph shows that over 60% of service providers have an hourly rate between 100-150 USD. This shows that most service providers are willing to operate at the lower range of the pricing table. It indicates of accessible prices for everyone and even no historical data is not shown here, this can indicate the lower prices also in the future when more drone pilots are entering the market. Therefore, the expectations for lower prices in Karte's thesis might be possible in future. Yet, compared to the industry average the mapping service providers are able to charge higher rates on average, but at the same time the top of the rates is cut off. For this research DroneDeploy analyzed data from over 200 mapping services providers



Figure 7 Hourly rates for mapping service (DroneDeploy.com)

Below, the third graph introduces the average hourly rate by industry. This data is most important when thinking drones in agriculture and can be compared to industry averages introduced previ-

ously. The data shows that the industry serviced plays a role in determining the hourly rate. However, the data does not show the amount of work done or needed inside the industry. For example, Oil and gas industry is very limited when at the same time real estate and agriculture is more open market with more potential customers. This can mean lower hourly rate but more hours at the same time making the income of the business greater after all. Alone this does not mean there is no potential in all of these industries. Yet, the average hourly rate of agriculture is around 162 USD (134,32 €, 3.5.2021). In total with 5 hours a day for 5 days a week for six months (26 weeks), the total revenue would be 105 300 USD (87 309,81 €, 3.5.2021). These sums however can be hard to reach at the beginning, but with proper connections the market shows potential.

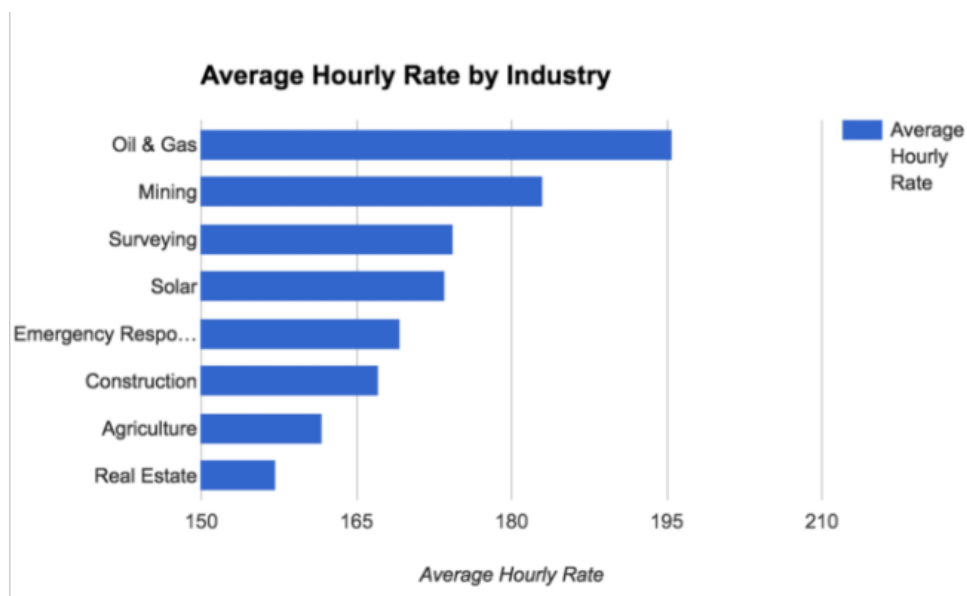


Figure 8 Average Hourly Rate by Industry (DroneDeploy.com)

2.8 Summary of knowledge base

This chapter sums the literature review and introduces the main point from the material. Drones have been developed to its modern state from old military technology. In its modern state the drones can execute complicated automated operations as single pilot operations. With advantaged connections between drones and other machines required in agriculture, the combinations can provide efficient operations. At this time, connecting machines and taking full advantage of the technology can not be fully established in agriculture. Drones can map the fields and do spraying and seeding but operating tractors and drones together is hard at this time. Top brands like DJI are developing better connectivity and also better hardware to fully satisfy the needs of agriculture.

Rules and regulations are big part of flying the drones. European Union have set more strict rules and Finnish Transport and Communications Agency (Traficom) is adapting rules to Finnish drone industry. From the beginning of the 2021, the new test for all drone pilots is necessary and drones should not be operated without proper permissions. Also, airspaces limits flying of drones and all the flights should be planned.

Providing drone piloting service is not mainstream in Finland. At least yet. Most of the examples are from global markets and widely the drones are used in United States. Some drone manufacturers and service providers are also setting foot in Africa were for example malaria can be fought with drones effectively. In Finland most drone operators offer imaging services and commercial videography. Some companies also provide industrial inspections. Service providers offering drone piloting for agriculture are not common at this state.

Drones in agriculture can be used in many ways and drones can be attached with complex accessories to handle many of the agricultural needs. Drones can be used for crop state monitoring (growth rates, irrigation/fertilization requirements, diseases, damage and ripeness assessment), crop yield forecast, calculation of fertilization, vegetation state assessment, soil moisture monitoring, assessing crop nutrition, irrigation system monitoring and irrigation optimization. Heavy commercial drones are also capable of precise spraying and seed spreading. All this together makes a drone an efficient tool for every farm in Finland.

Literature review introduce DJI Agras T20 as an example drone. T20 is newest advantaged agricultural drone. T20 can provide wide functions to be established in farms. Drone can be connected with DJI Phantom 4 RTK, that can provide field data for Agras T20. Combined these two the fields can be calculated and analyzed efficiently. Phantom 4 RTK can do imaging and provide 3D data for T20 to use. Phantom 4 RTK also makes crop analysis and can send data directly to T20. Therefore, T20 knows how much to spray/seed the field thanks to its capability to regulate the amount of products used.

Most drone businesses operate with hourly rate and because operating drone in agriculture in Finland is not yet common, the exact rate is hard to calculate. The literature review examined data from US market, where using drone in agriculture is more common. Hourly rates varied between different industries that the drone is used for. In the data (Figure 8) there were eight main industries and their average hourly rate for drone piloting. In those eight industries the highest rate was in oil and gas industry and lowest in real estate. The rates varied around from 195 to 155. The range in these averages are only 40 USD and shows pretty stable rate in all the industries. The research done by DroneDeploy does not observe differences between the need for drone services. For example, the real estate can be the best business even the hourly rate is lowest. Agriculture showed low results also in the DroneDeploy research. It was second lowest with around 160 hourly rate. Professional on Drone U say the pricing of the service however should not be based on the hours. They recommend the pricing to be hectare based. Most farmers know precise costs of their traditional operating and therefore the hectare-based pricing model could show straight indication if the drone is more profitable than traditional methods. There are no significant service providers offering agricultural drone service and therefore the literature does not cover existing businesses or actual profits/potential the businesses have. The rough estimates on the pricing can be calculated from the data from US market. Calculations can be divided based on the specific drone's performance. The example drone in chapter 2.4 can do over 10 hectares/hour in optimal conditions(dji.com) but in reality, the performance varies between 5-7 hectares/Hour. The average agricultural hourly rate was 160 USD. 160 USD divided with DJI Agras T20 performance of average 6 hectares/hour generates the 26.7USD price/hectare. These numbers are only estimates and can vary between drones and different operations.

