Scope of Cloud Farming in Ireland

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JITHIN DAS V
10360975

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DUBLIN BUSINESS SCHOOL
Declaration

I, Jithin das V declare that this research is my original work and that it has never been presented to any institution or university for the award of Degree or Diploma. In addition, I have referenced correctly all literature and sources used in this work and this work is fully compliant with the Dublin Business School’s academic honesty policy.

Signed:                                      Date: 07/01/2019
Acknowledgments

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Thank you to all farmers who participated in the survey and special thanks to ones who helped me to find others.
ABSTRACT

The development in information technology had already influenced the different sectors and its impact on agriculture is termed as smart agriculture. The budding technologies like Big Data, machine learning with cloud computing extended the scope of smart farming which also called smart cloud farming. Smart farming is widely used in developed countries like USA, Europe Australia etc and developing countries like Israel, China, India etc. However, the adoption of this technology depends on factors like age, sex, geographic region, culture etc. Ireland had a slow growth towards smart farming despite of its great potential of being a technical hub and great agricultural dominant country. This literature review discusses about smart farming technologies and its embracement in different countries. Traditional farming is now in a transforming stage to Smart Farming. Smart Farming Technology helps farmers to increase yield and efficiency. Ireland is an agriculture-dominated country and also one of the technology hubs in Europe. It is necessary to understand the opinion of farmers before implementing any technology in agriculture. To understand the influence of Smart Farming in Ireland, a study is needed to understand the attitude and perspective of Irish farmers towards using Smart Farming Technology like Cloud Computing. The study also compares Ireland with the adoption of other countries and will suggest a way to improve from the present system. The research will be helpful for Agro-Tech companies, government, and researchers

The research followed mixed method. Data collected through survey and interview helped to find insight about reason for slow adoption of Irish farmers and compared it with other countries. It also helped to find the perception difference between farmers towards using Cloud Computing technology in their farm. The old farmers showed reluctance to using new technology but the adoption rate is good among the young farmers. Research helped to recognize the limiting factor and way to improve the adoption among farmers. The research also helped to find out the medium through which farmers can be strongly influenced. All the results are based on the data collected and conclusion made.

Keywords: Smart Farming, Smart Farming Technology, Cloud Computing, Irish farmers
Contents

List of Figures .................................................................................................................. 8
List of tables ...................................................................................................................... 9
List of Abbreviations ....................................................................................................... 10
Chapter 1 ............................................................................................................................ 12
1 Introduction .................................................................................................................... 12
  1.1. Precision Farming ................................................................................................. 12
  1.2. Smart Farming ...................................................................................................... 14
  1.3 Research Question ................................................................................................. 15
  1.4 Research Aim and Objective ................................................................................ 15
  1.5 Research Scope and Limitation ............................................................................. 16
  1.6 Dissertation Roadmap ........................................................................................... 16
Chapter 2 ............................................................................................................................ 18
2 Literature review ........................................................................................................... 18
  2.1 Agriculture Revolution: From Green to Digital .................................................. 18
  2.3 Reception of Smart Farming Technology ................................................................ 20
  2.4 Technologies Fueling Smart Farming ..................................................................... 21
    2.4.1 Cloud Computing and Decision-making tools .............................................. 21
    2.4.2 IoT in smart farming ..................................................................................... 23
    2.4.3 Field Technologies ....................................................................................... 24
    2.4.4 M2M or machine-to-machine implementation in smart farming .............. 24
    2.4.5 Robotic agriculture ...................................................................................... 26
    2.4.6 Role of Big Data in Smart farming ............................................................. 26
    2.4.7 Machine learning in digital farming ............................................................ 28
  2.5 Innovative farms in Singapore ............................................................................... 28
  2.6 Digital India ............................................................................................................. 30
  2.7 Evolution of Israel in agricultural technologies .................................................... 31
  2.8 The progress of European countries in SFT ......................................................... 33
    2.9 Researches acknowledged in EU ...................................................................... 36
    2.10 Drivers for Adoption ....................................................................................... 37
    2.11 Adoption Model ............................................................................................... 38
    2.12 Literature Contextualization ............................................................................ 40
Chapter 3 ............................................................................................................................ 41
3 Research Methodology ........................................................................................................... 41
  3.1 Research Philosophy ........................................................................................................... 42
  3.2 Research Approach .............................................................................................................. 42
  3.3 Research Design .................................................................................................................. 43
    3.3.1 Research strategy .......................................................................................................... 43
    3.3.2 Sampling ....................................................................................................................... 44
    3.3.3 Time Horizons .............................................................................................................. 45
  3.4 Data Collection .................................................................................................................... 45
  3.5 Data Analyses ...................................................................................................................... 46
  3.6 Research Ethics .................................................................................................................. 47
  3.7 Research Limitation ............................................................................................................ 47

Chapter 4 .................................................................................................................................. 48

4 Data Analysis and Finding ...................................................................................................... 48
  4.1 Survey .................................................................................................................................. 48
    4.1.1 Age, Education and farm ............................................................................................... 48
    4.1.2 Farmers attitude towards using Information Technology ............................................... 50
    4.1.3 Perception of farmers towards using cloud technology .................................................... 54
    4.1.4 Farmers technological and information seeking behavior .............................................. 56
    4.1.5 Farmers perception of CC potential to deal with challenges .......................................... 58
    4.1.6 Communication between farmers .................................................................................. 59
  4.2 Interviews ............................................................................................................................. 61
    4.2.1 Farmers attitude towards Information Technology ........................................................ 61
    4.2.2 Perception difference of farmers towards CC ............................................................... 62
    4.2.3 Farmers perception of CC potential to deal with challenges ........................................ 63
    4.2.4 Impact of CC on farmer’s role ....................................................................................... 64
    4.2.5 Barriers to adoption ...................................................................................................... 65
    4.2.6 Communication between farmers .................................................................................. 66
    4.2.7 Slow adoption compared to other countries .................................................................. 67
    4.2.8 Farmers insight on young farmers .................................................................................. 67
    4.2.9 Farmers view to improve from the present system ......................................................... 68

Chapter 5 .................................................................................................................................. 71

5 Discussion ............................................................................................................................... 71
  5.1 Determinant for the adoption of Cloud Computing .......................................................... 71
  5.2 Farmers technological and information seeking behavior ............................................... 73
List of Figures

Figure 1: Percentage of farmers who used fertilizer spreader with the precision instrument in the EU over the three years (2013, 2014, and 2015) ..........................................................13
Figure 2: M2M (Machine to Machine) platform architecture ..................................................25
Figure 3: The quantity milk yield per cow in a year over the different country ..........................33
Figure 4: The number of patents produced by different countries in the European patent office (EPO) member state in the year 2017 .................................................................35
Figure 5: Drivers of adoption - Ex-Post (source: Pierpaoli et al., 2013) ................................39
Figure 6: TAM model (source: Lai, 2017) ..................................................................................39
Figure 7: Research Onion (Source: Saunders, Lewis and Thornhill, 2015) .................................41
Figure 8: Type of farm .............................................................................................................50
Figure 9: Responses for IT in farm management .....................................................................50
Figure 10: Respondent using IT in the farm ..........................................................................51
Figure 11: Adoption of Information technology among non-adopters in future ....................53
Figure 12: Digitalizing agriculture ........................................................................................54
Figure 13: Cloud Computing usage ......................................................................................54
Figure 14: Purpose of using Cloud Computing .......................................................................55
Figure 15: IT applications in Smartphone for farm .................................................................55
Figure 16: Recordkeeping in farm ..........................................................................................56
Figure 17: Medium used by adopters for information ..............................................................57
Figure 18: Medium used by Non-adopters for information ....................................................57
Figure 19: Areas to develop the application ..........................................................................58
Figure 20: Adoption barrier ..................................................................................................59
Figure 21: Communication medium between farmers ............................................................59
Figure 22: Rating of communication .....................................................................................60
Figure 23: Information sharing with companies .....................................................................60
Figure 24: Adoption factors ..................................................................................................73
List of tables

Table 1: Advantage of the vertical farm over Conventional farm (all data from Al-Kodmany (Al-Kodmany, 2018)) ........................................... 29
Table 2: Educational Background ............................................................................. 49
Table 3: Age Group ........................................................................................................ 49
Table 4: Technology used ................................................................................................. 52
Table 5: Adopted farmers ................................................................................................. 52
Table 6: Demographic Smartphone usages in Farm ......................................................... 56
Table 7: Age, gender, Education, farm information ......................................................... 61
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>CC</td>
<td>Cloud Computing</td>
</tr>
<tr>
<td>DAFM</td>
<td>Department of Agriculture Food &amp; the Marine</td>
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<tr>
<td>CEMA</td>
<td>European Agricultural Machinery Association</td>
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<tr>
<td>SFT</td>
<td>Smart Farming Technology</td>
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<tr>
<td>GNSS</td>
<td>Global Navigation Satellite System</td>
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<tr>
<td>UAV</td>
<td>Unmanned Aerial Vehicle</td>
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<tr>
<td>RFID</td>
<td>Radio Frequency Identification</td>
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<tr>
<td>FMIS</td>
<td>Farm Management Information Systems</td>
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<td>CSA</td>
<td>Climate Smart Agriculture</td>
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<td>NDFT</td>
<td>National Digital Farming Test Bed</td>
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<td>TAMS II</td>
<td>Targeted Agricultural Modernisation Scheme II</td>
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<tr>
<td>TAM</td>
<td>Technology Acceptance Model</td>
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<tr>
<td>IoT</td>
<td>Internet of things</td>
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<td>PF</td>
<td>precision Farming</td>
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<td>PA</td>
<td>Precision Agriculture</td>
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<td>SFT</td>
<td>Smart Farming Technology</td>
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<tr>
<td>EPRS</td>
<td>European Parliamentary Research Service</td>
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<td>IFA</td>
<td>Irish Farmer Association</td>
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<td>ICT</td>
<td>Information and Communication Technologies</td>
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<td>Agtech</td>
<td>Agricultural technology</td>
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<td>R&amp;D</td>
<td>Research and development</td>
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<td>SF</td>
<td>smart farming</td>
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<td>FBN</td>
<td>Farmers Business Network</td>
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<td>WSN</td>
<td>Wireless sensor network</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<tr>
<td>GIS</td>
<td>Geographical Information System</td>
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<td>UAV</td>
<td>Unmanned Aerial Vehicle</td>
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<td>Acronym</td>
<td>Description</td>
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<tr>
<td>VRT</td>
<td>Variable Rate Technologies</td>
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<td>MVNO</td>
<td>Mobile Virtual Network Operators</td>
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<td>RFID</td>
<td>Radio Frequency Identification</td>
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<td>PM</td>
<td>Process-Mediate</td>
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<tr>
<td>MG</td>
<td>Machine Generated</td>
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<td>HS</td>
<td>Human Sourced</td>
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<td>ANN</td>
<td>Neural Network</td>
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<td>SVM</td>
<td>Support Vector Machines</td>
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<td>DL</td>
<td>Deep learning</td>
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<td>EPO</td>
<td>European patent office</td>
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<td>Germany</td>
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<td>4IR</td>
<td>Fourth Industrial Revolution</td>
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<td>United Kingdom</td>
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<td>AK</td>
<td>Austria</td>
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<td>IFCN</td>
<td>International Farm Comparison Network</td>
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<tr>
<td>EPRS</td>
<td>European Parliamentary Research Service</td>
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<tr>
<td>CEMA</td>
<td>European agricultural machinery</td>
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<tr>
<td>FDI</td>
<td>Foreign Direct Investment</td>
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<td>ASEAN</td>
<td>Association of Southeast Asian Nations</td>
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<tr>
<td>AVA</td>
<td>Agri-Food and Veterinary Authority</td>
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Chapter 1

1 Introduction

The change in agriculture after the advancement of cloud computing technology is inevitable and shows bright scope in future. Cloud computing is the technology to connect many IT backend tools such as network, storage space, server space and other services to people with the help of internet connectivity, such that it is independent of the resource and location (Mell (NIST) and Grance (NIST), 2011). The sectors like the retails, hospital, education, software, pharmaceuticals, banking, etc. make use of cloud technology. However, with the development in the IoT (Internet of Things) and Big Data made the cloud technology to be adopted efficiently in the agricultural sector. According to Goraya and Kaur (2015), cloud technology is capable of storing a large number of databases, a database about farming may have information about various farming practices, crop information’s, pesticide, fertilizer, etc that help farmers in decision making procedure (Goraya and Kaur, 2015). This concept brings the idea of cloud farming. The smart cloud farming plays an important role as a decision supporting tool that guides the farmers to take more effective farming decisions that will be beneficial for the farmers and the industry.

The change from the traditional workflow of managing farm to closely monitor the crop, animal, and land precisely by identifying the temporal and spatial variability is called precision farming. In precision agriculture, the land managed by location and smart agriculture is an extension to the precision farming, it uses farm data and position for better management and helps to carry out real-time events in the farm (Sundmaeker et al., 2016). Outstanding development on the Internet of Thing and Cloud Computing (CC) technology propelled Smart Farming (Wolfert et al., 2017). Teagasc Technology Report 2035 termed agriculture using Cloud technology as farms in the cloud, Teagasc report called Smart Farming as “Farms in the cloud” because with the current technology available a farm can run in the real time with the help of data and algorithm (Teagasc, 2016).

1.1. Precision Farming

At present precision farming (PF)/precision agriculture (PA) is leading the world. A study conducted by the European Parliamentary Research Service (EPRS) states PF as a method to enhance and track the production process in agriculture using modern digital techniques (EPRS, 2016).
Farmers in the USA show great interest in using precision technologies. More than 80% of farmers use GNSS technology in USA (Brewster et al., 2018). Other than the USA, developed countries like Canada, Australia and European countries like Sweden, Denmark, Finland, and Germany show progressive usage of precision technology (Say et al., 2018). Analysis of the use of machinery for agriculture in the market in Europe shows 70% of machinery for different operation uses smart technology (Say et al., 2018). However, EPRS (2016, p. 37) proclaimed that beside the availability of a wide range of PF technique only 25% of farm in Europe utilizes PA technologies. According to European agricultural machinery (CEMA) (2016), PA is set to have become more trending among farmers by 2030, however, overall adoption of precision technology in Europe (35%) seems to be very low. Figure 1( all the data obtained from CEMA (CEMA, 2016) ) represents the uptake of Ireland on the use of fertilizer spreader with a precision instrument which seems to be very low over the years from 2013 to 2015 compared to other countries.

![Figure 1: Percentage of farmers who used fertilizer spreader with the precision instrument in the EU over the three years (2013, 2014, and 2015).](image-url)
1.2. Smart Farming

Beecham report says that smart farming needs to be advanced to meet the growing need of foods by consumers (Gorli and Yamini, 2017). Saverio Romeo, Beecham chief research officer, says that the UN evaluated that there ought to be an expansion of 70% of the production of food by 2050 and furthermore, for the sustainable use of crop in enhanced way Beecham report suggest farming should start accepting Smart Farming Technology (SFT) (Scroxton, 2017). The acceptance of smart farming in agriculture varies globally. SMART AKIS report states that uptake of Smart Farming Technology (SFT) in Europe is comparatively lower than that of America. However, the report also says that the adoption of SFT is more in countries like the UK, Germany, and Netherlands [9]. According to CEMA (2017), *Digital or smart farming is a technology that makes utilization of PF innovation and furthermore it makes use of data management tools and intelligent networks*. Smart Farming with the help of cloud computing is known as Cloud Farming or Farms in the cloud.