3 Methodology and Implementation

A research methodology builds the structure for the research itself. It generates guidelines to the research process. This factor is important for successful implementation of the research. Various tools and techniques were used to conduct this research. These are presented in the upcoming subchapters below. This chapter also introduces data analysis, data collection and the plan for the research quality and ethics process.

3.1 Research approach and strategy

The goal for this research was to study how modern drone technology can be used in agriculture in Finland. Thesis does it by seeking possibilities and to examine how the relevant literature and theory can help businesses to gain more understanding of the technology and its possibilities, not to give a straight yes or no answer to complex and diverse phenomenon. The research was conducted in a form of questionnaire for farmers all over Finland.

In this research, the qualitative approach is enriched by analyzing both non-numerical and numerical data. The research could not have been utilized completely as quantitative research due the complexity of data collected. With qualitative data the research collects more precise data and gives the opportunity for complex answers for the respondents. "Qualitative research is not, and should not be, able to produce generalizable information as quantitative research would" (Salonen, 2021). In addition, the questions are hard to be built 100% numerical due the fact that every farmer is in different situation and is already doing things in their own way. Therefore, quantitative data collection strengthens the research and makes the result more reliable.

3.2 Data collection

The most common methods for data collection for qualitative research are survey, interview, observation and information that can be collected from various articles (Sarajärvi & Tuomi, 2017, 79). In this research, the primary data was collected in April 2021 through a google-forms survey. The language of the survey was Finnish. Finnish language was chosen due most of the respondents were agricultural people from Finland. This lowered the barrier for people to answer to get as

many responses as possible, so the survey could give valuable knowledge of drone usage in agriculture. The respondents pool consisted of farmers and farm workers who are closely attached to agriculture in their everyday actions. The pool was selected due it has the most potential and most knowledge of agriculture in Finland and people working there are the ones using the drones now and in the future. Therefore, these respondents' answers were the most valuable for this research.

Topic was examined with a survey. Methods used to collect data were qualitative and quantitative. Quantitative data was used to build general guidelines for the research. the qualitative study complemented the findings of the quantitative study. Respondents answered multiple-choice questions and open-ended questions from which qualitative data were collected. Survey gathered primary data. Secondary data were collected from US based sources to give reference on financial side. The primary data of the study was collected with a Google Forms survey tool. The conducted survey gathered 23 responses from the professionals working in agriculture. Questions were designed based on the key elements this thesis aims to answer. The aim was to have some questions relatively freely structured to which would give enough space for respondent's own interpretations and correlations of the phenomenon. This could be used by the researcher to tie the answers together and build the big picture of the drone usage in agriculture.

3.3 Data Analysis

The data collected for the research was partly numerical trying to recognize patterns in respondent's behavior. Part of the data was also non-numerical trying to take a deeper dive into topic and to build base for more structured research. This gives the researcher with a few resources a deeper view of the topic examined in the thesis. Choice of data collection is partly problematic. It comes with a problem of dividing the research on qualitative or quantitative segments. The choice of the segment placement is not unequivocal. This makes it hard to focus on easy data analysis method.

The multiple-choice questions with answers are presented and also analyzed with a descriptive statistics method. Open-ended question are analyzed with thematic content analysis. Thesis identifies and describes themes that arise from the data. The researcher analyses the presence, meaning and relationships of words and concepts to make inferences related to research questions. Due

to limited responses, the goal was not to calculate certain keywords found from responses but rather to discover patterns and similarities.

3.4 Plan for research quality and ethics

Qualitative research isn't a single unified research method, it contains several traditions that differentiates from others. According to Sarajärvi & Tuomi (2017, 155), validation means the research examines what has been promised and reliability stand for that the results of the research are repeatable if the study is repeated with the same data collection and data analysis methods. Reliability and validity terms are criticized in qualitative research. They have been developed for the quantitative research. They mainly concern the needs of quantitative methods (Sarajärvi & Tuomi, 2017, 155). The researchers various backgrounds factors influencing interpretation, such as my education and experiences with drones, which modifies the choices made in the thesis. This builds a challenge to the reliability and validity of the study. Attention should be paid to systematic clarification of the research process and stages.

“Good research is guided by ethical commitment which affects the reliability and validity of the study” (Sarajärvi & Tuomi, 2017, 144). The reliability consists of the research methods and credibility of the results. Validity of thesis forms from the data collection tools as well as data analysis methods. A clear reporting on how the data was collected is important. Also reporting what data analysis methods were used to analyze the data is fundamental for the research process. The researcher's role is to be fully transparent and trustworthy in the research. The author ensured that the research data from the survey were handled in an ethical manner. It means that out of all 23 responses no names or any other sensitive information were used in this research. The invitation letter for the survey and survey questions are presented in appendices section (Appendix 1 & 2). The participants of the research were informed in the letter about the purpose of the research to confidently respect the respondent's anonymity. All of the responses of the survey were treated confidentially. Responses will be deleted after the research and thesis is finished. The identity of any respondent cannot be identified. The author of the thesis also ensured that the data acquisition process was handled ethically, and other work done by researchers, and sources of literature for the thesis were cited properly. Next page table introduces the timeline and the stages of the thesis and research project. The thesis was done between January 2021 to May 2021, including all the necessary work.

Table 1 Research timeline with stages

Stage	Timeline
Identified research problem	January/2021
Reviewed the literature	February/2021
Specified the purpose of research	February/2021
selected the frameworks	March/2021
Data collection	April/2021
Analyzing the data	April - May/2021
Finalizing the research	May/2021

4 Results

Fourth chapter consists of the results of main questions asked from questionnaire. First ten questions are taking a look into questionnaires profiles and basic knowledge of drones and using drone at the farms. Next four question examines people's knowledge of rules and regulations in Finland set by Finnish Transport and Communications Agency (Traficom). Last three questions examine the possibility of farmers outsourcing the drone operations for third party operator. One of the open end questions studies the need of farmers and the ways they feel the drone can be used in their industry. The total responses were 23. Therefore, strict estimates can not be done based on this data. However, this data shows some basic guidelines that can be used in future studies. The data is partly compared to data introduced in chapter 2.7. These two data sets are showing data that can be discussed for studying the topic.

4.1 The knowledge of drones

The data revealed that 14 out of 23 answered to open end question about their role and 9 of those were full time farmers and farm owners. The other were employees or part time farmers among with their day job. This builds up the reliability of the research and shows that the target audience was chosen correctly and even the number of responses is not considered a lot, the quality is still good. The second question asked if questionnaires are familiar of drones being used as a tool in agriculture (Figure 9). The data shows that 91,3% of questionnaires knows that drones are used at farms. This shows that even drones are considered as the future and new possible way of doing things, farmers are already familiar with the technology existing and its possibilities to be used as a tool in agriculture. Only 2 out of 23 people have not heard of drones in agriculture and this builds good base for business as drone operator. (Figure 9.)

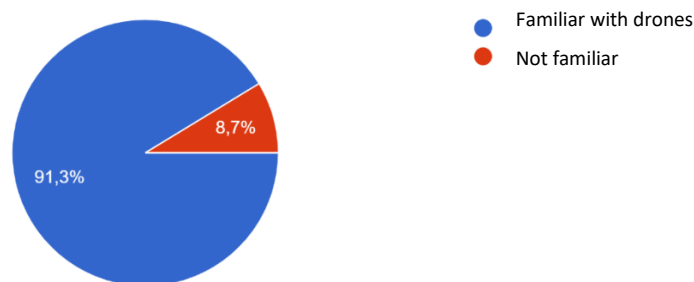


Figure 9 Respondents believing in drones in agriculture

According to preliminary data from the structural statistics on agricultural and horticultural companies, there were about 46,700 agricultural and horticultural businesses in Finland in 2019. The number of farms has decreased by 900 from the previous year. During 2019, less than two percent of the premises were closed. The number of large farms of more than one hundred hectares increased and the number of farms of less than one hundred hectares decreased or remained unchanged in all size classes. (luke.fi) This shows that based on the research over 40 000 farms are familiar with the drones used in agriculture.

The research also examined the knowledge of different manufactures trying to recognize the best-known brand. (Figure 10.) Using well-known brands can generate the advantage for drone pilots and operators. If farmers know the brands, they better understand the quality and the differences. Therefore. Using the high-end brand in drones can build more reliable customer relationships. In the question, 7 different options were given. Last being that none of the brands are known by the questionnaire. The most known manufacturer was DJI. DJI (Shenzhen DJI Sciences and Technologies Ltd) is a Chinese based technology company. Their headquarters locates in Shenzhen, Guangdong but they have manufacturing facilities located around the world. DJI had over 70% of the world's consumer drone market at March 2020. At the same time no other company having more than 5%. (Schroth, 2021) DJI's drone technology is widely used in the music, television and film industries across the globe.

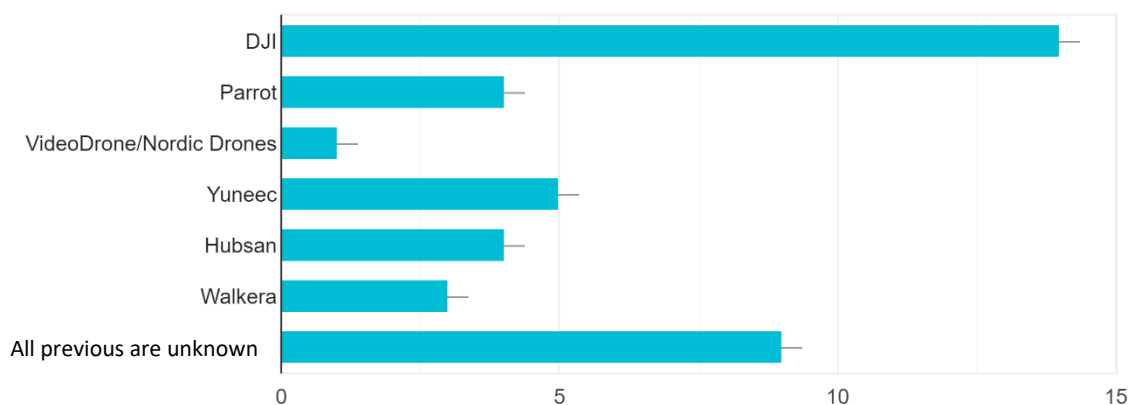


Figure 10 Most known brands

The second well-known brand was Yuneec. It is currently third in terms of market share globally (Schroth, 2021) and based on the research it is well known also in Finland. Parrot was next with

Hubsan. Parrot is globally number four and Hubsan not reaching even top ten. Therefore, Hubsan is well known in Finland compared to global statistics. The Finnish based VideoDrone, previously known as Nordic Drones, was marked as a known brand by only on questionnaire. This shows the weak point in Finnish drone manufacturing and even with strong knowledge, Finnish farmers are not familiar with local brands. The brands for the research were selected by the availability in Finland.

The data shows people's knowledge of drones being used in agriculture but does not mean they are using drones. The next questions were about the usage of drones of respondents (Figure 11.). Responses shows 69,6% of respondents either use or knows someone who is using drone as a tool in agriculture. From those using drones 33,3% says they have been using drones for more than 4 years. These numbers show clear interest of drones and their advantages for farmers. Only 11,1% of all drone users have been using it for less than a year. Based on the data, the technology has been used for long by many farmers already. This has both good and bad effects on third party service providers. It is good that drones are used. It means people are interested in the advantages of the drones and are willing to use them in their daily operations. On the other hand, there are not many drone pilots at this stage and those farmers are the pilots themselves. This can reduce the need for outsourcing the services.

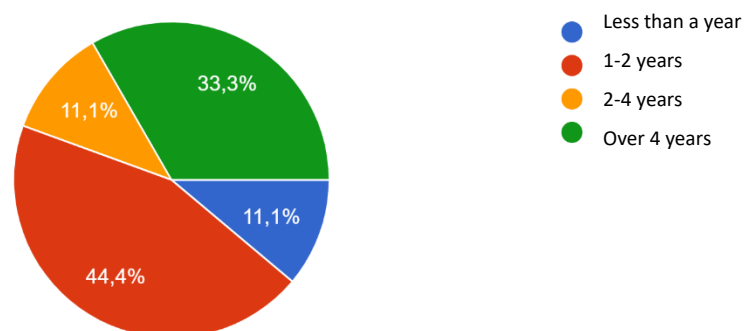


Figure 11 How long the drones have been used

The cost of drones that can be used in agriculture can cost from around 1 000€ to tens of thousands of euros. The thesis also examines how much the respondents are willing to pay for drone technology. The question also had option for those who are going to outsource the operations for

third party. 13% said they are willing to outsource the whole process and not investing any capital into own devices. The same 13% was the amount people who said they are not going to use drone nor investing into it now or in the near future. The rest were willing to invest anywhere from 0 to over 40 000€. Largest group of respondents said they are willing to invest 1 000€ to 2 000€ into drones. This price range is pretty aware when it comes to high end consumer drones. That price range is not enough for commercial drones. This shows most respondents are not willing to invest into heavy duty multifunctional drones like DJI Agras T20, which was introduced in chapter 2.4. Second largest group is ready to invest in the range of 2 000€ to 5 000€. The other 17,3% answered they are going to invest 5 000€ to over 40 000 euros. From 23 respondents one responded that they are investing over 40 000 euros into drones to be used as tool for agriculture. (Figure 12.)