Irish agriculture dominated by grass, 163000 people working in this sector accounting 26-billion-euro turnover in a year. According to the Department of Agriculture Food & the Marine (DAFM) food wise 2025, Ireland have great opportunities in the global market due to its reputation in sustainable agriculture production and its potential in foreign direct investment but financial competitiveness, lack of skill are limitation faced in escalating the dairy, meat, poultry, and fishery farm (DAFM, 2016). Teagasc (2016, p. 9) reports that the agro-food sector is the Irelands largest native industry that has a turnover of more than €10.8 billion in the year 2015. Moreover, Dairy farming is the most profitable sector in Ireland. Due to a large number of small producers and part-time farmers, the uptake of innovation and technology is very low (Teagasc, 2016, p. 12).

WIT President and TSSG founder Prof Willie Donnelly said in an interview that increase in demand of food and developed ICT technology and a multinational company like Google, Amazon, IBM, etc make a great scope for Ireland in smart agriculture. According to him, Smart farming is a combination of ICT and farming, by utilizing cloud computing technology along with data analytic tools for managing complete production of Food (siliconrepublic, 2015). Interestingly, association like Irish Farmer Association (IFA) had introduced an efficient program known as “SMART FARMING,” which not related with smart farming technologies (SFT) but it deals with efficient techniques for sustainable farming for farmers in Ireland. The recent 2017 report conveys that farmers followed under this program had
made a profit of average €8,700 and also helped in reducing the overall carbon emission by 10% (IFA, 2017). However, beyond the implementation of such program, the adoption of Irish farmers towards sustainable farming and smart farming technique is uncertain. Recently Mike Brady (2018), managing director at Brady Group agricultural consultants and also a journalist of Farmireland.ie said that, still a major portion of full-time farmers is reluctant to adopt new technology and the uptake is, even more, less among the part-time farmers.

The above introduction gave a brief idea about digitalized agriculture, its adoption rate in different part of the world and also Ireland. However, there is no exact statistics available for adoption in SF in Ireland, but reports, as mentioned above, shows its uptake is low. The whole thesis will give much detailed information about SFT and its adoption. More informations about the research is shown in “Dissertation roadmap.”

1.3 Research Question

The research question is “why Ireland is slowly advancing towards adopting the concept of smart farming within their farming process?”

Ireland as a whole shows little interest in adopting SFT in their farm. However, adoption of SFT is progressive in some of the developed European countries as mentioned in the introduction and also in countries like Singapore, Israel, and India which will discuss in the Literature review session. The research question aims at answering “Why Irish farmers are slowly advancing towards adopting the concept of smart farming Technology within their farming process compared to other countries.”

Secondary question

The research also aims at answering “What is the perception difference between adopters and non-adopter farmers in Ireland towards using Cloud Computing in the farm.” The research will also find out the perception difference between farmers which would help to analyze more insight into the perception of farmers.

1.4 Research Aim and Objective

The primary aim of this research is to find the disparity for slow adoption to Smart Farming Technology (SFT) in Ireland. However, the literature review would explain the usage and government policies in different countries to encourage SFT among farmers. Similarly, research also aims to find the approach and understanding of Irish farmers towards CC in their farm.
The objective is to find out

- Driving factors that lead to adoption for farmers
- Usage of CC technology among Irish farmers
- The scope of CC in Irish farm
- Methods to increase adoption
- Information is seeking platform and communication channel of farmers.

1.5 Research Scope and Limitation

The research will have a scope on determining the factors responsible for the slow adoption of SFT in Ireland and also helps to understand the attitude and perception difference between the adopters and non-adopters of SFT in Ireland. The study will be a benefit to Irish agribusiness sector, such as researchers, Agro-tech companies, government, etc.

The main limitation for the research is to find the farmers specific for the research and the degree of cooperation of farmers with the research. The lack of journals on the Smart Farming Technology among farmers in the Irish context is another limitation to be faced in this research.

1.6 Dissertation Roadmap

The research paper divided into different chapters. Chapter 1 start with an introduction explaining the facts and details of the research is explained, followed by research question and its details. Other than this chapter also includes research aim, scope, objective and limitation.

Chapter 2 discuss with the literature review supporting the research. It explores different SFT available and its adoption in different countries, drivers for adoption of technology among farmers and also introduced an adoption model useful for the research.

Chapter 3 explains the complete methodology of the research. Such as philosophy, strategy, approach, data collections are explained. It also explains the structure of the interview and questionnaire, ethics and limitation in detail.

Chapter 4 detailed the data obtained from primary research. All the data obtained by survey and interview divided into themes for the better understanding of the data received.
Chapter 5 will include all the discussion based on the data received from the previous chapter 4, and further divided into segments for better understanding.

Chapter 6 will have a detailed conclusion connecting the discussion and finding with that of the research question and also the objectives of the research with the future recommendation.
Chapter 2

2 Literature review

Literature review helps the reader to understand the research done by others that are similar to the proposed study and will help to aid the current study. Organize the literature in such a way that it discusses the topic from a broader section to a specified part of the study. The literature review identifies the problem in previous work, criticize it, and make a connection with the relevant research study. Literature section can also include an article or concept of previous work done by other (Creswell and Creswell, 2018, p. 25).

2.1 Agriculture Revolution: From Green to Digital

Agriculture is changing over the year by generations. A remarkable evolution noticed in agriculture during the first and Second World War known as machinery revolution, where new machinery introduced for agricultural practices. It was in the late 1990s where the yield of agriculture raised with the help of science, and it was the green revolution era in agriculture. However, development in technology is now shifting the agriculture to a new age of digitalized revolution (AFI, 2016). The Organization for Economic Co-operation and Development (OECD, 2018) defined Digital technologies as progress in the management of digital content with the help of information and communication technologies (ICT) such as the internet, data analytics, mobile technologies, etc. The innovation in technologies such as satellite crop sensing, machine learning, automated farming, sensors, and advanced software for analytics will be supportive for developing an enhanced version of agriculture in the more sustainable and productive method.

World Government Summit (2018) reports that demand for food had raised globally due to demographic issues. The report also says that there will be more consumption on animal protein due to change in lifestyle and urbanization. According to the Food and Agriculture Organization of the United Nations, agricultural output must increase to 70% by 2050 (FAO, 2009). Growing demand for food and hassled natural resources stipulate high yield of agriculture production sustainably. The World Government Summit report (CLERCQ, VATS and BIEL, 2018) says that it is critical to update the old technologies existed in agriculture and more new technologies should be generated to manage this issue in the coming days. The digital agriculture will make farms run with advanced technologies like sensors, robots, aerial
images, etc. The report also suggests that technological advancement in agriculture should be progressive enough to meet customer needs (CLERCQ, VATS and BIEL, 2018). Modernization had helped agriculture to boost precision and smart techniques in the farm. PA is generally known as the next version of agriculture. This concept started growing when GPS is made available for the public. The idea is to make ample condition for an individual plant or animal to grow instead of treating with the help of technologies such that increasing the yield with less input and more profitability. PA was a possible solution for monitoring, managing, guiding and sensing of farm and farming related machine (CEMA, 2017). According to European Committee of Agricultural Machinery Manufacturers Associations (2017), the development and availability of cheap sensors, Big Data analytics, fast internet, and cloud computing had helped in increasing the possibility of precision agriculture. This phase of agriculture enhanced the data algorithm for farm process management and will help farmers in observing every operation of their farm from one place from one or many sources.

Even though both types of farming use technology for its yield, the common difference between them is minor but its noticeable, PF focus more on a specific controlling of farming using the precise equipment’s like tracking the animal using self-operating machines, observing the soil using sensor technologies and differentiating a farm using temporal and spatial differences etc. Smart farming which is also known as Digital farming not only use the precise equipment’s. It collects all data from the machines used in farming and makes them communicate with each other. It produces a real-time data to the farmers in a more organized way using the mobile phones or tablets, such that farmers can access information of all farm operation from a single point and even have the flexibility to choose the devices for various operation depending on their efficiency (Giesler, 2018). Globally there is a huge rise in the trends of the smart-farming market. The report from StratisiticsMRC (Reuters, 2018) supports the current shift, as per the report the digital agriculture market is now $5.77 billion in 2017 and is expected to climb $18.81 billion by 2026, accounts a Compound Annual Growth Rate of 14% during the period. Population growth, rising demand for food and shortage of land is the main forceful factors for this inclination besides that advancement in technology leads to profitability and productivity. The low cost of cloud services, sensors and other smart farming technologies (SFT) and increasing government assistance towards encouraging smart farming is also the reason for its market growth (Reuters, 2018).

Even the trend is visible in the global companies shifting their interest towards the agriculture with the development of digital technologies. Corporate like Bill Gates and Richard started a
company that can grow “clean meat” and Investment of IKEA David Chung in vertical farming shows the future trend of companies growing interested. Moreover, statistics show an 80% growth in Agricultural technology (Agtech) companies’ from the year 2012 to 2015 (CLERCQ, VATS and BIEL, 2018). According to a report from Joint research center of European Commission (ZarcoTejada, Hubbard and Loudjani1, 2014) More than 68% of cases show that use of precision technology is profitable; Most of the farmers need to reduce the cost without affecting the production in the competitive economy. The introduction of information technology in PA enhanced the optimization and quality of farming. Moreover, it also helped in controlling the environmental impact like eutrophication, carbon emission, etc.

2.3 Reception of Smart Farming Technology
Digitalizing agriculture would help farmers in a remote area on accessing information regarding farming extension and advises. It was difficult for them before due to the expenses. Furthermore, it allows farmers to get connected with suppliers, identify the input cost and appropriate technique for their farm and quality of production. This attribute helps the secluded farmers to unite in the live market and increase the quality of life which would be supportive for farmers in developing countries (OECD, 2018). The perception of smart farming technology varies in developed and developing countries. The report of the Australian farm institute (2016) says that deploying smart technology and Big Data usage in farming in the USA is relatively high especially in the crop sector, report says that more than 40% of the corn farmers in the USA produce 70% of the production with the help of digital technologies in farm (AFI, 2016).

According to Say et al. (2018), USA is one of the leading countries having high innovative technologies, apart from USA other developed countries like Canada, Australia and some European countries like Germany, Denmark, Sweden and Finland have some level of adoption to PA technologies. The author states that similar kind adoption trend seen in some of the developing countries like Argentina, Brazil, Turkey, and South Africa. According to Leonard (2014; Say et al., 2018) says that more than 80% of farmers in Australia use automatic guidance and Steele (2017) reports that also 98% of farmers in Western Canada uses the GPS guidance (Steele, 2017; Say et al., 2018). The countries that invest more in Research and development (R&D) in smart farming (SF) are found to have more publications. The countries like the United States, Germany, Japan, and South Korea lead the list in their contribution towards SF research by investing more in R&D. Furthermore, the
developed countries are more inclined towards implementing scientific creation due to their high investment in R&D (Pivoto et al., 2018).

The situation in European countries is different from others developed and developing countries. Smallholder farm dominates EU farm and interestingly farm size of Europe is much smaller than the US and Australia. Moreover, the growth of farm size in Canada, Argentina, and New Zealand is higher than EU farm. Although there is an increase in the use of precision technologies by among smallholder farm, CEMA report states that only 25% of EU farmers are accessible to precision technology. In addition to it, the report also suggests that ignorance of smallholder farmers in the EU region regarding the uptake of precision technology would affect them in competing against countries like Canada, Argentina and New Zealand (E. A. M. A. CEMA, 2017).

2.4 Technologies Fueling Smart Farming

2.4.1 Cloud Computing and Decision-making tools
Cloud computing is the technology that connects different datacenter or servers with the help of internet such that it can be scalable, secure, fast and redundant. The computational and scalable feature of cloud helps to control equipment connected to it without any human touch. Agriculture can utilize this technology to store the data in a centralized location. Several new app and software are developed that can run in any platform such that it helps farmers in deciding on various activities such as herd management, usage of fertilizers and pesticide, feed for animals, moisture and temperature of the soil, etc. The conventional software had helped farmers in the business activities. However, with the help of new technologies integrating a large number of data generated from different sources in agriculture help in building software with decision-making capability for the farmers (Es et al., 2016). Farm Management Information Systems (FMIS) are software tools that used to collect farm data and process it for decision making, and the results would be helpful for farmers. The fields they best used are field operation management, herd management, yield estimation, machinery maintenance, human resource management, etc. However, most of the farms in Europe are small that make FMIS adoption slower (Brewster et al., 2018).

Kaviya et al. proposed working system architecture for cloud computing (2017). According to the architecture, the cloud computing technology will keep the records of data obtained from some sources from the farm regarding fertilizer used in the plant, its environment,
prevent disease, etc. Electronic file Storage for recording information. When any consumer searches for the details, the user will find the necessary details of the plant in the database through the network and help them in reaching a decision process. Pattern identification technology is the technology used by cloud computing to identify the growth of the plant, and with this technology, anyone can monitor the growth of the plant (Kaviya, Vigneshvwaran and Leela, 2017).

Besides the conceptual framework, some companies do business with the help of cloud technology in farming. Farmobile is one such company that makes money with agronomic data of growers. There will be a definite subscription fee for the users annually; however, the farmer who shares their data in this platform will get a reward on 50% of their income originated by selling data. Moreover, Farmobile standardizes the data of each farmer who shared their data for easy access to users. Similarly, Farmers Business Network (FBN) is another platform with Google Ventures. FBN helps farmers in seeking information regarding seeding. Currently, FBN had collected data from more than 7 million acres of the farm across 17 states. They have information regarding more than 500 crops. FBN is a network shared among a community of farmers and subscribers who can access the network with a small annual fee (EPRS, 2016).

Interestingly the green revolution after the world war second marked the use of nitrogen fertilizer in the field which in turn helped farmers in increasing the production and profit but this had a devastating impact on the environment like an increase in greenhouse gas emission, lack of oxygen in water affected the aquatic life and it started degrading the water. After the arrival, new technologies like improved computing and data model helps to reduce the usage of nitrogen in the field. Farmers were not sure about the amount of nitrogen to be used in the field before but after the development of cloud-based nitrogen usage service in the field helped farmers in not using excessive nitrogen in the field. The scalable feature of the cloud-based services helped in determining the precise amount of nitrogen needed for each crop in the field (VAN ES and WOODARD, 2017).

Recently, Keenan system executive chairman Gerard Keenan told that there is a great scope of Agtech companies. He also said that “There is an emerging revolution going on in Ireland right now.” According to Gerard, development of cloud computing technology boosted the Agtech companies. He added that before the development of cloud technology they used to have a smart box that needs manual handling to transfer the data with the help of a memory
stick. However, after implementing this technology in his ecosystem, there is no human interaction needed, and he can monitor and identify the data without asking the customer who can help them and vice versa (Independent, 2018).

2.4.2 IoT in smart farming

IoT or Internet of Things means any devices that can send or receive data and get connected to external network or devices or any application. An IoT device can be of any form it ranges from sensors to wearable watches. The IoT devices have an interface of sensor I/O, storage, Audio, and video interface. Agriculture utilizes IoT for various purposes like managing the water for irrigation, observing the soil, temperature, pest, and weather in the farm (Nayyar and Puri, 2016).

The small size of sensor nodes helped to extend its application in agriculture. Sensors help to know the environmental parameters that are useful to schedule the irrigation, spray pesticides, etc. The information from the soil helps to know the need of water and type of crops to be planted. Rehman (2015) discussed the automated network-based irrigation system with smart technology. It consists of sensors that can monitor the temperature, humidity, and moisture in the soil and leaf wetness. It also has a module where it can communicate with the sensor and send the information to a long distance through wireless. The software unit has the data information from this board and can be accessed by farmers in the PC using the software. The sensor checks the soil on a timely basis, and an alarm will be activated if the water content is low such that water can be sprayed in a timely and optimized manner (Rehman, 2015, p. 15).

Cloud IoT platform help farmers in preventing the disease from crops. The sensors in the field integrated to give the information regarding the weather such that decision support system integrated into the cloud platform help in minimizing the treatment product to be used in plants and make it more effectively based on the historical data comparison. Foughali et al. proposed a working model for detecting the “late blight” disease in plants using IoT platform. This work model consists of sensors that integrated on the different plants and a cloud server to store the different parameters like humidity, temperature, etc. When any signs of this disease noticed at the early stage on plant an SMS will be sent to farmers mobile, increase the efficiency of this model by more aerial images using IoT devices (Foughali, Fathallah and Frihida, 2018).

According to Anthony King (2017), there is an app that can measure the growth rate and quality of fruit with the help of photograph and it is made possible with the help of sensor
implemented on the fruit. Richard Green, an agricultural engineer at Harper Adams University, says that there are drones equipped with RGB camera that are capable of identifying the pest and monitor the growth of crops in the farm (King, 2017). A data analysis company for agriculture called Agribotix in Boulder, Colorado developed drones that provide infrared images of the field that can identify pest and issue in irrigation with the help of their machine learning used in software (King, 2017).

2.4.3 Field Technologies
The technology such Global Positioning System (GPS) is a US unit and its access to the public made the growth all over the world (CEMA, 2017). The improvement in sensor technologies had made PA possible, and the use of Global Navigation Satellite System (GNSS) helped in making more precise. The PA technologies controlled traffic farming, and the auto-guiding system proved very successful in large farms of Europe, USA, and Australia (ZarcoTejada, Hubbard and Loudjani1, 2014).

Technologies like autonomous vehicle are broadly categorized into a vehicle that runs on the field mounted with equipment to monitor and an aerial system like drones vehicle that runs above the field and help in analyzing the field with photographs (EPRS, 2016). The development of Unmanned Aerial Vehicle (UAV) or Drones had a great scope in farming. Its used in virtual fencing, herd management and can even check the state of crops (Walter et al., 2017). According to the PWC report, the current market for drones used in agriculture around the globe stands at $32.4 billion. Unmanned Aerial Vehicle Systems International Association states that usage of drones in agriculture would increase to 80% across the globe. However regulation plays a barrier to the adoption of drones especially in Europe (PWC, 2016; EGSA, 2017).

Variable rate technologies or VRT used for a different application depend upon the choice of a plant in the field (E. A. M. A. CEMA, 2017). According to Es et al. (2016), VRT technologies further divided into a map based and sensor based. Map based VRT functions on the previous map of the field that having information regarding soil sampling, temperature, etc. whereas sensor-based VRT had no such mapping instead of the sensors used to collect the data timely from the field and it acts according to the need.

2.4.4 M2M or machine-to-machine implementation in smart farming
M2M implementations in smart farming of agriculture industry allow farmers to remotely calculate the condition of the soil, equipment monitoring, weather tracking, and evaluation of
the health of livestock and crops, with the help of computers, mobile phones, and other devices. In the M2M esteem chain, the partners involve module sellers, network suppliers, M2M stage and application suppliers, gadget stage suppliers, versatile administrators, aggregators and Mobile Virtual Network Operators (MVNOs). The module fixed on any material will send information with the help of network suppliers and is data collected by application supplier makes the data possible to be visible in any platform to the end users that include farmers, agribusiness and cooperative who make the decision process accordingly (GSMA, 2015). Figure 2 is a combined structural design derived from architecture proposed by the Global System for Mobile Communications (GSMA) intelligence (GSMA, 2015) and Hindustan Computers Limited (HCL) (HCL, 2011).

Implementing cloud computing in the M2M architecture will assist in collecting huge data for the operation in farming and can run the application in the cloud platform with fewer resources in less bandwidth. Moreover, the speedy response in the cloud platform will help to
save the time and cost of the end user (Abraham, 2016). Companies like Moocall had developed an IoT sensor tagged to livestock that is pregnant such that it gives timely information like temperature, heartbeat, etc. with the help of its embedded M2M chip. Similarly, there is another cloud-based observing application called Cattle Watch that helps to recognize the position and movement of every livestock (Guerra, 2017).

**Radio Frequency Identification (RFID)** is technology such that a tag mounted on the ear of animals helps in receiving data that include information about the temperature and weight of the animal and make it easy to monitor the animal. This tag also plays a significant role in automatic robotic milking and feeding system (Es et al., 2016). Many usages of RFID technology is observed in Central and Northern European countries like Germany, Denmark, and Sweden, etc compared to developed countries like Ireland, UK, France, etc (Bach, Zoroja and Loupis, 2016).

### 2.4.5 Robotic agriculture

The OECD (2018) states that robots help farmers in increasing productivity and alter the work with the help of sensors and act as an extended eye to farmers. Its application can be used in automatic milking in the dairy industry and harvesting in vegetable production (OECD, 2018). At the farm level, the robotic application is mostly utilized in automatic milking although the adoption towards this practice is low. However, a recent report from EU foresight states that more than 50% of the farm will insist on robotic milking in their farm (UKRAS, 2018). On the other hand, a recent Teagasc Foresight Report 2035 states that uptake of robotic milking in Ireland is low due to the cost and complexity of equipment (Teaagasc, 2016).

Es et al. (2016) pointed out the application of robots in an electronic feeding system where the machine helps to analyze the breeding, and it separates the animal from the other. Furthermore, it also feeds the animal by the data collected from an individual animal (Es et al., 2016). However, AFI (2016) says that automated milking helps in saving time, labor and cost and farmer can concentrate to another area in the farm.

### 2.4.6 Role of Big Data in Smart farming

There is a large number of data received from various sources such as the Internet, IoT sensors, etc and need a platform to combine them and convert to predict the behavior, outcome, dependencies, and relationship between various factors through a platform known as Big Data. This combination of data will help in building a decision-making model (OECD,
According to Wolfert et al. (2017), the role of Big Data in SF is still in the development stage. He also pointed out the challenges and classified into technical and organizational. Encouraging the application of Big Data in SF would bring more business opportunities, and it can overcome most of the technical confront. Data privacy is another challenge for implanting Big Data in SF (Wolfert et al., 2017).

According to the report of Devlin (2012) data generated in the field is grouped into three

a) Process-Mediated (PM) – It refers to the data of various process in agriculture such as information about fertilizer, spray, data related to purchase, transaction, seeding, etc. However, most of the data will be in a structured form. According to Schönfeld et al. (2018), Big Data helps the farmers to use the precise amount of fertilizers, water, pesticides which also helps in reducing their adverse environmental effect.

b) Machine Generated (MG) – This includes data generated from many sensors such as aerial images from drones, data from Unmanned Aerial Vehicle (UAV), information from IoT sensors, data received from robots. Moreover, the received data can be in audio or visual which is an unstructured form of data (Wolfert et al., 2017).

c) Human Sourced (HS) – HS include data that is already collected or recorded by humans in the form of a written book, art, video or audio related with smart farming which is made available on the internet (Wolfert et al., 2017).

Schönfeld et al. (2018, p. 115)Companies like Mosanto are utilizing the possibilities in this area by collecting and processing the data and help in decision-making process such as best fertilizer to be used and expected production at the end of the year with the help of collected data and their comparison. Such companies are not only helping farmers but in turn, making business with the help of analyzing and selling of collected data.

The data from IoT devices used in agriculture is connected internally using wireless technology. Collected data is load into a centralized system controlled by a software which is very difficult but companies like Intelligent Wireless Network solves this problem by creating specific WLAN in agriculture such that data are automatically collected into a centralized system without the help of any human effort. However, these data have to be converted into usable form companies like On-farm, Mosanto, etc created a cloud-based platform where farmers can easily access any information regarding the farm. Moreover, data that can be accessed by the public is used by companies like Climate corp that make use of
Big Data technology and help farmers to give real-time information (Faulkner and Cebul, 2014). Steve Lock, the developer of GrassOmeter, says that Big Data is significant in agriculture. Steve added that he would implement the application of Big Data in his device in future and the data generated would be helpful for fertilizer and seeding company in Ireland(Independent, 2018).

### 2.4.7 Machine learning in digital farming

Progress in technologies like Big Data and machine learning had transformed the digital world of agriculture into a more data-intensive sector. Machine learning can be defined as the analysis of data by machines and predicting an optimal output without the help of external programming code (Liakos et al., 2018). The UKRAS (2018) states the importance of machine learning in robotics. According to the report, the challenge in machine learning is the learning capabilities of the machine without any supervision like open-ended learning; for example, the machine should be able to learn the new seasonal change, pest, disease, etc in the field.

Deep learning (DL) in agriculture helps to identify the dependent factors for different species of plant and animals with the environment. It is almost impossible to build a structured model for monitoring the animal-plant, and environmental factors and deep learning would help agriculture in such a situation (Nanyang Zhu et al., 2018). In coming days, it would help to determine the metals in the soil and would help to determine the type of plant appropriate for that soil to grow crops (RIRDC, 2016). The application of DL in smart farming machinery would help to build more precise equipment, for instance, a robot that could pick an apple at its ripening stage which needs a lot of data set learning before to come into conclusion. Furthermore, DL would also help to optimize the production system of agriculture in determining the price of an agricultural product which would be very helpful for the farmers (Nanyang Zhu et al., 2018).

### 2.5 Innovative farms in Singapore

The PWC report Singapore as the only ASEAN country that receives more than 60% of the FDI. However, Singapore is one of a developed country in Asia stands first in technological readiness among the other countries (PWC, 2018). Report means that there will be greater adaption of technology and automation in different sectors of Singapore. This progress in innovation helped Singapore in embracing Sky Green, an innovative farming technique. Sky Green is vertical farming usually followed n the country having less amount of land for
agriculture. In this plants are stacked in the vertical base of building in urban areas. The conducive ambiance is made to help the plant grow like LED for sunlight, automatically controlled water spray to plant, etc. Sky green is the company that looks after vertical farms in Singapore. The sky green started in an open area in Singapore in the year 2011, and it makes a yield of 800kg of vegetable from 1000 towers (Seignette, 2016).

<table>
<thead>
<tr>
<th>Factors</th>
<th>Traditional Farming</th>
<th>Vertical Farming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land usage</td>
<td>Minimum farmland (&gt;=5acre) depends on the type of crops used</td>
<td>One vertical farm is equivalent to 480 conventional farms.</td>
</tr>
<tr>
<td>Water</td>
<td>Need more water</td>
<td>Only 10% of water used in Traditional farming</td>
</tr>
<tr>
<td>Electricity</td>
<td>More Consumption</td>
<td>68% efficiency LED light cut overall cost</td>
</tr>
<tr>
<td>Yield</td>
<td>Limited crop rotation per year</td>
<td>Maximum crop rotation per year</td>
</tr>
<tr>
<td>Technology</td>
<td>Integrating technology is hard</td>
<td>It can be fully controlled, monitored and automated.</td>
</tr>
</tbody>
</table>

Table 1: Advantage of the vertical farm over Conventional farm (all data from Al-Kodmany (Al-Kodmany, 2018)).

The Agri-Food and Veterinary Authority (AVA) of Singapore worked with farmers for embracing innovative technologies in the field. AVA urges farmers to join agricultural productivity fund which help farmers obtain 30% discount on any precision technologies using in their farm. The collaboration of researchers, practitioners and policymakers play a significant role in transforming the farmers. AVA encourages citizens to buy domestic agro products to encourage the farmers. AVA also facilitates an account manager for every farm to give them guidance on technology adoption, financial and trade (Huimei, 2017).
2.6 Digital India

GDP of developing countries like India is growing at a rate of 2% per annum which is more than the developed countries states in the report by OECD-FAO. India is a dominant agriculture country, and more than 56% of people depend on the farming sector. Interestingly, India being a developing country stands second in the world for agriculture output, and India had turned from an agriculture importer to exporter. According to the author, there is a major shift in Indian agriculture towards adopting modern technology (ICRISAT, 2016). There is a great inclination towards agriculture by startup companies of India is seen over the years, and it is estimated that by 2022 the precision market interest would grow globally by a rate of 13.09%. The USA has its dominance over embracing new technologies. However, It is predicted that precision market growth in China and India would reach 18.09% in the year 2022 (Seth and Ganguly, 2017).

The technology adoption in a developing country would be difficult in a country like India where most of the farm is smallholder which is less than 2 hectare. Precision technology adoption in smallholder farms will be hinder if farmers and stakeholder don’t have enough qualification. Different methods should be implemented by the authority for embracing the technology and make aware of people. Tata Kisan Sansar network train the farmers with new precision techniques and all the farmers engaged with this program obtained GIS data without any fee. The farmers getting a good yield in their farm through this program are honored by prizes from the company Tata (Kaka et al., 2014). According to the 2015-16 agriculture report from Government of India (2016) communication problem was a major factor in passing new information among the farmers. However, the usage of mobile changed that differentiation existed before. The mKisan portal of government connected many farmers. Through this program, farmers are free to ask any question related to technology and information regarding crops.

Moreover, through this portal, the authority can send information to consents in their native language through SMS. Over 1.6 crore farmers were registered through this program. In 2016 the government launched two mobile application named Agri Market and Crop Insurance. The former helps farmers to keep update about the market prices and help them to take a decision whereas latter deals with premium amount and loan details regarding with any crop (GOI, 2016).
The report by Kaka et al. (2014) knows as “India’s technology opportunity: Transforming work, empowering people” conveys a scheme followed in Uganda known as The Grameen Foundation. Under this scheme, an individual is selected from a region who well knows with others and moderately skilled. The selected representative is trained on using the smartphone and app that can be helpful to farmers and these individuals are sent to the field for teaching others. The report states that this scheme was successful and attracted many farmers in using new technologies in the farm (Kaka et al., 2014). The “uberization” culture in farms of India proved revolutionary and was widely accepted by farmers. The M&M(Mahindra & Mahindra) company had developed an app known M&Mtriango that help farmers to take tractors and farm equipment for rent and would be helpful for smallholder farmers who doesn’t want to invest high cost instead pay for service scheme. Digital technologies usage in farms attracted many startups like Stellapps Technologies who provide service to smallholder dairy farmers for optimizing and monitoring dairy farm. The Big Data, IOT, cloud, data analytics are used by this company to help farmers with enhancing milk production, Insurance to animals, payment by farmers, etc. there are companies like Agnext who develop drones and sensors in India for farming with the aim of collecting the data from the farm. The main barrier for startups before was financed, but Startup India scheme from the government had attracted and encouraged many new and young entrepreneurs (Seth and Ganguly, 2017).

**2.7 Evolution of Israel in agricultural technologies**

According to IIA (2016), Israel evolved as a leader in the innovative technologies in the world. The country stood out and emerged as an example of developing and developed countries. The improvement in ICT technologies of Israel had attracted much foreign investment in the country. The competitive advantage of Israel in bringing ICT in agriculture had made Israel grow its interest in smart technologies (IIA, 2016). KPMG (2018) reports says that Israel had emerged as a role model country globally. It is possible because of the talent and culture of people especially farmers in Israel who are ready to work with new innovative technologies in agriculture. The farmers in Israel are working as a team with the research team which helps the innovators to test the new technologies within themselves and later expose it to the world. The size of Israel is one-third of Ireland, and moreover, most of Israel is covered by dessert which is not a favorable condition for farming. However, Israel copes this limitation with producing more with limited resources. They are famous for developing on-farm technologies that can interact with farmers (KPMG, 2018).
The availability of arable land in Israel is not more than 20%, but Israel is the only country where more than 300 multinational corporations are running on R&D operation employing more than 50000 people (KPMG, 2018). The interest of the government in supporting the new startups had increased the investment from foreign countries which makes less invest from the government. According to the report from Start-Up Nation Central, USD 80m was invested by the Israel companies in 2017 for on-farm technologies, but USD12.5m were invested for mart farming from foreign countries in the first half of 2017 which later increased to USD26m (SNC, 2017). The strategy of Israel can be seen from the beginning of providing education and training to people. Instead of educating students for answering some specific question to get passed on a test, Israel encourages student by motivating them to become an entrepreneur. This long-term vision on innovation extended them to improve the country and resulted in emerging as a leader in technology for turning desert into agriculture, irrigation and desalination techniques (KPMG, 2018). The farmers in developing countries are more concerned with the scarcity of water for agriculture, whereas Israel is working for drip irrigation technique over 50 years to turn their desert into agriculture and Israel use 50% of its used water for irrigation. According to Naty Barak, Chair of the ISO technical committee says that drip irrigation technique is simple and not expensive. Most of the farmers around the world are unaware of this technology, and he believes that would be the reason for slower adoption (ISO, 2017).