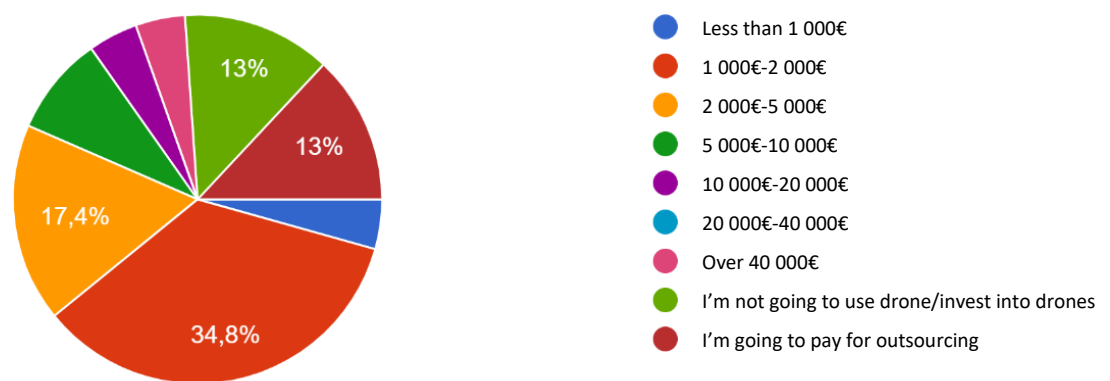


Figure 12 Financial resources used on drones

Figure 12 shows also 13% of farmers are not going to use drones in agriculture. This shows the reliability of the data and therefore generates more value. None of the respondents said they are going to start operating drone in one year but 26,1% are going to start in 2 to 3 years and 30,4% are going to wait over three years.

The technology keeps developing all the time and naturally not everyone is going to take the step towards the new technology when it is relatively new. That is why this thesis also examines the interest into technology as it is now. The question was divided into three options. 47,8% answered

that they are happy with the existing technology and there is no need to wait for new innovations to show up to the market. 43,5% however also said that they are going to wait until the technology develops. The development has been rapid in the last few years and many farmers seem to be willing to wait for even more advantaged drones. This can be partly due to the problem introduced in chapter 2.7, where professionals think the biggest problem these days is that there is no complete way to deliver data and use it effectively. Most drones and tractors for example are not connecting and sharing the information. This can make the data usage more complicated and the result of the research implicates and supports that many are willing to wait for these technologies to develop. There is no estimate when the drones are getting the leap into more sophisticated data usage and transfer, but following the development of the past few years the expectations of the late comers are most likely filling up soon. This graph also shows a lower amount of respondents resistant to drones because only 8,7% indicates not to use drones at any point. The higher number introduced previously can be more towards how things are currently. When drones get more advanced, it seems that even more farmers are going to use the technology.

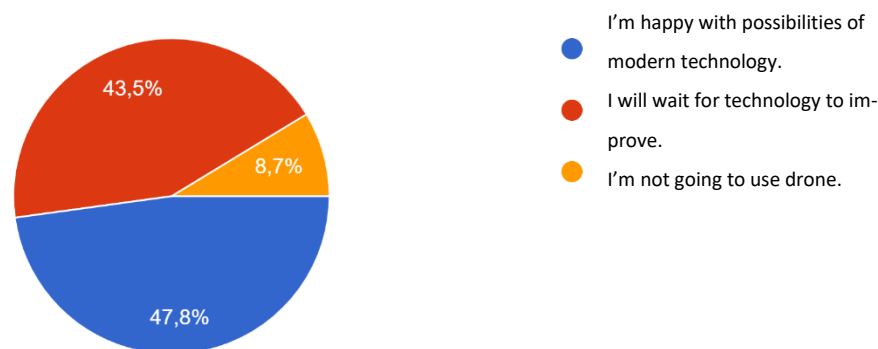


Figure 13 The opinion on drones technological state at this time

Looking at Figure 14, below again 13% believes the drones are not going to be more common as a tool in agriculture as they are now. This differentiates from the previous result. As new technology comes to market, some people are not willing to take it into use immediately and therefore skepticism is a natural reaction. Yet the majority of respondents believe the drone usage is going to get more common in the future.

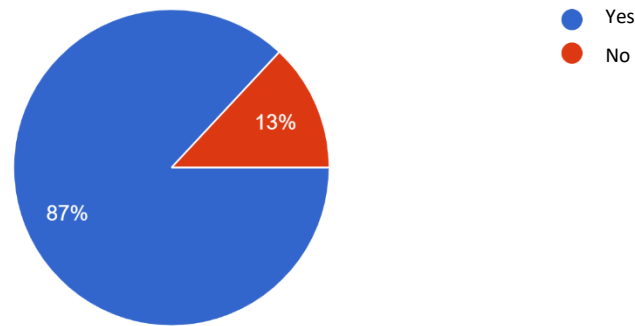


Figure 14 Respondents thoughts on drones becoming more common in agriculture

4.2 Rules and regulations

As introduced in the chapter 2.5, the rules and regulations are getting stricter. In Finland the most guidelines for drone usage are based on the EU regulations and then transferred into Finnish laws. The following four questions were to examine the knowledge of these new rules and regulations that were set at the beginning of 2021 by Traficom. Based on the results of the research only 8.7% of respondents are not familiar with the 2021 rules and regulations. 43,5 percent knows there are new rules for 2021 but have not explored them more. Almost half (47,8%) are familiar with new rules. These two together mean 91,3% of respondents have heard of or are familiar with new rules and regulations. This result shows how people are interested in the rules and therefore the fundamentals of developing working and efficient system where drones can be operated.



Figure 15 Respondent's knowledge about new rules and regulations.

However, the rules are well known based on the data, it also shows how only 26,1% have participated into new required test to operate a drone (Figure 16). As written earlier in chapter

2.5. the rules have an affect on all pilots. The data shows the potential of more pilots, that have not taken the test, operating the drone. This means some pilots might be flying without permission and required training. This can be considered as a threat to a whole industry. If the rules are not followed and regulations are not followed, it can lead into more restrictions that can cause harm for legal drone pilots and operators. Yet, only those 8,7% have not heard about the rules.

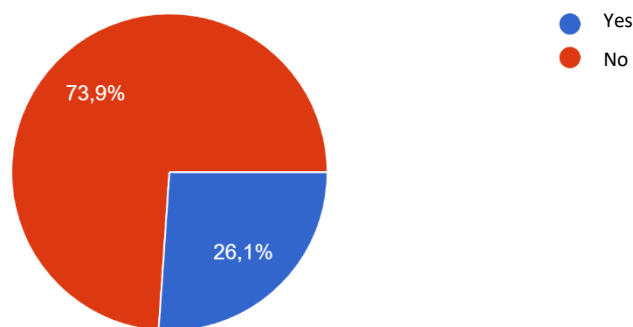


Figure 16 Amount of respondents who have taken the test.