Israel transformed the water industry into a new level. The environmental limitation of surplus water made them superpower in this industry with effective R&D. The UN report says that 40% of the world population will suffer from a shortage of water by 2050. Due to these reasons, even the WorldBank was ready to accept theory technologies and decided to help them by expanding it to developing countries. Globally water technology market is healthy, and it mainly consists of monitoring irrigation, sprinklers, timers, etc. Over 80% of water technology export is done by Israel that accounts for 30% of the global water market. Even developed countries like the USA are concerned about Israel technology because California in the US can use only 5% of used water for irrigation whereas in Israel it's 80% (Leumi, 2016). On the other side, Israel had a strong developed artificial intelligence which had evolved enough to detect the ripeness of fruit, automating the process of packing, picking and quality control. Israel even contributed their technical knowledge in robotic farming by creating a robot that can copy the human movement (KPMG, 2018).
The culture had a strong impact on the development of any country. Culture of Israel teaches people to grow as fearless in failure beside this Israel system had less stringent law on bankruptcy and regulations that inversely increased the confidence among people to face the failure in starting a new endeavor. Moreover, R&D department of Israel is working collectively with the help of specialized nine universities which works together for any innovations nationally and globally. This collaborative behavior among universities eradicates competition and confusion. Instead they support each other ventures (A. Ciobo, Rizos and Lloyd, 2018). However, figure 5 depicts the milk yield per cow in the year 2017 as per the International Farm Comparison Network (IFCN) (IFCN, 2017). Israel stands first in milk yield per cow compared to other countries (see Figure 3). The Israel dairy industry is well advanced, and even countries from Asia, Africa, and Europe were likely to embrace Israel technology. Afimilk, an Israel company is a pioneer in the dairy sector technologies, and they developed devices that can monitor, feed, check the protein level and even the health condition of a cow in the dairy farm (Leumi, 2015).

![Milk Yield per cow in 2017](image)

**Figure 3**: The quantity milk yield per cow in a year over the different country.

### 2.8 The progress of European countries in SFT

The EU agricultural sector is covered by 60% of the land is suitable for growing crop whereas 34% is appropriate for grazing and pasteurization and remaining 6% is appropriate for nuts, vegetable, olive, etc. Surprisingly the landholding in Europe is declining over the
years by 3.7% between the years 2012-2013 (Schrijver et al., 2016). The turn down of smallholder farmers and more importance to larger farm is the main reason for the decrease in landholding. 70% of farmers in Europe have only practical knowledge whereas 20% of farmers have basic training where 8% of them had gone through complete agricultural training. However, 80% of farmers over 65 years didn’t have any guidance in agriculture (Schrijver et al., 2016). The EIP-AGRI Focus Group (2015) says that the training of farmers directly depend on the proportion of adoption of precision technologies and also added that it would be the key reason behind the low embracement of technology in North West European countries. According to Zarco-Tejada et al. (2014), there is a lack of report regarding PA in Europe and Collective analysis of such reports would help to develop the business of precision agriculture. VRT and auto steering technology are mostly used in Europe, but the penetration of these technologies in central and eastern Europe is low (Zarco-Tejada, Hubbard and Loudjani, 2014).

The adoption of SFT among EU is relatively high in the larger farm; however, the recent report from parliament states that it is difficult for smallholders to get along with digital technologies due to insufficient knowledge and dilemma on investing. This unequal equilibrium among small and large farm would effect in utilizing the potential of digital agriculture in EU (EURACTIV, 2017). Farmers in EU are not attracted to the SFT, instead they are covered with cynical and uncertainty (Reichardt and Jürgens, 2009; Knierim et al., 2018). However, Ulrich Adam, Secretary General of CEMA told that many rural areas of EU are still doesn’t have a proper infrastructure such as broadband and proper training (EURACTIV, 2017). The farmers of northern Europe are more inclined to use computer. These countries are developed, and farmers in this area have a normally larger farm. It is found that 30% of German, less than 20% of Danish and Finnish farmers are optimistic about using computers (T. Balafoutis et al., 2017).

The European Patent Office (EPO) monitor the development of technology across the world and is made into a report feasible for the followers after the development IoT and other technologies like cloud computing, Artificial intelligence, etc. The fourth industrial revolution (4IR) means a technology that connects larger operation to perform an automated task such as we see in agriculture, food processing industries, etc. The patents are innovation made by a company such that they can market their patented product in the European countries (Ménière, Rudyk and Valdes, 2017). From figure 4(all data from EPO) it is clear that Germany (DE) is leading the patent in all sector including vehicle, agriculture, health
care, etc, followed by France (FR) and United Kingdom (GB). Ireland (IE) stands in 13th position in the 4IR patent application right behind Denmark (DK) and Spain (ES).

![European patent granted in the year 2017](image)

**Figure 4:** The number of patents produced by different countries in the European patent office (EPO) member state in the year 2017.

According to Schrijver et al. (2016), Netherland farmers have higher efficiency in output monetarily comparing to other countries. About 64% of farmers have received basic training, and 6% had received proper full agricultural training which is relatively high compared to other countries. The GNSS and robotic milking in Netherland are very high. Another important factor with the Netherlands is that they open the data about farm publicly so that anyone can access the data and would help them to know the type of crops suitable for soil and weather (Schrijver et al., 2016). The Dutch farmers are well educated and trained. So they update with the latest technologies available and make themselves competitive. They even hire an advisory board for finalizing the decision regarding farm it can be about legal and technical which help farmers up-to-date. The agricultural courses provided in Netherland include managerial and technical subject (OECD, 2015, pp. 150–186).

Most of the pig farmers in Netherland use management information system that can record and monitor all the pigs and its related information. The technology helps them not only to increase production but also to collect and analyze the data easily. More than 4400ha of land is used for greenhouse horticulture, and tomato is the main vegetable produced. However, the recent development in ICT helped them to increase the production with fewer resources. The
use of advanced robots, sensors, monitoring system helped them to optimize the yield sustainably. The government encourages innovation by providing benefit in tax, Incentives and other credits. Many Dutch retailers have their app to help customer the origin of a particular product that even includes pig meat such that it directly connects the consumer with the farmer (Hoste, Suh and Kortstee, 2017). One of the large positive for Dutch is a strong research and innovation team under Wageningen University that not only conducts significant research in food and agriculture in EU but globally. The investment in agriculture innovation by the private sector had been enhanced by the development in the institution. The partnership between private and public sector had enhanced with the help of strong funding & R&D in Netherland (OECD, 2015).

2.9 Researches acknowledged in EU

The European Horizon 2020 smart-AKIS had done a survey in 7 countries namely the Netherlands, Germany, the UK, Serbia, Spain and Greece about the perception of digital technologies and smart farming. Based on the result from survey several factors influence embracing SFT in Europe. One of the significant factors that divide north and south Europe is education. The farmers from northern EU are a well educated while from the south are least compared to the north, which is one of the main obstacles for adoption. SFT ignore the smallholder farm is another reason. However, next factor is the lack of proper advisory service in Europe for making aware of farmers. Survey also conveys that EU policies like subsidies and direct payment are making farmers not to try anything new and continue with the present situation (Knierim et al., 2018). The research of Long et al. (2016) regarding difficulty in adoption of climate-smart agriculture the Netherlands, France, Switzerland and Italy reports some factors such as lack of awareness and training among farmers, High initial cost and low return of Investment, developing a technology that is not suitable to the consumer which result to lack of interest, legal issue such as no tax benefits on innovative technology and regulation in use of some technologies. The researcher also says that the research should be explored to other countries which are not on the list to know more about the factors affecting as a barrier to smart agriculture (Long, Blok and Coninx, 2016)
2.10 Drivers for Adoption

There are drivers for adoption of SFT like CC for the agriculture sector. Rising demand for food worldwide needs some technology to increase the yield and efficiency. According to the report from the United Nation suggest that world population is growing by 1.10% every year, it would reach 8.6 billion in 2030 and 9.8 billion by 2050 (United Nation, 2017). Food Wise 2025 report suggests that the growing population need an overall food production of 70% increase by 2050. Moreover, the report also added that the future need for food production could be meet only by embracing and utilizing the new technologies (DAFM, 2016). A sustainable and more efficient way of producing food can only be obtained by introducing efficient SFT like Cloud Technology that would optimize the yield.

The increase in agricultural practices could lead to a rise in carbon emission to the atmosphere. The Climate Smart Agriculture (CSA) (2016) report suggest that forestry, agriculture, and other land use contribute 24% of global greenhouse gas emission and it can reach 30% by 2025 (Curtin and Arnold, 2016). The recent Teagasc report shows that an increase in agriculture production in Ireland would raise the carbon footage by 9% by 2030 (Teagasc, 2018b). The CSA report suggests farmers uptake new technologies to tackle this situation (Curtin and Arnold, 2016). However, according to Symeonak et al. CC will assist CSA and help to increase the yield and efficiency. CC also facilitates agricultural information storage, access, and management (Symeonak, Arvanitis and Piromalis, 2017).

The CSA (2016) report suggests that Ireland have a great opportunity and potential to grow its production by 85% in the year 2025 that is a growth of 19 billion euro. Globally, there will be an increase in demand for consumption of protein food, which inversely will extend the export market of beef, seafood, dairy, etc (DAFM, 2016). The global competitiveness of Irish market needs technology like cloud, IoT, Robotics, etc to be used an effect to increase production and efficiency (Teagasc, 2016). According to Teagasc Foresight report 2035, digital automation in Irish agriculture is expected to grow and will facilitate more production and efficiency (Teagasc, 2016).

Many technical factors drive the adoption of Cloud technology on the farm. The ability of Cloud technology to integrate with IoT and Wireless Sense Network can be used for a different application like soil monitoring, humidity, temperature, etc. Land records automation, Weather forecasting, and high storage facility are other features that assist farmers (Symeonak, Arvanitis and Piromalis, 2017). According to Hristoski et al., the use of
cloud-based FMS is increasing in agriculture and estimated that it would reach USD 2.71 billion by 2022 (Hristoski et al., 2017). Furthermore, the social website has a significant role in communication with farmers to embrace new technology. Twitter and Facebook are the conventional media for farmers working in the field. AgChat in twitter, farmers group in YouTube also plays an essential role in updating latest information among farmers (Brewster et al., 2018).

The European Union and Irish government are equally encouraging farmers to uptake new technology in their farm. The Internet of Food and Farm 2020 is a program to encourage the use of IoT in the farm by 2020. Beside a vision, this program also aims at research and technological development in agriculture. The other objective of this program is to help farmers in the decision making of farm-related operation and also ensure the data related issue like security, Interoperability, etc (Sundmaeker et al., 2016). Ireland also had schemes like Knowledge Transfer Program that teach students and equip farmers with new technology. The main intention of this program is to make farmer’s multi-skilled in farm and educate them to utilize on different technologies like GPS, weather prediction, computer-based imaging, robotics, etc (Teagasc, 2016). “National Digital Farming Test Bed (NDFT)” is another program by Teagasc to encourage young farmers with cutting-edge technology and support the adoption of digital technology in the farm (Teagasc, 2016). “Targeted Agricultural Modernisation Scheme II (TAMSII)” is a scheme from the Irish government to encourage young farmers to use up to date technology in their farm by providing grants of 40-60% on the technology used (DAFM, 2018).

2.11 Adoption Model
Pierpaoli et al. explained the drivers of adoption through Ex-post model. If a farmer is called as an adopter, then he would be educated, having a large farm, sound finance, soil quality, etc. According to Pierpaoli et al. farm size is an important factor that influences the adoption behavior of farmers. Confidence in the computer is the second most affecting factor in using any technology. However, age has a variable effect on the adoption behavior but young farmers are most likely to embrace technology. While there are cases where old farmers are most likely to adapt to technology (Pierpaoli et al., 2013).
Technology Acceptance Model (TAM) is the theoretical model of Ex-Ante. TAM is proposed by Fred Davis to explain the behaviors of user’s acceptance in using a computer model. The model introduced two factors Perceived Usefulness (PU) and Perceived Ease of Use (PEU). PU means the degree to which user possibility to use a system that will be beneficial for the user. PEU is the extent to which user feels the system is effortless to use (Lai, 2017). According to Pierpaoli et al. TAM is a suitable method to understand the attitude of adoption of users (Pierpaoli et al., 2013).

The success of any new Precision Agriculture technology depends upon PU and PEU. However, the addition of these two features will help to understand the attitude of adoption of Users or is known as Ex-Ante model. The approach to use any new technology directly depends on cost. High cost of technology would affect the loss of users in utilizing new technology (Pierpaoli et al., 2013). The Smart-Akis research on SFT adoption in the
European countries suggests that demographic don't have any effect on the adoption of technologies. From the study, the farmers are found to be positive towards its usage. Moreover, the report suggests that cost, knowledge about SFT or infrastructure are the main barrier towards the adoption of SFT (Knierim et al., 2018). Non-adopters do not have ample skill to manage new technology, but PU and PEU are influenced by cost and farmers are ready to ignore the low-performance level of the technology they use. Timely service, demo and a free trial of new technologies are always encouraged by users (Pierpaoli et al., 2013).

2.12 Literature Contextualization

Literature contextualization means how a literature review would help in research. The literature review explained the application and adoption rate of SFT available in farming. More importance is given to Cloud technology, IoT, Big Data, ML all of these were interlinked. It also suggests the way it supports the farmers and agriculture with the idea that it can be implemented in Irish farms too.

The other session includes the Smart Farming adoption in different countries like Singapore, Israel, India, and Europe as a whole. Countries like Singapore, Israel; India is selected because of its same size and Smallholder farmers like in Ireland. Literature would help to recognize the culture and driving factors of farmers in different countries that led to adoption. It also helps to study the government policies and regulation in their countries to encourage farmer’s adoption.

A small session is included that conveys the Smart Farming research initiate din EU countries. Both types of research in the context were based on the factors affecting embracement of SFT in EU countries. The findings of these researches can be applied to this study for better results and conclusion.

Literature Review also discussed drivers of adoptions among farmers that will be useful to apply in the research while analyzing the CC usage among Irish farmers. An adoption model is also included that will help to get a view on the attitude of Irish farmers towards using CC in the farm.
Chapter 3

3 Research Methodology

Research methodology is a crucial section of a research work that is being done on an explicit subject. Research is carried out on a systemized manner with the help of a platform. Under this section, different methods and approaches, which are being employed for fetching useful information in relevance to the research study, are described. The methodology helps the reader and researcher to properly recognize the different stage of study and techniques that are being included for the appropriate beginning of research (Taylor, Bogdan and DeVault, 2015).

In concern to the current study, this chapter assists in understanding and analyzing the scope of SFT especially CC in Irish agriculture. This chapter assists in understanding the current usage, attitude and perspective of Irish farmers towards adopting CC technology in their farm by gaining knowledge regarding the applicable, philosophy, approach, strategy, data obtaining methods, sampling process, and analysis techniques that are segregated as per the Saunder’s Onion model of research. The research will be following a mixed method research type. The chapter is categorized into simpler sub-segments which aid in enhancing the understanding levels of the reader regarding the applied methods in the primary research study to obtain useful and relevant information. In addition to it, the ethics of the research together with the limitations of the methodology are also discussed in this chapter.

Figure 7: Research Onion (Source: Saunders, Lewis and Thornhill, 2015)
3.1 Research Philosophy
According to Saunders et al. (2015), research philosophy means a method of trust and hypothesis about a developing subject. As shown in Figure 7 there are five research philosophies. The research considered both positivism and interpretivism (Saunders, Lewis and Thornhill, 2015).

Positivism philosophy is generally a scientific approach where existent theoretical concepts are applied for the development of hypotheses, which are examined and either accepted or rejected. The research worker is unaffected through this type of research work. Positivism provides a highly methodological structure. On the different side, interpretivism is applied to research studies that are qualitative by nature. It allows an accurate interpretation and evaluation of the varied information sources that are acquired with the aid of primary along with secondary techniques for gathering relevant data (Leitch, Hill and Harrison, 2010).

Pragmatism is when research commenced due to researcher trust and belief. It supports both positivist theoretical concept and the qualitative nature of interpretivism. Pragmatist believes there are multiple ways to address the research question (Saunders, Lewis and Thornhill, 2015). The research needs to collect the survey data for information in the context of acceptance and usage levels of farmers regarding the SFT like cloud computing and descriptive information in the context of attitude and perspective levels of farmers regarding the CC technology.

3.2 Research Approach
The research approach is helpful in obtaining the rationale for the research with the assistance of well-specified guidelines. A research approach is broadly segregated into two types that are termed as inductive as well as deductive. When research starts with a theory, then the conclusion is made with the help of data collected is called deduction and is used in quantitative analysis while data is collected to build a new theory is called induction (Saunders, Lewis and Thornhill, 2015).

Research follow an Ex-Ante adoption model which is not the primary objective of the research but would help to understand the attitude of Irish farmers towards using CC technology in their farm and also helped on recognizing effecting their adoption. However, the research preferred more insight data for answering the objective for slow adoption compared with other countries, and more data is collected to build a theory between the perspectives of adopters and non-adopters towards technology. The research follows the
Inductive approach. Moreover, according to Saunders et al. (2015), the inductive approach needs a small sample while compared to a deductive approach to conclude (Saunders, Lewis and Thornhill, 2015).

3.3 Research Design
The next layer of Saunders onion after approach is research design that includes strategy, time horizon, and sampling, etc. The research design is all about presenting the research question (Saunders, Lewis and Thornhill, 2015). This session will have clear ideas about the question, the source where data to be collected and analyses it, research method chose for and ethics issues faced.

3.3.1 Research strategy
Strategy means an arrangement of action to fulfill a task. Research strategy helps the researcher to answer research questions. As from the Saunders Onion, there are eight research strategies; Experiment, Case studies, Archival, Survey, Ethnography, Action research, Grounded theory, Narrative Inquiry. All the strategies are equally important (Saunders, Lewis and Thornhill, 2015).

At first case, study strategy was considered as it would help to gain broad knowledge about SFT technology especially CC usage in agriculture. However, availability of research based on CC in other industry is available but not particular to the agricultural industry. Although there are Smart–Akis research as explained in literature review based on SFT adoption comparison among EU countries available. It was very broad and need time to set up which is beyond the time frame allocated for the research. However, no researches were found comparing the SFT adoption with other countries in an Irish context and also adoption and usage of CC technology among Irish farmers. So case study is omitted.

According to Saunders et al. (2015), survey strategy uses both deductive and inductive approach. Survey strategies are best for business and management research (Saunders, Lewis and Thornhill, 2015). This research will have a survey strategy since it collects quantifiable data through questionnaire survey and also conducts a structured interview, that is common questions to all respondents were asked after the survey. The survey was conducted among the Irish farmers doing the diverse type of farm and from a different part of Ireland. The responses from the father would help to answer the research question.

This research doesn’t follow a mono-method but rather follow multiple methods especially mixed method for data collection. According to Saunders et al. (2015), multi-method uses
more than one quantitative or qualitative data collection and if both qualitative and quantitative techniques are combined for data collection than it is known as a mixed method (Saunders, Lewis and Thornhill, 2015). The research used questionnaire survey for collecting data from the farmers through an online platform called Google form. The questionnaires are designed with the logic of separating two groups of farmers (adopters and non-adopters). Research also conducted a Qualitative data collection method like a structured interview with selected respondents. However, a concurrent mixed method approach is followed because it used the separate qualitative and quantitative method but interpreted together for a broad response of research question and other findings from Irish farmers.

3.3.2 Sampling

Sampling can be termed as the process of fetching a relevant group of individuals that are capable of offering relevant data for the research work. According to Kumar (Kumar, 2014), the accuracy of research finding depends mainly on the sample size selected. Selecting a precise sample of a relatively low unit of population than there is a higher degree of obtaining true indication (Kumar, 2014).

It is very hard to get information from the common people regarding this topic, and it does target specific people as mentioned the title. The research targeted the farmers from a different part of Ireland. However it was very difficult to find the farmers from the Dublin area, but research doesn’t demand any specific area, and it gives more importance to the opinion from farmers.

Sampling Technique

The research follows nonprobability sampling method. In this method, targeted sample cannot be picked individually from the population. So sample unit is selected by “considerations”(Kumar, 2014). Snowball sampling method is followed. According to Kumar (2014), snowball sampling is a method of selecting a target population for the sample using connections, and this sample will be useful when there is a little knowledge about the sample population (Kumar, 2014).

The research is focusing on farmers who are located in diverse in Ireland, and it is very hard to survey farmers because most of them will be isolated from the main city and probability to give a survey to unknown people is less. For the further lead of research three to four people
are selected through a social website and direct contact. Then made use of snowball method and started making a network with their connection.

3.3.3 Time Horizons
Time horizons mean the amount of time required to find the answer for your research question. It is broadly classified into longitudinal and cross-sectional studies (Saunders, Lewis and Thornhill, 2015). Cross-sectional studies are more comfortable to academic research where research is undertaken for a particular time, and most of the academic research will be time constrained, while longitudinal studies are time-consuming but it makes the researcher follow a changing pattern (Kumar, 2014).

Cross-sectional studies will be more comfortable for this research considering the time constraints. However, the study needs to observe the change in farmer’s behavior over time so it can be longitudinal studies too. According to Saunders et al., Longitudinal studies can be literature section where a large amount of data available and primary data collection can be cross-sectional (Saunders, Lewis and Thornhill, 2015).

3.4 Data Collection
The data collection of research will depend on sampling and strategy. The research is a mixed method where it needs both a quantitative survey and qualitative interview. The descriptive information collected in qualitative data would help to understand the meaning of quantifiable data collected (Saunders, 2011).

The questionnaire for the survey was designed in such a way that it can divide the participant into two groups as explained below. The Cloud Computing being more technical terminology would be difficult to understand for the participants, so a brief description about it was given with the questionnaire. The cloud computing usage and its application were analyzed in the research by using the phrase “Information Technology” in the questionnaire to make it simple.

The survey questionnaire collected the age, gender, and educational information of the participants along with the subjective questions. Research collected the quantifiable data with the help of Google form platform. The questionnaire had three sections

- The first section collected the personal attributes and common opinion towards using the Information Technology. The participants were categorized as adopters and non-adopters from the last question of this session.
• The second session collected the attitude and perspective of farmers towards using Cloud Computing, SFT, adoption barrier, information seeking method, and area of preference.

• The last session was a common question to all farmers and collected information about communication medium and opinion towards digitalizing the agriculture.

Snowball sampling was used to find the respondent for an interview, and they also take part in the survey. However, all the interviews were recorded with the permission of respondent and a brief idea about the questions were explained to them before starting an interview. However, randomly selected six respondents where three of them are not using any CC in their farm while others use some CC application on their farm. Interview questions were structured, and the same questions were asked to all the farmers that include both groups of farmers. The interview will help to find the insight of farmers regarding their attitude and perspective towards using CC technology. Most of the interviews were telephonic, and few were face to face. Interview questions are designed to understand the view of farmers towards using CC in the farm, impact on their role, adoption drivers, improve from the present system and also insight about the reason for slow adoption of technology in Ireland.

3.5 Data Analyses

The examination and filtering of the retrieved information are necessary for the accomplishment of valid and error-free research work. The analysis phase is crucial in research work, as it assists in offering well structured and accurate data that enhance the validity and authenticity of the research work. Data analysis techniques such as the thematic, statistical and graphical analysis techniques are applicable in the research works. The quantitative data received is analyzed by software like MS-Excel and graphical representation of data is made.

Thematic analysis is applied for analyzing the primary data through related themes for gaining proper discussion over the research subject (Gill et al., 2008). The research also has qualitative data, and to filter and group the response into meaningful Computer Assisted Qualitative Data Analysis Software (CAQDAS) like MAXQDA used for transcription of interviews and NVivo is used for grouping and filtering the interview response into a useful form. Data filtration is needed because some response of farmer’s to a particular question were deviated but rather used their response and made use of it in the research. All the users who participated in the survey were secured by coding with a new name.
3.6 Research Ethics
The research had followed all the ethics. The ethical issue like the maintaining privacy of the research respondents is resolved using storing the confidential data of respondents in an encrypted manner through software tools. All the respondent participated in the survey, as well as interview, were asked to sign in the consent form, and the primary researches were done only after their willingness. Most of the participant had submitted their consent form through an online form, and few interviewees who were having face to face interview have signed the consent form. During the survey or interview name, location, field size and income of the respondents were not asked to respect their security. All the data collected were following EU data protection and won’t be shared with any third parties.

3.7 Research Limitation
The research faced many hurdles while from the beginning. Some of the limitations of the research are

- The research faced many obstructions in finding the respondents. Since, the research demand survey and Interview, it was very hard to find a sample size to do primary research.
- Data protection rules made the research hard to find an appropriate audience. Direct visiting in farms was hard and time-consuming and traveled a lot of place in Dublin to find the farmers and ask permission for an interview and but was able to find only few.
- Time to get an appointment with farmers for interview
- Proper knowledge about SFT and application of CC in agriculture were necessary.
- It was hard to find relevant journals related to Smart Farming in an Irish context.

Limitations are part of research but have to face the hurdles to conclude the result. Stress free would make work easier. The snowball sampling method helped to complete the research and to find some leads. It is good to take advice from the supervisor before diverting to a big mistake, and the advice from the supervisor had helped this research.
Chapter 4

4 Data Analysis and Finding

All the finding done in this research is evaluated. The study was based on the impact of CC and Smart Farming on the Irish farm. However, surprisingly it was challenging to find the respondent for this research. We seek the help of many agricultural organizations in Ireland, but it was tough for them to share the information of respondents due to stringent data protection rule. Later we got respondent with the help of social media like Facebook, LinkedIn and we tried visiting the farm place directly to find the farmers. It was complicated to see the farmers in the Dublin area but was able to find some through snowball sampling method. The research followed the mixed methodology and will be fulfilled with survey and interview. The review was done through Google form and respondents were able to access it by sharing it in whatsapp group of farmers with the help of people contacted through social media. The recorded interview data are transcribed with the help of MAXQDA, qualitative analysis software. The data are structured from the nodes created in the software NVivo and Manuel thinking.

4.1 Survey

4.1.1 Age, Education and farm

A total of 32 responses are received for the survey. The entire respondents are farmers from a different part of Ireland. The participants are of different age group and doing a diverse type of farming. However, Out of the 32 responses, 7 are females, and 25 are males. Table 2 shows the educational background of different respondents participated in the survey and more than half of the respondent participated is having a Third-Level Degree.
### Table 2: Educational Background

<table>
<thead>
<tr>
<th>Education</th>
<th>No. of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>1</td>
</tr>
<tr>
<td>Lower Secondary</td>
<td>1</td>
</tr>
<tr>
<td>Upper Secondary</td>
<td>3</td>
</tr>
<tr>
<td>Third-Level Nondegree</td>
<td>6</td>
</tr>
<tr>
<td>Third-Level Degree</td>
<td>16</td>
</tr>
<tr>
<td>Post Graduate</td>
<td>5</td>
</tr>
</tbody>
</table>

While Table 3 represent the different age group of the users. A number of participants are between the ages 25-44 year of age.

### Table 3: Age Group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>No. of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-24</td>
<td>6</td>
</tr>
<tr>
<td>25-44</td>
<td>18</td>
</tr>
<tr>
<td>45-64</td>
<td>6</td>
</tr>
<tr>
<td>Above 65</td>
<td>2</td>
</tr>
</tbody>
</table>

More than 60% of respondents are entirely dependent on farming while others (37.5%) are doing farming as part-time. Moreover, 28.1% of the respondents are following mixed farming while 71.9% are not. Most of the participants in the survey are dairy farmers while the least is sheep farmers (Figure 8). In Figure1 horizontal axis represents the number of farmers and the vertical axis represents the type of farm.
4.1.2 Farmers attitude towards using Information Technology
One of the crucial questions in the survey was the influence of information technology on the farm would make its maintenance more manageable. Surprisingly, 96.9% believed that IT would make farming easy. While 3.1% of respondents said “No.” The responses of the participants are shown in Figure 9.
The question regarding the use of IT by the farmers in Ireland made the researcher to divide the respondents into two groups. It is observed that 62.5% of respondents use some kind of IT in their field and are named as adopters or Group A, while the remaining 37.5% does not use any technology or non-adopters or Group B (Figure 10).

![Respondents using IT in farm](image)

**Figure 10: Respondent using IT in the farm.**

Following are the common Information technology used in Ireland based on the response from the participants attended in the survey.
The adoption is observed more in Dairy farming especially between the ages 25-44 year of age (Table 5). It is found that adoption is good among the farmers using the mixed farm as well. Moreover, out of the 20 responses of farmers who use some Information technology four are part-time farmers as well.

<table>
<thead>
<tr>
<th>Age</th>
<th>No. of farmers</th>
<th>Farm</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-24</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>25-44</td>
<td>15</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>45-64</td>
<td>1</td>
<td>x</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 5: Adopted farmers

In contrast to this the farmers from Group B (Non adopters) were asked about their opinion to adapt to any information technology in future and the results shows significant portion (58.3%) like to adopt some information technology in their farm while 25% is skeptical about
taking it and a small percentage (16.7%) had no plan to utilize technology in future (Figure 11). Out of the 12 responses, 7 (58.3%) of the non-adopters was having age above 45 years.

![Willingness to adopt IT](image)

**Figure 11: Adoption of Information technology among non-adopters in future**

However, the same percentage of farmers from Group B as in Figure 11 are likely to use and learn farming related application for controlling and monitoring different areas in farms as per the response on question related to “tracking all the transaction, weather, soil, crop/animal information of your farm through a platform in your mobile. Will you accept and try to learn such technology?”

The respondents were asked for their opinion on digitalizing the agriculture and most of the farmers (71.9%) pick yes for digitalizing agriculture. In contrast to it, 18.8% of farmers are not sure about it, and a minimal section of farmers (9.4%) are not ready to accept the change (Figure 12).
4.1.3 Perception of farmers towards using cloud technology

The adopters of information technology were asked whether they use any CC technology on the farm. However, more than half (70%) of farmers use some technology in their farm, and the remaining 30% do not use any type of such techniques (Figure 13).

Most of the farmers use CC technology for recording animal data and stock. Other farmers use it in an application like GPS for fertilizer, grass management, financial budgeting, etc. (Figure 14).
An analysis is also made among the farmers who adopt technology on using any farming application in their Smartphone. 80% of farmers use application in their Smartphone (Figure 15).
Most of the dairy Farmers use Smartphone app for farming applications, and a significant portion of farmers who uses are between the ages 25-44 (Table 6).

<table>
<thead>
<tr>
<th>Age</th>
<th>Male</th>
<th>Female</th>
<th>Dairy</th>
<th>beef/sheep</th>
<th>Tillage</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-24</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>25-44</td>
<td>10</td>
<td>1</td>
<td>9</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>45-64</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 6: Demographic Smartphone usages in Farm

4.1.4 Farmers technological and information seeking behavior

Most of the farmers (70%) who adopted information technology keep the records of farming details with the help of software and Book/diary. However, 30% of farmers only use software to keep the farming details.