Figure 17 shows that 34,8% of all respondents have not heard of training being available for everyone. Bigger part with 47,8% of respondents has heard about the possibility of training for drone operating. The rest 17,4% have participated into some sort of training for drone pilots. This means in total of 65,2% of all know that there is training available. This shows peoples interest into drones and also knowledge of new rules. This in general builds up for more safe drone piloting.

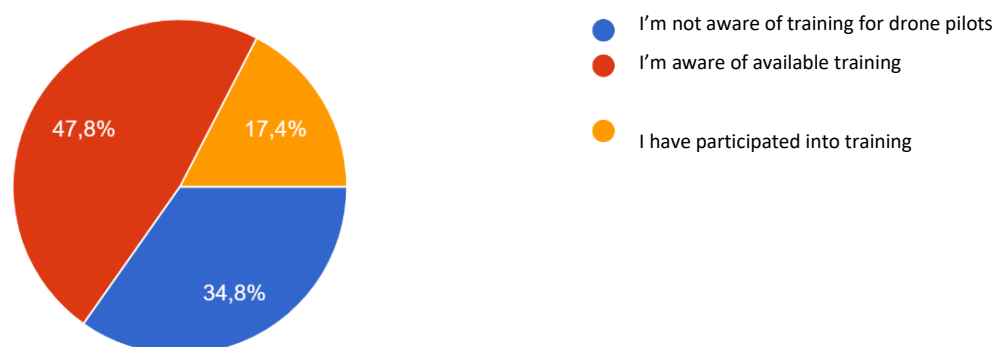


Figure 17 Respondent's knowledge of training for piloting drones.

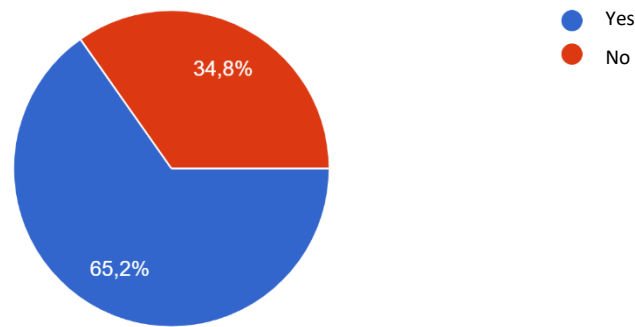


Figure 18 Willinges to participate training.

Out of the pool of 23 respondents 15 (65,2%) answered they are ready to participate into training by themselves or they are ready to participate as a business by sending their employees to the training.

4.3 Outsourcing drone operations

Last three questions examined respondent's willingness to use third party service provider to handle piloting fully or partly in their farms. Questions included two multiple choice questions and one open end question so respondents could tell more on how they feel the drones could be used in their operations and what are the biggest advantages for them based on their own experience. With these questions, the thesis targets to examine the business opportunities and respondents' opinions on how much they are ready to use for outsourcing.

By outsourcing the farms aims to save time and money. With drones, the saved time could be used to focus on higher quality of products. This all however means that outsourcing the drone operations have to be financially reasonable. Out of all 23 respondents 11 responded to be ready to use outsourcing for drone operations if it is financially reasonable. This is 47,8% of all and even the respondents pool was small this shows good signs for drone pilots. 30,4% meaning 7 out of 23, said they are ready to outsource some of to operations done with drone. This too generates a good base for drone operators and shows farmers true interest into using drones in their farms and even using service providers with drones. The rest of the pools 23 respondents said they are not ready to outsource drone operations. This group of five people also includes those who do not

believe they are going to use drones as a tool in their farm. Therefore, the amount of people against drones in farms is not large.

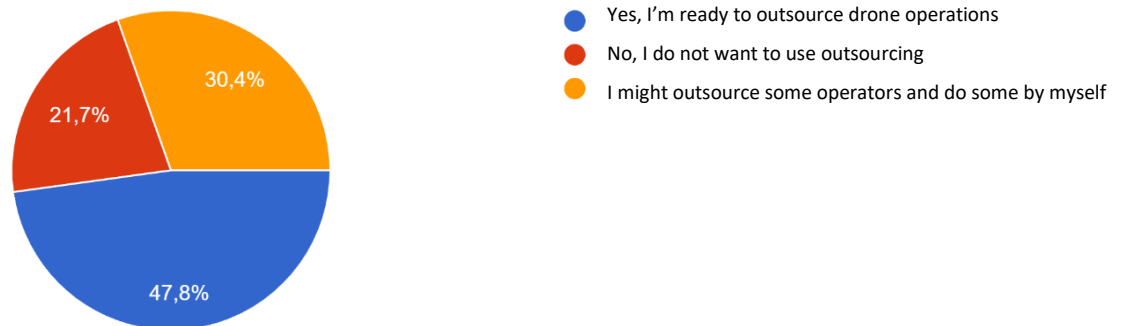


Figure 19 Willingness for outsourcing.

Lot of functions can be done at farms by drones, partly automated and some still manual work using drone as a tool. The thesis examined what respondents think about the functions of their farms that could be done by drone and in what aspects the drones could build value and make financial benefits. The responses varied a lot yet still built a good wide picture of all the functions possible to be done with drones. The most mentioned things was imaging of the fields.

Respondents mentioned the images could be used to take images of fields to recognize the growth and its problems more easy. Respondents said these images could be used to water the fields more accurate and to find differences between areas and fields. Images help to find weak spots and also strong spots to generate important information, so the field can be managed more accurate and right decisions can be made. One mentioned that precise measurements could also be done based on the photos taken. Modern softwares like DroneDeploy, which was introduced in chapter 2.7, are able to calculate measurements to get valid information of true sizes of the fields.

The images can also be used for other purposes and some were mentioned by few respondents. The drones are widely used for imaging marketing material for different purposes. In this research also farmers mentioned that delivering high quality marketing material for farms can be useful and needed. As mentioned in chapter 2.7 the farms are growing the amount of large farms is more than ever. This means they operate more like other companies and corporations and also marketing is needed. Therefore the drone can be a useful tool to generate professional video and

photography to be used in the marketing materials in social media for example. One also mentioned the products of the farm and marketing them. The drone footage could be used not only to market the farm but also the physical products of their own. The drone footage can be used as a b-roll to build stories around the brand and products. This usage was however only mentioned by one and it does not implicate the same amount of need than other functions mentioned. However this shows the variety that the service providers can offer.

Respondents also brought up the need for using a drone with animals. The drone could be used as a device to check the pastures. The drone can be flown close to animals and with normal or thermal camera the animals could be checked and counted. Searching for animals could also be done with drones. Effective and fast movement and automation drones can be very helpful tool for search missions on animals. The same methods are already used for human search and rescue missions and now, as mentioned in chapter 2.7, the prices of this complicated and sophisticated technology is lowering as they get more common for every day use. This means the thermal cameras for example are more available and can be used for surveying and searching of animals as well.