The farmers who embraced information technology were asked about the digital medium they access information. Out of the 20 responses 14 respondent selected YouTube, Whatsapp, Facebook, and Farming news portal as the primary intermediate they used to get information about new technology. However, 45% of respondent finds Twitter as another source of information. While a small percentage (1%) of people find information through farmers journal app, Google plus and word of mouth. However, none of them seek the help of wikis or blog to find information (Figure 17).
On the other hand, Non-adopters were asked the same question about updating new technology considering their use of limited usage in the digital platform. Nine respondents of 12 farmers found paper as the primary medium to upgrade any new technology.

Moreover, another significant portion updates knowledge through other farmers (7). However, tiny percentage of farmers finds information through digital platforms like digital news (3), YouTube (2) and Twitter (1). However, 2 participants from farmers find Television (TV) as a source of information (Figure 18).
4.1.5 Farmers perception of CC potential to deal with challenges

The Group A farmers are asked to pick the area of preference where more application based on farming should be developed, and the result shows that 55% of farmers need an app for Accounting in farm and 45% need in herd management. While another significant portion (50%) claims that there is a need of an application to be developed in all the areas such as supply chain, herd management, accounting and precision information like weather, humidity, etc. (Figure 19).

![Areas to develop application](image.png)

Figure 19: Areas to develop the application

There are difficulties in adopting any information technology among the Group B farmers that also can be relatable to the already existent users that could help in enhancing the user experience (Figure 20). However, more than 65% of farmers felt small farm size as the primary reason, and another significant portion finds difficulty in the initial investment (50%) and Complexity to use (41.7%). Then there are other issues like uncertainty about the value of the technology used (33.3%), inappropriate technology in the farm (16.7%), data sharing (16.7%), lack of knowledge about the technology (8.3%) and the difficulty of using technology among older farmers (8.3%).
4.1.6 Communication between farmers

The response from the Irish farmers says that more farmers prefer Group meeting as the standard medium for communication. However, social media is the next medium where most of the farmers from Group A communicate followed by E-mail, SMS, Intranet, paper/magazine. While Group B farmers use Email as the second most medium to interact with other farmers followed by social media, E-mail, SMS, and another medium like phone calls, in person, mart, etc (Figure 21).
The rating for communication between farmers in Ireland for an exchange of information is more prominent among the farmers who adopted some technology while it is an average rating of connection between non-adopter farmers as represented in Figure 22.

![Figure 22: Rating of communication](image)

This communication diversity also made an impact on the opinion of farmers in sharing the information with other IT technologies. The Group A (adopters) is ready to share data for the agricultural development. Although a significant portion of Group B (non-adopters) shows interest in exchanging information whereas another major part of Group B farmers are skeptical and not at all interested in sharing information to companies as shown in Figure 23.

![Figure 23: Information sharing with companies](image)
4.2 Interviews

The research followed a structured interview pattern, the same questions were asked to all the participants, and the respondents were divided into two groups based on their answers received. There are six participants joined in the interview, and all of them were farmers doing a different type of farm. The interviewees are coded as IN, and an individual number is assigned for all answerer. The details of all interviewee are shown in Table 7.

<table>
<thead>
<tr>
<th>No</th>
<th>Age</th>
<th>Gender</th>
<th>Education</th>
<th>Type of farm</th>
<th>Adopted any Information Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN1</td>
<td>45-64</td>
<td>Male</td>
<td>Third level non-degree</td>
<td>Mixed(Beef, tillage, sheep)</td>
<td>NO</td>
</tr>
<tr>
<td>IN2</td>
<td>45-64</td>
<td>Male</td>
<td>Upper Secondary</td>
<td>Beef</td>
<td>NO</td>
</tr>
<tr>
<td>IN3</td>
<td>45-64</td>
<td>Female</td>
<td>Post-Graduate</td>
<td>Mixed(Beef, sheep)</td>
<td>NO</td>
</tr>
<tr>
<td>IN4</td>
<td>18-24</td>
<td>Female</td>
<td>Post-Graduate</td>
<td>Dairy</td>
<td>YES</td>
</tr>
<tr>
<td>IN5</td>
<td>25-44</td>
<td>Male</td>
<td>Third level degree</td>
<td>Dairy</td>
<td>YES</td>
</tr>
<tr>
<td>IN6</td>
<td>45-64</td>
<td>Male</td>
<td>Third level non-degree</td>
<td>Mixed(Dairy, Tillage)</td>
<td>YES</td>
</tr>
</tbody>
</table>

Table 7: Age, gender, Education, farm information

4.2.1 Farmers attitude towards Information Technology

The farmers have a positive approach to the impact of Information Technology on farming. According to IN4 "world is becoming more digitalized and the IT sector is growing rapidly, and I think it would benefit us farmers to utilize that more because farming is a very kind of very manual labor intensive job anything will help to reduce that to some degree. I think it should be used, maybe that’s where we are kind of missing out a bit. I think farming hasn’t caught up with maybe other industries in that regard".
However, the response of IN6 is also similar and says that “I think technology is going to have a greater impact, certainly, going forward, technology is there people tend to embrace it.” A similar response is received from IN5.

The Non-adopters like IN3 said that IT would make their life easier “I manage the farm but I don’t actually live near the farm, so I would be able to do a lot of the work and the management of the cattle's, and you know a distance away. So, for me, it would be wonderful”. A similar response was received from IN1 "of course this will because its progress all the time and you have to move with the times."

On the other hand, IN2 had a different opinion "Anything that makes the farm more profitable and more open to everyone." According to him, anything that proves profitable and can be used by anyone in the farm would have a greater impact on agriculture.

### 4.2.2 Perception difference of farmers towards CC

The benefits of CC among farmers have a different opinion, and it does vary from the adopters to non-adopters. The IN6 had already started using the cloud technology in the farm and made his work easier, he says “we do use CC here on farm for recording and stuff because we have 3 or 4 different staff members on the farm. so if I use cloud, if I update on cloud, all of that has it on the devices straight away which is extremely useful”. According to him embracing technology had improved efficiency in farming “here on our farm use of technology has improved output and efficiency.”

IN4 have a different opinion about CC, according to her “we probably don't use a lot of internet in farming. Particularly I use technology a bit in farming, but I suppose it’d be on one device so that information will be on your computer and it’s not synchronized across maybe multiple devices, so it probably would help I think anyway information whatever it may be for transmission in farm”. But she finds it very helpful in solving the paperwork through mobile app, she said “here is one aspect we implemented, let’s say last year, which is registering of our calves, so we have an app now for the phone so that it makes the job much easier so I think the transmission between paper jobs and getting them on to digitalizing them and making them more instant, I think will be beneficial”.

According to IN5, CC is considered as a tool that makes life more comfortable; he had a favorable view towards using CC in farm and said that "Yes sure I would see that as a
positive thing, because if it can make management easier. Then obviously that's kind of the direction we are looking to go in, to improve the efficiency of the farm”.

The farmers who don’t embrace any technology had a different view on CC technology, and their reason would be a prevailing opinion for other farmers in Ireland. IN3 says that “It sounds wonderful, but unfortunately we do not have Internet access where we live” and she also added that such technology would make her life easier.

However the remaining two farmers are older compared to other farmers, and IN2 said: “Cloud technology, I'm saying it's good for younger people, the older people like myself, I'm 69 and Its more difficult to pick it up to change”. In contrast to this, IN1 had a different opinion. He said “in terms of views in technology to track your animals, the animals progress, the animal movements, the animals health, etc. tracing where your animals come from, tracing where your animals go ,this is all new for this progressive and it will continue that way and I am happy along with that”.

In addition to this, IN1 also said that it could not beat the human touch and it should be a combination of both. However, IN2 also had the same opinion that “you'll have a certain amount that you can do, but you'll still have manual work to do. Like you can't do it all from a desk” but the response from him convey that its not only the reason that makes him away, there are other reasons such as “The big farmers yes, the smaller farmers you know, they wouldn’t have the finances to go there. So I think, that why it might be too far. He said “might be too far” means the reason for not embracing any technology among farmers.

4.2.3Farmers perception of CC potential to deal with challenges
The farmers in Ireland are very optimistic in adapting to new technology. It is evident from the responses. IN5 said that it could improve the efficiency and reduce the environmental impact “I think it can improve our efficiency and I also think that it can improve our awareness say on our environmental impact as well.” IN4 pointed out the area it could bring improvement “I suppose, herd management or account management. I know from farmers that, do you know there is, a lot of it is still paperwork if you get me. So there's constantly paperwork piling up. I think that's an area that needs to be tackled".
IN6 suggested the opportunities for SFT in the current scenario and pointed out a recent issue. He says “More productivity from the existent. This has become an issue, this summer with the hot weather and we couldn’t grow enough crops. It certainly improves better record, better information”.

The same issue is supported by IN1 based on the problem of lack of water that Ireland faced in the year 2018 “I would say after the dry summer, they need to put the things caps on where we used in wet weather to store water to have for the dry periods and that what we have to look upon”. He also added that ”Israel could be a perfect example, where they managed to take water and turns the desert green and produce stuff and them probably the best for using it, technology like that.”

IN6 also suggested that SFT would be useful for animal welfare. According to him “The software will tell you if the animal is sick or ill before you can visibly see it yourself, so I think that helps you control animal welfare.”

However, for farmers like IN3, usage of SFT like CC would make their life easier but situation surround them causes them not to use it. She says “Well for me it would make my life easier. It’s not going to change because my dad isn’t going to change” She meant “my dad isn’t going to change” is that her father who runs the farm now is not going to embrace any technology due to his age.

### 4.2.4 Impact of CC on farmer’s role

The usage of Information Technology may or may not affect the position of a farmer in the field. Irish farmers have a different opinion to this, and the collective responses from the adapters are different to that of non-adopters. Respondent IN6 says that “I don’t think it would affect the role, it would probably make him more in control of your information and you’re more aware, it would probably make you a better manager. It allows you to manage your farm better when you have better information”, “you” in the context represents farmers.

IN4 have a different opinion, and she says “there’s only so much you know one person can do if utilizing that information technology then reduces labor hours of the farmer,” “information technology” used here resembles CC technology.
IN5 told that “it will give more information to the farmer and it will also allow the farmer to increase his efficiency on the farm.” However, he also added that “I think it will be used in tandem with the, you know, the practical on-farm experience that the farmer will have.” The respondent used “it” in both the context implies the CC technology.

The response from respondents IN1, IN2 and IN3 is contradictory to this. According to IN1 using Information Technology would affect the farmer but not in his lifetime, he says “it’s underpinned by everything, at the end of the day you have to come back into your farm. I think what I want me to tell you is that someday there will be a robotic tractor that will go up to the field and put your crop, and you will sit and you just monitoring it, and I don’t think it will happen, may will happen in future will not happen in my lifetime and I would get no pleasure in farming sitting in office with a joystick”.

While IN1 said it would affect pleasure in farming, IN2 have a different opinion that it would not affect his generation but younger generation “Yeah would affect the role of the farmer but the younger farmer, who is in college now come up with degree he's more likely to embrace it and go with it because he's starting at a younger age and for the older farmer like myself it's a bit more difficult having said that, there are some of them who use it I know, but you need to have an aptitude for it”.

However, IN3 says “But as my dad is in his 78 years he's not willing to you know and the Internet, and all this is all a foreign thing to him and but then you know we'll miss certain things as well. Traditional methods of farming I think we often” from her response it is clear that aged farmers are reluctant to change and it would affect the traditional farming technique of Irish farmers.

4.2.5 Barriers to adoption
The farmers have concerns before using any information technologies like CC technology in their farm. It can be different from one individual to other. IN6 says “Not everyone, not every staff member is computer literate. So it has to be easy to use, it is the most important. And once it does the job and it is easy to use, then my staff can use it as well.”

However, IN4 support the above statement by adding more into it and says “I suppose, well one of them is the cost of it, not as much as the cost on its own but the cost-benefit of it. So
analyzing kind of how much it costs and what can it bring to the farm and how much time can it reduce or what kind of an impact will it make. So you wouldn’t have a problem paying for it if it is going to impact”.

In addition to this IN5 told its “data protection, of course, would be one thing.”

The participant used data protection means that the security of the data he shares with other companies.

The response from non-adopter farmers such as IN1 is that “you will do anything that makes us a better farm, an easier farm to run and any technology that’s out there that will help you to do less lessen the workload and increase the productivity of your land and the performances of your animals then you use it”. But for other farmers, they look mostly in how it suits their farming such as IN2 says “the first factor I would look at is cost, that’s number one, and number two there is how it’s going to improve what I’m doing.”

4.2.6 Communication between farmers

As seen in the survey, a group meeting is one of the main areas where more farmers communicate. Exchange of information will be more in such discussion groups that lead to asking on Knowledge Transfer Program awareness among farmers. However, 30% of farmers interviewed are not aware of this program. However, farmer IN5 is concerned about sharing his data in such program "I don't know a lot about it to have an opinion on it as I'm not part of the knowledge transfer scheme. Sometimes knowledge transfer means, like giving away, makes me nervous, sometimes giving away my data and data is valuable in my book, and I'm not too keen in giving my data because I put a value on it".

Other 50% are aware and part of the group. IN3 is a member of the Knowledge Transfer Program for beef, and she said “it's more and more producing productivity and make sure that animal welfare and things like, yeah you pick up things. It's a good way of networking”.

For IN5 it helps to exchange information and solution to farming problems, and he says "it provides me a forum to me to accept information from the like-minded individual."

IN4 have a different opinion, and she believes that it needs to be improved "it is helping to a
certain degree, but again some improvements might be needed to be looked at or just the way it's done, or that can help farmers."

4.2.7 Slow adoption compared to other countries
There can be a barrier to adapt to some technology, and it can be the reason for slow embracement of any technology. Recognizing the cause would help to reach into a solution. It could be helpful if we compare with the way other countries solve the problem. However, the barrier can be different in countries, and it can be an environmental, demographic or socio-economic factor. Ireland's slow adoption to Smart Farming technologies to farmer IN2 is that “the Irish farmer is way behind because of its size; I mean if you're comparing Ireland with New Zealand or some of the bigger countries, concerning England. The bigger farmers can afford technology, while Ireland is a bit behind on that”.

The farmer IN5 have another opinion about it “I thought the aging demographic of Irish farmers are, of course, is probably is the biggest factor. The number of young farmers, I thought it's a problem across all Europe, but in particular, in Ireland, you know the young farmers are going to take on that technology you know its small and then on top of that you know the assistance available to the farmers to use that technology”. The farmer IN6 also had the same opinion of IN5, and he said: "in this country, a lot of farmers are older, a lot older than me so they won't embrace information technology and I think in other countries there are younger farmers."

IN4 had a different opinion and believes that "Probably farming is so labor intensive and there has been that culture in Ireland, is that sometimes we find hard to you know give time to other aspects so if it is learning a new skill or looking at information technology systems that can benefit us, we don't put time in to it because there are so many aspects to farming that are required".

IN3 finds it due to the rising trend of doing other work other than farming "Our people to manage they have to work outside the farm as well." The speaker meant by “outside the farm” is that Irish farmers have to look for another job to maintain their life.

4.2.8 Farmers insight on young farmers
All the respondents have a different view about the opinion that Information Technology can bring young people into farming and the impact that new generation could bring in Irish
agriculture. The answerer IN6 says that “Young people bring new skill and it's happened in a lot of farms that the younger generation comes in and they're the ones to bring IT. So it's vital that young people enter the business”.

Farmer IN4 said it could attract young generation from the non-farming background as well "yes I think so, and it would probably attract more people from the non-farming background as well."

IN5 believes that Information Technology can attract young generation like it attracts the people in other industries "Yeah, I definitely think it would, yeah because young people are more and more as well as been drawn into other industries that have that kind of technology available to them and it basically you know the new language young people are embracing that so if you want to attract them to the likes of the agricultural industry, you know practical farming, then I think it definitely can lead to being incorporated into one way or other”.

IN2 believes that new generation is looking forward for the income they generated from farming and it is the primary factor that would attract them “you see the big difficulty with farming is the profit end of it and young people today are just going to be driven by you know they try to make them live. So first number one thing is finance for them, to be able to make a decent living and if they see if they can make a decent living in farming I think they’ll do well”.

IN1 also had a similar opinion "It depends on getting at the end of the week or end of the month."

The response from IN3 also supports the opinion from two farmers about Information Technology “I think it’d make them easier. Don’t think that attracts. So you know how we live anyway. It's small. You couldn't survive on one farming”.

4.2.9 Farmers view to improve from the present system

There are some suggestions from farmers that could promote the adoption of Information technology in farming. Most of the farmers say that there is a lack of awareness among the old farmers, but it's excellent among young farmers. IN4 said that media plays an essential role in keeping farmers informed. However medias were not concerned to prioritize the news
during drought in Ireland and as a result the message was not received well by farmers and lead to lack of production “Farming is such a seasonal activity, and there's always so much news in it that maybe sometimes that will get pushed down and not get headline news”. IN4 also said that discussion group is the best way to make Irish farmers to embrace Information Technology “I suppose, one of the best ways I think any way to get information across to farmers is through their discussion groups. It's kind of like a group of 20 farmers, and they might have guest speakers, so that is a very beneficial way because they don't have anything better than somebody standing in front of you telling you specifically your focus is on them”.

According to IN6 ease of use and cost plays a significant role in making farmers use the technology "Ease of use and expense, they're the two things that stop people. And it's getting cheaper to use it but ease of use is the most important thing and a lot of use smartphones now, so that has made it easy to use IT, it's not back in the office, it's in a phone in your pocket, so I think that's the most important thing that its mobile friendly".

However IN5 said that education could bring changes in agriculture and also government assistance with discussion groups would help in embracing new technology "it's a slow process, and I thought it would have to start from you know the education side of things so when young farmers have been educated that how technology can be incorporated on their farm. So I think that would be a good starting point is going to colleges and show how can government as of gone out to you know to establish the existing farmers, they have a discussion group and that and get in out of them and show on how the technology can be used”.

IN3 believes that a good source of information and informants will help farmers like her in using any technology "if we had information, if someone was able to present an awareness of how, comment to the farm, assess the farm and tell us what you could do this or that and this would make your life easier".

According to respondent IN2 cost and the grant would make farmers in using Information technology in their farm “cost reduction, some sort of grant, maybe 40 % or something like that”.
However, IN1 said contradictory to the opinion from other farmers, according to him, embracing new technology will be impossible among farmers above 70 years because it’s a human condition. When asked him whether there is lack of awareness among farmers he replied "While the younger ones no but, the older one yes. All older people by their very nature are always reluctant to change whereas the younger one is coming down any streets and you saw 4 and 5yr old on I pads, they might be watching some cartoons, but they are learning to use I pads before we all going to learn.”
Chapter 5

5 Discussion

The finding from the previous chapter is discussed in this session. The primary objective of this research is to find the reason for the slow adoption of SFT in Ireland compared to other countries. CC is an SFT, and its impact would be evaluated for a further conclusion of this research. The research would also answer regarding the adoption barrier between adopters and non-adopters farmers and would suggest the way to improve from the present system. This chapter will be divided into further sessions for explaining.

5.1 Determinant for the adoption of Cloud Computing

The research helps to find the main drivers for adoption. Socioeconomic factors like age, sex, education have an impact on the adoption of Information Technology. According to Pierpaoli et al. (2013) age of farmers on adoption varies. Distinguishing between the adopters and non-adopters with age difference is tough. However, in some cases, the young generation is more acceptable to new information (Pierpaoli et al., 2013). The response from the survey showed that young farmers in Ireland are adopting Information Technology like CC. The research of Knierim et al. says that demographic factor like age doesn't have any dependency on the adoption of Smart Farming in the European country (Knierim et al., 2018). However, the interview with old farmers in Ireland shows a strong reluctance to use new technology due to their lack of interest and the firm belief in their traditional farming. Interestingly, most of the non-adopter farmer's show interest in accessing CC technology in their farm. According to Knierim et al. (2018), farm size and farm type have a significant influence on the adoption of Smart Farming technologies (Knierim et al., 2018).
Size and perceived ease of use are competitive and contingent factors of Ex-Ante model. Perceived ease of use in the TAM model is influenced by other factors like education, support availability, computer efficiency and previous experience in using any technologies (Knierim et al., 2018). Dairy farmers in Ireland are observed more embracing new technology. Furthermore, small farm size is the primary reason for non-adopter farmers for not using any SFT in their farm. However, complexity and ease of use is another factor that makes them away from using new technology to all farmers. One of the farmers told that developing the software or mobile application less complicated would enhance their usability among the computer illiterate staff members. Complexity is the main factor that affects the adopters and non-adopter farmer equally in Ireland. However, a perception of complexity on use is high among the non-adopter farmers; In addition to this lack of experts to initiate the learning process among non-adopter farmers is another reason, the response from one of the farmer suggested lack of presence of informants on passing the information to explain its usability.

According to Ex-ante model Cost, perceived benefit and usefulness are other factors affecting the attitude of adoption. Cost is the main factor that makes farmers away from embracing any technology. The initial investment is a significant barrier for most farmers. However, a beef farmer told that he is unsure about its value and suitability of Information Technology in his farm. On the other hand, many farmers believe that SFT like CC would increase its productivity but skeptical about its benefits on their farm. It is observed that part-time farmers are less likely to adapt to CC technology. However, most of the non-adopter farmers had more than one job, and they earn less from the farming which makes them concern about investing to a new technology that they are not sure about its return of investment.

However, infrastructure factor like the absence of the internet also affect the adoption of technology among farmers in Ireland. Moreover, data security is another concern for farmers who already adapted to technology to go further improvement in their farm.
5.2 Farmers technological and information seeking behavior

There are many alternatives to seeking information for farmers to choose an innovation through a decision-making process. The source for data depends on individuals. It is tough to find a pattern of information seeking behavior of farmer and pattern would help in the extension of information and would help farmers to access the data from fewer sources without any error (Hill, 2009). The survey among Irish farmers shows that the digital platform has a high impact on information seeking behavior of Irish farmers. YouTube, WhatsApp, Facebook, and farming news portal are the primary digital sources used by farmers who adopted Cloud technology in their farm. The Non-adopters seek information through the paper, and other farmers and a small amount of farmer prefer TV and digital platform to explore the data.

The method of data documentary would help to analyze the working behavior of farmers, and all farmers who adopted technology use either diary or software or both for recording farming data events. A significant portion of Irish farmers use both methods to record the data and most of the farmer’s use Excel and other FMIS app to record the data.
5.3 Communication between farmers
A proper communication channel between farmers is needed for farmers to get more information about technology. Identifying the correct communication channel would help to introduce new technology to farmers and also help to pass information from the government, researchers and Agro-tech companies. However, the response from the Irish farmer shows that most of the farmers are communicated in the group meeting. Teagasc (2013) report on discussion group says that 20% of farmers who participated in such program are more likely to adapt to new technology. Furthermore, the participant in such discussion group should be in a stage to share all information regarding their farm to increase the knowledge between each other (Bogue, 2013). Knowledge transfer program introduced by DAFM (Department of Agriculture, Food and Marine) is a discussion group to increase the skill among Irish farmers. According to an interview with farmers in Ireland, non-adopter farmers are not aware of this program, although one from the non-adopter and adopter has a high opinion. However, sharing information and not implemented in the best way are the reason for some farmers to keep away. Social media, SMS, and Email also find a significant impact on the communication between farmers. However, it is observed that communication between farmers among non-adopters is lower than that of adopters and non-adopter farmers are skeptical towards sharing their information with companies due to lack of knowledge about the technology, data protection, etc.

5.4 Cloud Computing usage among Irish Farmers
One of the main objectives of this research was to find the rate of utilization of SFT among the farmers. Interestingly, more than 60% of farmers surveyed are using some information technology and out of that 70% uses cloud technology in their farm. It is good to know that more than 70% of farmers like digitalizing agriculture.

As discussed in the Finding chapter, most of the farmers make use Cloud technology for different application in the farm like recording animal events, then herd management, recording stock, financial budgeting. However, more than 25% of females make use of cloud technology. The response from one of the female farmer is that they find useful for paper works related to farm through the mobile platform. Another farmer use makes use of it in the office for updating information regarding stocks. Most of the farmers are making use of this for off-farm practices. However, some farmers use IoT sensor like Moocall for cows, application to record background farm data like PastureBase, an RFID tag.
Surprisingly, more than 55% of farmers who don't use any technology would like to make use of cloud technology in the future. Most of them would want to use technology for animal track and health, online application, GPS and yield mapping.

5.4.1 Perception difference between adopters and non-adopters
The approach of farmers towards using CC in their farm is positive, but perceptions of these farmers are different due to various reasons. While interviewing with farmers, all the adopters have the same view towards using CC. It makes their farming more easy to manage and efficient. However, non-adopters have a different view towards using CC. Different factors like lack of internet connectivity, age, strong traditional culture, and small farm size are the major perceptions of non-adopter farmers towards using CC in their farm.

5.4.2 Scope of Cloud Computing in Ireland
In the present scenario, utilizing CC technology had a great scope in Ireland. The survey from farmers says that they need more application for the heard management and financial budgeting. However, the response from farmers says that open cloud-based application is complicated to use. The Agro-Tech companies have a great scope in Ireland if they develop a more cloud-based app for farmers which is mobile friendly and easy to use.

According to the report of Teagasc Horticulture Development Department on drought condition says that it was tough to grow crops and vegetable in the outdoor. Gradually the input cost of production increased. It affected the irrigation, pest control, and harvesting and overall production plummeted (Teagasc, 2018a). Farmers suggested that the effective use of such technology as Israel did for controlled water usage. Smart Farming technologies could prove successful while in such adverse condition.

5.5 Farmers View to improve from the present system
There are specific suggestions provided by the farmers to improve the coordination and usability of technology among farmers in Ireland. Lacks of awareness among the farmers is the primary area to improve. Paper is the medium where most of the non-adopter farmer which mostly having small farm size check to update information on new technology in Ireland. However, an answer from one of the respondent said that during drought, headlines in the newspaper were pushed down, which leads to ineffective awareness among farmers.

As discussed before in this chapter, the discussion group should be encouraged and is another area to improve where more farmers would meet themselves and exchange information.
Education among the young generation is another factor suggested by the farmer. According to Teagasc survey, it is found that the average age of farmers is increasing all the year which stands 57 year in the latest study (Donnelly, 2015). Educating young farmers and make them grow interested in agriculture with new technologies like any other industry, would have a more significant impact on Irish farms. 50% of farmers interviewed have an insight that digitalizing agriculture would attract more youth and they are the generation to bring new ideas to farm. However, another 50% believes that income from the farm would determine the participation of young farmers.

As discussed, ease of use and reduction of the cost would help in increasing the adoption behavior of farmer, but farmers are expecting grants from either government or Agro-Tech companies — however, schemes like TAMSII that encourage especially the young farmers to avail a subsidy of 60% of the invest in technologies and other infrastructure (McMenamin, Adviser and Longford, 2018). An expert having information on all available technology in every discussion group of the farmer, as suggested by one of the farmers, it would increase the knowledge among non-adopter farmer as well as adopted farmers on new technology.

5.6 Slow adoption compared to other countries

Teagasc technological foresight 2035 report states that technology adoption among Irish farmers is traditionally low. According to them educating farmers on new skill and expertise need a fully informed advisory board, appreciation for the change and drivers for change (Teagasc, 2016). As we discussed in the Finding chapter demographics of age, have a strong influence in low adoption rate in Ireland. The more experienced farmers above 65 years of age strongly believe in their traditional farming and reluctant to digitalize technology. Moreover, when they give the farm to the next generation, they also follow the same path and won’t go further for any adoption in their farm. The respondent who interviewed would like to make use of herd management software and IoT sensor, even though her dad is not ready to accept any new technology. The response shows the influence of aged farmers towards family members. There is a lack of skilled and informed advisory board in Ireland to keep up to date and encourage farmers. Countries like India is having small farm size and aged farmers like Ireland, but the advisory committee is having a strong interaction with farmers and help them to learn new technology by encouraging farmers with new schemes available to them.
Change in the interest of the young generation is another factor that affects the technology adoption in Irish farms. The response from the farmers implies that the next generation would be attracted if they sense a good income from the farm. However, young and old age should work in tandem to enhance the condition in the farm. Moreover, most of the farm in Ireland is small size and unavailability of suitable technology with less initial investment is another reason. Response from non-adopter and adopter farmer that makes them away from using SFT is cost. There is no grant available, or farmers are not aware of the subsidy available to use new technology. However, the change is still needed to be monitored after the introduction of TAM II in Ireland. Countries like Singapore, Vietnam, and Israel encourage farmers to use precision technology by providing the grant.

Data ownership is another reason; Countries like Netherland open the farm data for the public helps the farmers in the decision-making process. However, farmers in Ireland are skeptical about the data sharing. However, the response from the Irish farmers is that they give value to their data and that makes them not interested in a program like Knowledge Transfer Program.

However, these are the main problem that affects farmer in slow adoption compared to other countries. No access to internet and location of farm in remote area is also the reason, and it was evident from the responses of farmers interviewed.
Chapter 6

6.1 Conclusion

The research ended up in the stage of conclusion after proper reasoning of factors and comparison. The main objective of the paper was to find the reason on slow adoption to Smart Farming Technology in Ireland. However, after proper reasoning of the quantified data and opinion from farmers study finds that demographic age is the primary reason highlighted from most of the non adopters, lack of strong advisory board to communicate with farmer and lack of interest of young generation are also major reason effecting Ireland.

Research also helped to find the perception difference between adopters and non adopters. After conversation with two different groups of farmers, aged farmers showed Strong reluctance to use new technology because of their lack of interest to learn new thing and strong believe in their traditional farming system. However, major portion of the farmers adopted CC in their farm are young farmers with strong belief that these technology could bring change in the farm and increase efficiency.

There is a great scope of SFT like CC in Ireland and can be effectively utilized in irrigation system as explained in literature review and also more cloud based application supporting in mobile format in herd management and accounting would bring great reception among farmers. This would be good for new and existant Agritech companies to work on.

After analyzing the results the best way to improve adoption of any SFT in Ireland is, to have a strong advisory board, giving allowance and grant in using Smart Farming Technologies in farm can increase adoption rate among the adopters and non-adopters, and effective use of discussion groups like Knowledge Transfer program.

However, it is good to know the information seeking and communication channel of of farmers. Paper is the medium where most of the non-adopter farmers update their information about new technology whereas; YouTube, Whatsapp, and Facebook are the digital platform having strong influence in information seeking behaviour of adopters. Discussion group is channel where most of the farmers communicate and utilizing this group effectively could bring remarkable changes.

Ireland still needs attention to encourage more Agro-Tech companies to bring development in the farm with the farmer needs. There are certain areas where more cloud technology can be utilized to bring successful by developing a mobile application and IoT technologies in herd management and financial budgeting. Adoptions are relatively high among the dairy farmers.
However, it is crucial to develop cloud-based app among the beef/sheep and tillage farmers as well. It is encouraging to see that most of the young generations have a positive attitude towards using cloud technology in their field.

Educating youth, Digitalizing farm and promoting agricultural benefit in the school would attract more young generation from the non-background as well. However, all this taken into account Ireland is in a transitional phase but a strong awareness and coordination between farmers, researchers and government are needed for further enhancement in the rural area.