As introduced earlier in chapter 2.4, drones can be used for more than just taking images. They can work as the tool of the future. Drones provide huge potential for new ways of doing things. Few respondents mentioned drones to be used for fertilization and spraying pesticides to the fields. This is exactly what new drones are offering and therefore the supply and demand encounters with latest technology. With drone the work can be done precisely and accurately. This reduces the amount of liquids needed and some farmers are seeing this as the future and are ready to use drones for these jobs. However, some of the respondents do not see the future so bright. Some writes that they think drones to be more helpful in forest industry and not so much with agriculture. This topic was covered widely in Kartes thesis and will not be reflected in this research. Some also wrote that the devices will probably evolve rapidly for another 5-10 years. The respondent is looking forward to first see others experiences. People also does not believe in the performance of drones. Respondant thinks the facts about the performance is not possible to achieve at this point and therefore wants to wait for technology to develop even further.

Financial resources for outsourcing

Many farms operate with different financial resources and also their way of doing things can vary a lot. This theme was examined with last question of research where respondents were able to estimate the amount of money used for outsourcing the drone operations for third party operator.

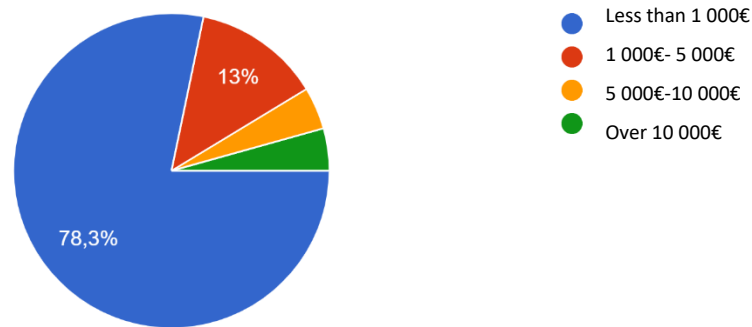


Figure 20 The financial investments to outsourcing.

The scale varied from under 1 000€ usage to over 10 000€ usage. 78,3% of respondents are willing to use 0-1 000 euros for outsourcing, which is showing some resistance for drones as were came forth also in previous questions. However, this shows even lower interest than other questions showed. 13% meaning 3 respondents said they are ready to use 1 000€ to 5 000€ for outsourcing. 1 respondent answered they are willing to use 5 000€ to 10 000€ and also one said to be ready to spend over 10 000€ for outsourcing in one year. Combined 21,7% of respondents are ready to use more than 1 000€ for the drone services.

5 Conclusions and discussion

This chapter includes conclusions and discussion of the research and thesis. All the main points are introduced and discussed by the author of the research. Objective was to recognize market opportunity for drone usage in agriculture to partly replace heavy polluting machinery with modern technology. Study started by introducing current state of drone usage and finally answer if the farmers are willing to outsource some of its operations for third party service provider and therefore create a business opportunity for drone service providers. Research is done to help recognizing general guidelines that can be followed in future studies. This thesis does not try to give in-depth analysis of the whole market, but to introduce theory and possibilities.

5.1 Answers to research questions and discussion

The research examined the main questions and tried to build a picture around these. The main questions of this thesis were:

- RQ1 Are farmers and people working in agriculture familiar with drones?
- RQ2 How is drone technology currently used and are farmers willing to use drones?
- RQ3 How much financial resources farms are ready to invest into drones and outsourcing?
Does these indicate market potential?

These main questions and the survey build around them, tried to examine a market opportunity for drone service providers. Point of the survey was to find indicators on how familiar people are and how things are at the time of the survey, do they find drones as the future and is the technology being used. The last main thing the survey examined was the financial side of the drones. How much are farms willing to use on drones and specially on outsourcing. All these topics were covered on the survey and results shows uniformity in the responses.

RQ1 Are farmers and people working in agriculture familiar with drones?

Most of the respondents were familiar with drones in agriculture. Only 8,7% of respondents answered otherwise. This show that people owning a farm or working in the farms are aware of the

technology and its possibilities to be used in agriculture. Only 9 out of 23 did not know any of the manufactures introduced and this supports the idea of farms strong knowledge of technology even the drones are not widely used in agriculture in Finland. At least yet. The knowledge is a positive sign when considering doing business in any field. The basic knowledge among the target audience can help businesses when selling the service. However, it can create presumptions, in which case the assumptions must be able to be met or refuted relying on the examined data. The service must be of high quality and professional in order to insure the potential clients.

RQ2 How is drone technology currently used and are farmers willing to use drones?

39,1% answered that they do not know anyone who is using drones in agriculture or they are not using them by themselves. This means over 60% of all respondents are already using drones or knows someone using. That states the idea of people in agriculture already using drones as some sort of tool to help produce better results in their farms. Out of all respondents only 30,4 percentage say they are not planning to use drones in farms in future. This shows that almost 70% are willing to take the drone for their agricultural arsenal of tools. Therefore, many farms are already using drones and many of those which are not are planning to use drones in future.

The volumes compared to the global market are large and this may indicate that drones are already in use but at a basic level. The layout of the question also does not allow for an accurate determination of how many drones are actually used. However, only about a third say they have no plans to introduce a drone in agriculture as a tool. This supports the idea of market potential and shows that there is a lot of interest in exploiting the technology.

RQ3 How much financial resources farms are ready to invest into drones and outsourcing? Does these indicate market potential?

Farms are willing to use financial resources on outsourcing drone services, but the actual amount of investments varies a lot. Based on the data the potential for profitable businesses to be built around agriculture indicates to be possible. The biggest goal of this thesis was to find some indicators for service providers. Many questions focused on the willingness for outsourcing and the financial investments that farms are ready to make. First of all, the amount of money that farms are

ready to use on their own drones varied between 0 to over 40 000€ euros. However, most of the respondents are willing to invest between 1 000€ to 2 000€. This means most farms want to invest into basic consumer drones that can be bought from local stores. These drones are great tools and easy to use. Over fourth of the respondents are investing over 5 000€ into drones. This means they are using multiple drones, or they are investing into more advanced commercial grade drones, like DJI Agras T20 introduced in chapter 2.4

Previous researches shows that in forest industry many of the possible service users are thinking the service is too expensive, but they are willing to use service providers if the cost is lower. In this thesis respondents answered into question "Are you willing to outsource drone piloting for service provider if it is financially reasonable?". 47,8 percentage of all respondents answered to be ready to use professionals in all their need for drone. At the same time 30,4% said they are ready to outsource some of the operations done with drone. In total 78,2% are ready to use outsourcing of some form. This indicates a true business potential and shows that the need for professional drone pilots in agriculture is reality at this stage. The downside of this is that almost 80% are planning to use under 1 000€ for outsourcing in one year. The rest of the pool are ready to invest over 1 000 euros for outsourcing. Highest of all is some farms are going to use over 10 000€ for drone services. Even the amount of financial resources used for drone pilots varies a lot these results clearly indicates the business opportunity. The results indicates that it is possible to build a customer base and build a functioning business as a service provider in agriculture.

These results states that the need for drones introduced in chapter 2.7 is becoming more common also in Finland. The technology is more used in USA and most data is from there. The hourly rates of US market can be adapted into Finnish market also as a starting point. The people are familiar with technology and the DJI Agras T20 is a good example of a multifunctional drone that the modern farms need also in the north atmosphere. As written in the chapter 2.7 there are no benchmark for the results of the financial perspective. The numbers of the study cannot be compared to operational Finnish drone service providers due there are non to be found that do only agricultural piloting of drones. Some companies offer imaging services for farms, but no reliable numerical data on their profits and prices cannot be found. The rough estimates on the pricing can be calculated from the data from US market in chapter 2.7. Calculations can be divided based on the specific drone's performance. The example drone in chapter 2.7 can do 10 hectares/hour in optimal

conditions but in reality, the performance varies between 5-7 hectares/Hour. The average agricultural hourly rate was 160 USD. 160 USD divided with DJI Agras T20 performance of average 6 hectares/hour generates the 26.7USD price/hectare. These numbers are only estimates and can vary between drones and different operations. Therefore, every operation must be calculated separately, and accurate financial data is available only after more in depth analysis or after practical experiences. The financial estimates cannot be used into building of in-depth business models and plans. Estimates based on the results can only be considered as directional and no business should rely only on these numbers.

In the business side of view, collecting the market opportunity from the respondents willing to invest into outsourcing makes a good business only based on this research. Calculating the averages of those willing to use over 1 000€ using a method where averages of each category is used (Figure 20). For example, range from 1 000€ to 5 000€ averages at 3 000€. There were three respondents willing to pay this amount. Same goes with next category averaging at 7 500€. Highest range were used with amount of 10 000€. Only by calculating these three categories and their amount of responses together totals at 26 500€ ($3 \times 3\,000\text{€} + 7\,500\text{€} + 10\,000\text{€}$). Considering this amount of revenue is possible to achieve only with five clients shows strong potential with the business side.

The highest risk and downside with agriculture in Finland comes with seasonal changes. The agriculture is season in Finland is around 6-7 months. This means there is no business in the other time of the year. Therefore, running only business where providing service for agriculture can cause harm in the business perspective. Yet, this does not mean it is not possible to operate only seasonally. As introduced in literature review, there is around 46 000 farms in Finland. Based on this study 21,7% is ready to use more than 1 000€ for outsourcing. 21,7% of 46 000 is 9 982 farms and if every one of those farms uses the average of this 21,7% groups amount of financial resources, it means each uses 5 300€ ($26\,500\text{€}/5$). This produces market potential of $9\,982 \times 5\,300\text{€}$ which equals 52 904 600€ in sales. The reliability of these conclusions is poor due to the small amount of responses to the survey, but the results support the conclusion that there is an opportunity for a viable business in the agriculture sector and the results also support the previous conclusion about the existence of market potential for drone service providers in agriculture.

5.2 Assessment of research process and results' quality

The executed research had multiple limitations that may have affected the results of the research. The first limitation is the limited base literature and research. The time and the available resources affected the research. Comparing the results for reliable data was hard due the professional market studies are not available for public. The primary data corresponded to a very small proportion of agricultural sector. It was not possible to build reliable enough research for others to base their decisions. The validity also suffers from the low number of responses. However, the research was able to follow the planned data collection and analysis methods. It would have been beneficial to gather bigger audience for the research and therefore also gather larger amount of data. Also, the questions were set to basic level due the lack of previous research. The author had no information on farmers base knowledge and therefore the study had to be made simple.

Considering the previous, no major conclusions can be drawn from the study. There are more than 46,000 farms in Finland and 23 responses to the survey are not comprehensive enough to give an accurate picture. However, the research can be utilized in future research and it provides a good basis for research. In addition, it indicates of the potential in the market, but the calculations, for example, must be considered as indicative. As such, figures and information cannot be used to set up a business or make financial decisions. Drawing such conclusions would require deeper market support and broader research findings. However, the results can be compared with future studies and used in support of other studies. the following studies will demonstrate the reliability of the research in this thesis.

5.3 Ideas for future research

This research was meant to be just a glimpse for drones in agriculture and its market potential. This research was done to act as a starting point for future research and for businesses to take advantage of it. In future more research should be done and more people working in farms should be interviewed for more accurate data. The sums and details introduced in the research cannot be fully established as they are.

In future, the business can be split in the parts to take a deeper look inside the industry and focus more on specific categories and operations. For example, only look opportunities for imaging or

for using drone for spraying and seeding. This deeper research will give more accurate data and therefore give more specific answers. Also, the economic numbers in business perspective will get more accurate and the true business potential can be found. The more accurate data reduces risks for businesses to start operating in agriculture. This study also shows that basic knowledge of drones among farmers is good. Therefore, the future studies can start investigating the phenomena deeper and there is no need to study basic things. With more detailed studies more accurate data from bigger audience can be collected.

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Appendices

Appendix 1. Survey invitation letter

Dronen hyödyntäminen maataloudessa

Hei! Olen tekemässä opinnäytetyötä, jonka aiheena on tutkia dronen hyödyntämistä maataloudessa. Tällä hetkellä jotkin tahot ovat jo ottaneet nämä miehittämättömät ilma-alukset eli dronet käyttöön. Alla lyhyt esittely dronen hyödyntämisestä maataloudessa ja sen tuomista eduista. Tämän osuuden alla kysely, jossa selvitän tilojen/tilallisten tietämystä dronen tuomista mahdollisuuksista sekä ajatuksista tulevaisuudesta. Vastaaminen vie noin viisi minuuttia. Tutkimuksen luonteen vuoksi, jotkin kysymykset saattavat kohdallanne toistaa itseään. Pyydän teitä antamaan mahdollisimman tarkat ja kattavat vastaukset.

Maanviljelijä ei aina ehdi jatkuvasti tarkistamaan koko tilaansa tai peltojen kasvutilannetta, varsinkin kevään kiireisimpinä aikoina.

Uuden tekniikan käytön tavoitteena maataloudessa voi olla tuotannon tehostaminen, ajansäästö tai paremman yleiskuvan saaminen. Tämä voi tarkoittaa esimerkiksi satokauden tehostamista, riittävän kastelun varmistamista ja salaojituksen toimivuuden tarkistamista tai kasvien kasvun seuranta. Lisäksi viljelijää kiinnostaa aina maaperän hedelmällisyyden arviointi, rikkakasvien kontrollointi tai hyönteisten ja tuholaisien havaitseminen sekä torjunta.

Ilmasta käsin alueesta luotujen viljelykarttojen avulla ongelma-alueiden tarkistus on helppoa ja huomattavasti aikaisempaa nopeampaa.