Finally, the research question demands a conclusion that “Smart Farming Technology like Cloud technology will prove helpful in developing Irish agriculture. However, the reception is partial but certainly in a transitional phase. Age, cost and, lack of awareness is the main barrier among non-adopters while lack of allowance, unavailability, ease of use and data ownership is barrier among adopters. This certainly supports the reason for slow adoption rate but the involvement of more young farmers will be a game changer in Irish agricultural industry and soon Irish farms in the near future will be bright and digitalized.”

6.2 Research Limitation

The research faced many obstructions in finding the respondents. Since, the research demand survey and Interview, it was very hard to find a sample size for surveying. However, data protection rule hardly effected research to find an appropriate audience. Direct visiting in farms was hard and time-consuming considering the time available for research but helped in finding respondent for an interview, but research was demanding more farmers for the survey and Seeked assistance from Teagasc, IFA, Macra Na Feirme, and DAFM to find proper audience for this study but they were unable to help due to GDPR law. Following the mixed method, the process was time consuming due to large amount of data. However, Social websites like LinkedIn and Facebook was helpful in finding appropriate recipients. Thankful for the two farmers known through LinkedIn, who helped in finding the audience and shared the Google form in their group of farmers and even referenced farmers for Interview. The snowball sampling method helped to complete the research and to find some leads.
6.3 Future Recommendation

A study is needed among farmers in other departments of agriculture like the pig, poultry, and fishing that could bring more insight to understand farmers. Encourage farmers in discussion group would be very productive to bring any changes in current system of Ireland agriculture. Moreover, research recommends to improve the communication channel between advisory board and more awareness should be given to small holders because there will be farmers who like to know about new technology but don’t have a source to access information. Introducing grant not only to attract young people but for older people can bring changes in the technology acceptance behaviour of Irish farmers. The youth are future of Ireland and Irish agriculture, a discussion group in schools related with importance of agriculture and informing the students with new Information Technology available in farm would be a greater start for better tomorrow.
Reference


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Appendices

a. Personal Reflection

This session shares about my (researcher) experience in dissertation and master program.

I still remember my lecturer told in the Research method (Rm1) class. Dissertation is the time where you learn more about yourselves and beyond. It doesn’t mean that I didn’t learn anything during my masters but research shaped me as a person. I worked in group for assignment in college and it teaches me to be a team player but in group assignment it will be very hard to find our limits. When I came across doing dissertation proposal, I really think a lot to find a topic that equally beneficial and relevant for the society. The concept of smart farming came to my brain when I read an article about Netherland published by National Geographic Channel. I was surprised, when I heard the fact that Netherland is the second largest agriculture exporter in world. They utilize smart farming technology effectively. However, it was after many discussions with lecturer helped me to shape my research and research question specific in Irish context. Ireland is larger than Netherland and is an IT hub too but still adoption of new technology lacks among farmers, this concept actually helped me to build my research question. After the submission of my proposal and when I got mail “proceed for dissertation” makes me happy and anxious simultaneously.

At the beginning I find it really easy to kick start my research. Introduction session was easy to write it down because it was extension to proposal that I already have. When it comes to second chapter literature review, the process was time consuming. It was really hard to find the relevant journals to build themes in literature session especially in Irish context. I discussed with my supervisor and he guides me to complete the session and made me aware of proper citation to be used. Writing assignments in masters actually helped me when I started my literature session for research. At the end, I was able to shape my literature review even though it took little time but it helped to understand more about study the Smart Farming Technology and its practices in other countries.

Research method chapter doesn’t consume much time which helped me to concentrate more on literature review. However, time during data collection method was stressful. I approached many agricultural department but they were not able to help me due to data protection law. As a student, I have limited network with people over here. There was time where I was really stressed out because I couldn’t find any farmers before the timeline given by supervisor. I discussed with him and he supported me. However, I realized that there will be challenges for every research and I didn’t make my stress to take over me. I started networking through social website and even visited farm place nearby. It actually teached me to network with people and made me able to find farmers after a long hard work. Keeping the ethics lesson taught in my college helped me in keeping trust with all the farmers.

The data collection method was time consuming because of the there was a large amount of data collected that need to be converted into useful information such that it could answer my research questions and objective. It was during this time I learnt using CAQDA software like
MAXQDA and NVivo for my data analysis. The conclusion is made on the basis of data obtained and was able to answer the research question and objective. The supervisor guidance had really helped me throughout the process to shape my research.

Dissertation was actually training for me to control the stress and emotion within me. It made me learn to never back down. It also developed me as a person to work in pressure without any stress. I can frankly say without any hesitation that this research had built me as a person as well as a student. Masters program helped me to handle the situation in a productive manner and taught me the ethics to be followed. I’m really thankful to my college and lectures for giving such an opportunity. Furthermore, I’m really obliged to my supervisor because without his guidance and support I wouldn’t have completed my research.
b. Format for information Sheet

INFORMATION SHEET FOR PARTICIPANTS

PROJECT TITLE

Scope of Cloud Farming In Ireland

The research aims to find answers for Ireland’s slow advancement towards adopting the concept of smart farming technology within their farming process compared to other countries and this research will also answer the impact and acceptance of cloud computing technology in farming among the Irish farmers.

My name is Jithin Das v, a student of Dublin Business School pursuing MBA in Cloud computing. My research is supervised by my supervisor Mr. Abhisherk Kaushik and is affiliated to Dublin Business School.

WHAT WILL HAPPEN

In this study, you will be asked to...

The participants of this research will be asked to complete a questionnaire that comprises of questions related to information technology and behavioural of Irish farmers. After the completion, a face to face or telephonic interview will be held based on the availability of participants.

The following ethics are considered in the research

1. The age of the participants will be above 18+ ages.

2. No sensitive or confidential information of answerer will not be asked to disclose.

3. The privacy of respondents will be protected.

4. Respondents won’t be subjected to any mental and physical harassment throughout the process.

TIME COMMITMENT

The study typically takes 5-10 minutes to complete the questionnaire session and 15-20 minutes for the interview after the questionnaire. I respect for your precious time and you can stop the interview session at any time as per your convenience.

PARTICIPANTS’ RIGHTS

The interview will be recorded only for the purpose of analysis of my research.

You may decide to stop being a part of the research study at any time without explanation required from you. You have the right to ask that any data you have supplied to that point be withdrawn/destroyed.
You have the right to omit or refuse to answer or respond to any question that is asked of you. You have the right to have your questions about the procedures answered (unless answering these questions would interfere with the study’s outcome. A full de-briefing will be given after the study). If you have any questions as a result of reading this information sheet, kindly request to ask me before the study begins.

CONFIDENTIALITY/ANONYMITY

The data I collect does not contain any personal information about you except the name, age, education, and basic farming details. All these information is used only for my research. However, your request would be accepted and respected if you wish to stay anonymous and not to mention the name anywhere in the research document. All the data collected will be secured and will be kept confidential and won't be disclosed to any third person.

FOR FURTHER INFORMATION

I Jithin Das V and Mr. Abhishek Kaushik will be glad to answer your questions about this study at any time. You may contact me at 10360975@mydbs.ie or my supervisor at abhishek.kaushik@dbs.ie.
c. Informed Consent sheet format

INFORMED CONSENT FORM

PROJECT TITLE: Scope of Cloud Farming In Ireland.

PROJECT SUMMARY: Digital or smart farming is a technology that makes utilization of Precision Farming innovation and furthermore it make use of data management tools and intelligent networks. Beecham report (2017) says that smart farming need to be advanced to meet the growing need of foods by consumers. Saverio Romeo, Beecham chief research officer says that the UN estimated that there should be an increase of 70% of production of food by 2050 and furthermore, for the sustainable use of crop in optimised way Beecham report suggest farming should start accepting smart farming technology. The Research Mainly aims at answering the slow adoption level of Ireland towards smart farming comparing to other countries and also try to answer the significance of cloud computing in Smart farming of Ireland.

By signing below, you are agreeing that: (1) you have read and understood the Participant Information Sheet, (2) questions about your participation in this study have been answered satisfactorily, (3) you are aware of the potential risks (if any), and (4) you are taking part in this research study voluntarily (without coercion).

__________________________________  _________________________
Participant’s signature                    Participant’s Name (Printed)

JITHIN DAS V

__________________________________  _________________________
Student Name (Printed)                    Student Name signature

__________________________________
Date
d. Online survey consent form

SCOPE OF CLOUD FARMING IN IRELAND

INFORMATION SHEET FOR PARTICIPANTS

PROJECT TITLE: Scope of Cloud Farming in Ireland.

AIM OF THE RESEARCH
The research aims to find answers for Ireland’s slow advancement towards adopting the concept of smart farming technology within their farming process compared to other countries and this research will also answer the impact and acceptance of cloud computing technology in farming among the Irish farmers. My name is Jithin Das V, a student of Dublin Business School pursuing MBA in Cloud computing. My research is supervised by my supervisor Mr. Abhishek Kaushik and is affiliated to Dublin Business School.

WHAT WILL HAPPEN
The participants of this research will be asked to complete a questionnaire that comprises of questions related to information technology and behavioral of Irish farmers. After the completion, a face to face or telephonic interview will be held based on the availability of participants. The following ethics are considered in the research:
1. The age of the participants will be above 18+ age.
2. No sensitive or confidential information of answerer will not be asked to disclose.
3. The privacy of respondents will be protected.
4. Respondents won’t be subjected to any mental and physical harassment throughout the process.

TIME COMMITMENT
The study typically takes 5-10 minutes to complete the questionnaire session and selected respondents may be subjected to 15-20 minutes for the interview after the questionnaire. I respect for your precious time and you can stop the interview session at any time as per your convenience.

PARTICIPANTS’ RIGHTS
You may decide to stop being a part of the research study at any time without explanation required from you. You have the right to ask that any data you have supplied to that point be withdrawn/destroyed. You have the right to omit or refuse to answer or respond to any question that is asked of you. You have the right to your questions about the procedures answered (unless answering these questions would interfere with the study’s outcome). A full de-briefing will be given after the study). If you have any questions as a result of reading this information sheet, you should ask the researcher before the study begins.

CONFIDENTIALITY/ANONYMITY
The data I collect does not contain any personal information about you except the name, age, education, and basic farming details. All these information is used only for my research. However, your request would be accepted and respected if you wish to stay anonymous and not to mention the name anywhere in the research document. All the data collected will be secured and will be kept confidential and won’t be disclosed to any third person.

FOR FURTHER INFORMATION
Jithin Das V and Mr. Abhishek Kaushik will be glad to answer your questions about this study at any time. You may contact me at Jithin.DasV@mvbs.ie or my supervisor at abhishek.kaushik@db.ie.

By selecting the Yes option below, you are agreeing that: (1) you have read and understood the Participant Information Sheet, (2) questions about your participation in this study have been answered satisfactorily, (3) you are aware of the potential risks (if any), and (4) you are taking part in this research study voluntarily (without coercion).

07/01/2019

1. I accept *
Mark only one oval.

☐ Yes  Skip to question 2.

☐ No  Stop filling out this form.

SCOPE OF CLOUD FARMING IN IRELAND
Note - All the 32 respondents participated in the survey had signed consent form digitally through Google form as shown above. All the participant appeared for interview have done survey through Google form and digitally accepts the consent form.
e. **Interview Questionnaire**

1. What is your view on maintaining the farm with help of cloud computing technology?
2. Do you think that such adoption to information technology will have a greater impact on agriculture? What's your opinion about that?
3. What will be your take if you can control the farm maintenance from one place using smart phone and computer? Do you think it will make farming easy? If no what would be the problem?
4. Do you think the development of new information technologies on the farm would affect the role of the farmer? What’s your opinion?
5. What factors you look at before you using any information technology in your farm? What makes you away in using any technologies?
6. What do you expect from the government or any IT companies to favor technologies on a farm?
7. As a farmer what is your opinion regarding the strength and weakness of an Irish farmer compared to farmers from other countries?
8. Do you think there is a lack of awareness program between the farmers in Ireland in embracing any technology? What do you think about it?
9. How it can be improved from the present system?
10. Many countries like Israel are turning desert into agriculture with the help of smart farming technologies, what do you think the technology can change in Irish agricultural system?
11. Do you know Knowledge transfer scheme? What's your opinion about that?
**f. Survey Questionnaire**

Section

1. What is your Gender? * Mark only one oval.
   a) Female
   b) Male
   c) Prefer not to say

2. What is your Age group? * Mark only one oval.
   a) 18-24
   b) 25-44
   c) 45-64
   d) Above 65

3. What is your education level? * Mark only one oval.
   a) Primary
   b) Lower Secondary
   c) Upper Secondary
   d) Third level non degree
   e) Third level degree
   f) Post-Graduate
   g) Other:

4. Are you doing any job other than farming? * Mark only one oval.
   a) yes
   b) No

5. What type of farm you do? * Check all that apply.
   a) Dairy
   b) Beef
   c) Tillage
   d) Sheep
e) Poultry
f) Other:

6. Do you follow mixed farm?
   a) Yes
   b) No

7. Do you think information technology can make farm management easier? * Mark only one oval.
   a) Yes
   b) No

8. Are you using any information technology in farming? *
   (The technology such as sensors, Location-based services, automated systems, use of farm management etc can be accessed with the help of your Smartphone and computer).
   a) Yes Skip to question 9.
   b) No Skip to question 17.

Adopters

(Following questions are for respondent’s adopted information technology in farming)

9 If yes, what technology are you using?

10 What kind of record keeping do you follow to keep your farming details? * Mark only one oval.
   a) Software
   b) Book/diary
   c) Both

11. Are you using any cloud computing technology for your farm? *
   (Cloud computing is the technology to connect many IT backend tools such as network, storage space, server space and other services to people with the help of internet connectivity, such that it is independent of the resource and location. for example
   a) Blogs
   b) Other:
14. Currently do you use any IT application in Smartphone for any farming related services? * Mark only one oval.
   a) Yes
   b) No

15. If yes, for what purpose?

16. What is your area of preference where more farming application should be developed? * Check all that apply.
   a) Supply chain
   b) Herd management
   c) Accounting
   c) Precision Information (like weather, humidity,Gps tracking etc)
   e) Above all

(Skip to question 22.)

**Non Adopters**

(This section for farmers not adopted any technology in farming)

17. would you, like to adopt any information technology in future? * Mark only one oval.
   a) Yes
   b) No
   c) Maybe

18. If yes, what type of technology in future?

19. What are the major difficulties in adopting technology in your farm? * if Other, please specify. Check all that apply.
   a) Initial Investment
   b) Complexity to use
   c) Technology is inappropriate for farm
   d) Not sure about its value
   e) No proper communication regarding the technology
   f) Small farm size
g) Data sharing

h) Other:

20. How do you update new technology in farming? * if you checked "other" from options, please specify. Check all that apply.

   a) Paper
   b) TV
   c) Digital news
   d) Youtube
   e) Whatsapp
   f) Twitter
   g) Other Farmers
   h) Other:

21. If you can track all the transaction, weather, soil, crop/animal information of your farm through a platform in your mobile. Will you accept and try to learn such technology? * Mark only one oval. a) Yes

   b) No

   c) Maybe

Skip to question 22.

Continuation

22. Do you follow any country who use advanced farming using information technology? * Mark only one oval.

   a) Yes

   b) No

23. If yes, specify the country name?

24. What is the medium you use to communicate with other farmers in Ireland? * Check all that apply.

   a) E-mail

   b) Personal letters

   c) Intranet
d) Magazines or papers
e) SMS
f) Social media
g) Group Meeting
h) Other:

25. How can you rate the communication with other farmers for the exchange of information? * Mark only one oval.
   a) 1
   b) 2
   c) 3
   d) 4
   e) 5

26. What you think about sharing information with other IT technologies can bring more development in farming? * Mark only one oval.
   a) Yes
   b) No
   c) Maybe

27. If No/maybe, what would be the reason?
   (Please enter NIL if your previous answer to question was YES)

28. Do you like digitalizing agriculture? * Mark only one oval.
   a) Yes
   b) No
   c) Maybe