Dronea voi käyttää nykyään myös laajalti muuhunkin kuin vain peltojen kuvaamiseen/kuvantamiseen. Maailman tunnetuin dronen valmistaja on tuonut markkinoille kalustoa jolla voidaan mm. ruiskuttaa ja levittää siemeniä. Ruiskutusnopeus on jopa yli 10 hehtaaria tunnissa. Tässä linkki lyhyeen esittelyyn teknologiasta. https://www.youtube.com/watch?v=hGyLjO7KWeU&ab_channel=DJI

Kerään saaduista vastauksista aineiston, jota hyödynnän opinnäytteessäni. Saadut vastaukset tullaan käsittelemään luottamuksellisesti prosessin alusta loppuun ja alkuperäiset viestit hävitetään opinnäytetyön valmistuttua. Valmiista opinnäytetyöstä haastateltavan henkilöllisyyttä ei pysty tunnistamaan. Valmistuttuaan tutkimus on kokonaisuudessaan vapaasti luettavissa Theseus-kirjaston nettisivuilla.

Kiitos kaikille vastanneille! Jos teillä on kysyttävää, voitte olla yhteydessä alla olevaan sähköpostiosoitteeseen.

Terveisin,

Antti Simula

Jyväskylän ammattikorkeakoulu

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Appendix 2. Survey questions

Kerro muutamalla sanalla itsestäsi/edustamastasi toimijasta. (Ei pakollinen)

Oletko kuullut dronen eli miehittämättömän ilma-aluksen käytöstä maataloudessa? *

- Kyllä
- En

Onko jokin alla olevista merkeistä tuttu dronen valmistajana? (Voit valita useampia) *

- DJI
- Parrot
- VideoDrone/Nordic Drones
- Yuneec
- Hubsan
- Walkera
- Mikään näistä ei ole ennestään tuttu

Käytätkö itse tai käyttäkö tuntemasi taho dronea työkaluna maataloudessa? *

- Käytän itse
- Tuntemani taho käyttää
- En itse käytä/en tiedä tahoja joka käyttää dronea maataloudessa

Jos käytät dronea maataloudessa, miten pitkään olet hyödyntänyt ko. teknologiaa? *

- Alle vuoden
- 1-2 vuotta
- 2-4 vuotta
- yli neljä vuotta

Oletko suunnitellut dronen hyödyntämistä maataloudessa? *

- Kyllä
- En
- Käytän jo dronea maatalouden työkaluna

Drone käyttötarkoituksesta riippuen maksaa noin tuhannesta eurosta yli 50 000 euroon. Kuinka suuren taloudellisen sijoituksen olet valmis tekemään tulevaisuudessa/kuinka suuren investoinnin olet tehnyt droneen? *

- Alle 1 000€
- 1 000€-2 000€
- 2 000€-5 000€
- 5 000€-10 000€
- 10 000€-20 000€
- 20 000€-40 000€
- yli 40 000€
- En aio käyttää drone/investoida siihen
- Maksan/tulen maksamaan palvelun ulkoistamisesta

Millä aikavälillä uskot ottavasi dronen käyttöön työkaluna? *

- Vuoden aikana
- 2-3 vuotta
- Yli kolmen vuoden kuluttua
- Aktiivisessa käytössä jo
- En tule käyttämään dronea

Onko teknologia mielestäsi jo riittävää vai odotatko sen kehittymistä pidemmälle? *

- Olen tyytyväinen nykyisen teknologian mahdollisuuksiin
- Odotan, että teknologia kehittyy ennen kuin lähdän hyödyntämään sitä
- En aio hyödyntää dronea

Uskotko dronen käytön yleistyvän työkaluna maataloudessa yleisesti? *

- Kyllä
- En

Koulutus ja säädökset

Euroopan unionin asetusta dronejen käyttämisestä on aloitettu soveltaa 31.12.2020 alkaen.

Uusi dronelaki yhtenäistää droneja koskevat säädökset koko EU:n alueella. Suomalaisille dronejen käyttäjille uudistus tuo velvollisuuden rekisteröityä dronetoimijarekisteriin, aikaisemmin ilmoitusvelvollisuus on koskenut vain ammattilaisia.

Dronetoiminta järjestetään samalla eri kategorioihin, joille tulee erilaiset vaatimukset. Näitä luokkia ovat avoin luokka (open), johon suurin osa harrastajista kuuluu, sekä erityinen (specific) ja sertifioitu (certified) luokat, joita koskevat tiukemmat vaatimukset.

Nykyäädöksillä dronen lennättäminen vaatii suoritettua teoriakokeen sekä rekisteröitymisen.

Käyttökoulutuksia on vielä suhteessa vähän verrattuna alan kasvuun. Tässä luvussa tutkin tietoisuutta säädöksistä sekä koulutuksien tarpeesta

Oletko tietoinen 2021 voimaan tulleista vaatimuksista dronen lennättämiseen? *

- Olen kuullut vaatimuksista, mutta en ole tutustunut niihin
- Olen tietoinen vaatimuksista
- En ole tietoinen dronen lennätystä koskevista vaatimuksista

Oletko itse/onko edustamallasi taholla rekisteröitynyt operaattori joka on suorittanut teoriakokeen? *

- Kyllä
- Ei

Oletko kuullut dronen lennättäjille järjestetyistä koulutuksista tai osallistunut koulutukseen? *

- En ole tietoinen koulutuksista
- Olen tietoinen, että koulutuksia on saatavilla
- Olen ollut koulutuksessa

Oletko valmis osallistumaan koulutukseen itse/onko tahosi valmis osallistumaan koulutuksiin? *

- Kyllä
- Ei

Palvelun ulkoistaminen

Tällä hetkellä dronen palveluita on mahdollista ulkoistaa, mutta tutkimusten mukaan yleistä hintatasoa pidetään korkeana.

Palvelun ulkoistaminen mahdollistaa oikeaoppisen sekä tehokkaan dronen käytön, jolloin palvelun tilaajan ei tarvitse itse tutustua ja opetella dronen käyttöä. Tilaajan ei myöskään tarvitse huolehtia kaluston kustannuksista huoltoineen. Drone parhaimmillaan auttaa tunnistamaan ongelmia ja tehostamaan maatalouden tuotantoa.

Vastapuolena mukaan astuvat palvelun kustannukset, jotka ennustetaan laskevan tulevaisuudessa, kun miehittämättömien ilma-alusten käyttäminen alalla yleistyy.

Jos ulkoistaminen on taloudellisesti kannattavaa, oletko valmis ulkoistamaan palvelun täysin tai osittain ammattilaiselle? *

- Kyllä, olen valmis ulkoistamaan
- Ei, haluan hoitaa kaiken itse
- Voisin ulkoistaa osan töistä ja hoitaa itse osan

Tiedätkö toimintoja omassa toiminnassasi, jossa dronesta olisi hyötyä? Kerro lyhyesti käyttötarkoituksesta, jossa drone voisi toimia tehokkaana työkaluna

Arvio paljonko taloudellisia resursseja olette valmiina käyttämään palveluun vuodessa *

- Alle 1 000€
- 1 000€-5 000€
- 5 000€-10 000€
- yli 10 000€