Satellite technologies in UK agriculture

A Pathfinder study funded under the National Space Technology Programme (NSTP)

RESEARCH REPORT

Prepared by:

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CATAPULT Satellite Applications

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About London Economics

London Economics (LE) is a leading independent economic consultancy, headquartered in London, with a dedicated team of professional economists specialised in the application of best practice economic and financial analysis to the space sector. As a firm, our reputation for independent analysis and client-driven, world-class and academically robust economic research has been built up over 25 years.

Drawing on our solid understanding of the economics of space, expertise in economic analysis and best practice industry knowledge, our space team has extensive experience of providing independent analysis and innovative solutions to advise clients (public, private and third sectors) on the economic fundamentals, commercial potential of existing, developing and speculative market opportunities to reduce uncertainty and guide decision-makers. All consultants on our space team are highly-qualified economists with extensive experience in applying a wide variety of analytical techniques to the space sector

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About the Satellite Applications Catapult

The Satellite Applications Catapult was established in May 2013 as an independent innovation and technology company, created to drive economic growth through the development of satellite applications. The Catapult helps organisations make use of and benefit from satellite technologies, and bring together multi-disciplinary teams to generate ideas and solutions in an open innovation environment. The Catapult receives grant funding from the UK government via Innovate UK, in order to achieve these goals. The Satellite Applications Catapult has recruited highly qualified and skilled individuals across a range of disciplines to support the activities of SMEs and industry partners. It also has a wide range of facilities and laboratories to further support projects.

About the National Space Technology Programme

The National Space Technology Programme is funded by the UK Space Agency, with the goal to advance UK satellite technologies to higher technology readiness levels (TRLs), to support UK industry's ability to accelerate innovation, and to expand sales in both institutional and commercial space markets. The NSTP is managed by the Centre for EO Instrumentation and Space Technology (CEOI-ST) on behalf of the UK Space Agency.

With a vision to develop and strengthen UK expertise and capabilities in EO instruments, CEOI-ST is helping to position the UK to win leading roles in future international space programmes. The Centre was created in 2007 and is funded by the UK Space Agency and industry, with the aim to develop key capabilities through the teaming of scientists and industrialists. It supports projects to design and build new EO instruments and also runs a range or workshops, conferences and training courses. The Centre is set up as a partnership led by Airbus DS together with the University of Leicester, STFC/Rutherford Appleton Laboratory and QinetiQ.

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Executive Summary

The need for sustainable, efficient and cost-effective methods of farming has never been more pressing. As the global population continues to rise, the challenge to meet global food demands in a sustainable manner is becoming increasingly important. At the same time, farmers are being put under increasing pressure by prevailing market conditions.

Agricultural science and technology, known as 'agri-tech' – in particular that enhanced by satellite-enabled services – is an important facilitator towards a solution. For this reason, satellite-enabled agri-tech is one of the world's fastest growing sectors and, along with satellites, has been strategically identified by the government as one of the *Eight Great Technologies* in which the UK is set to be a global leader.

However, the take-up of such technologies in agriculture has been slower than expected and, despite its importance, there has been limited study of adoption and the constraints on its growth.

London Economics, in collaboration with Satellite Applications Catapult, set out to fill this evidence gap by conducting a market study on the current nature and extent of satellite technology application usage, the underlying drivers of demand, and adoption barriers in the UK's agricultural sector.

This research report outlines the findings of an online survey to farmers, which shows from a small sample of 50 respondents that farmers are aware of satellite-enabled agri-tech and use a wide variety of its applications.

Users gain from reduced input costs, increased quantity and quality of output, and environmental benefits, but still experience cost, mobile signal reliability, and equipment compatibility and standardisation problems.

There are also barriers to take-up present, including costs, reliability of mobile internet signal on the farmland, insufficient technical knowledge, and the benefits of the technology being unclear. Almost all current users sampled would like to see better standardisation of the equipment, software, and data across vendors and systems.

Understanding the circumstances and factors that influence the adoption of satellite technologies is crucial for developing targeted strategies to increase awareness of its benefits, overcome adoption barriers, and drive adoption. The information in this report provides guidance to policy-makers in the design of engagement and support programmes, and to the satellite industry to seek out opportunities in the agricultural sector.

Although robust and user friendly, this survey research does have its limitations. The report however provides a good starting point and provides UK-specific insights, and paves the way for further iterations of research into this growing market.

1 Introduction

1.1 Policy context

The need for sustainable, efficient and cost-effective methods of farming has never been more pressing. As the global population continues to rise, the challenge to meet global food demands in a sustainable manner is becoming increasingly important. At the same time, farmers are being put under increasing pressure by prevailing market conditions.

Agricultural science and technology, known as 'agri-tech' – in particular that enhanced by satellite-enabled services (henceforth satellite-enabled agri-tech) – is an important facilitator towards a solution. For this reason, satellite-enabled agri-tech is one of the world's fastest growing sectors and, along with satellites, has been strategically identified by the government as one of the *Eight Great Technologies* in which the UK is set to be a global leader.

However, the take-up of such technologies in agriculture has been slower than expected and, despite its importance, there has been limited study of adoption and the constraints on its growth.

1.2 Research objective

London Economics, in collaboration with Satellite Applications Catapult, set out to fill this evidence gap by conducting a market study on the current nature and extent of satellite technology application usage, underlying drivers of demand, and adoption barriers in the UK's agricultural sector. Understanding the circumstances and factors that influence the adoption of satellite technologies is crucial for developing targeted strategies to increase awareness of its benefits, overcome adoption barriers, and drive adoption. This information will also provide guidance to policy-makers in the design of engagement and support programmes, and to the satellite industry to seek out opportunities in the agricultural sector.

The study focused on the use of Global Navigation Satellite System (GNSS) in precision farming in the UK, but also included Earth Observation applications and Satellite Communications. Our two-pronged methodology involved **desk research** on the existing evidence on global adoption trends of satellite technologies in agriculture, and an **online survey of farmers in the UK** to measure actual adoption patterns, discover experiences of benefits and difficulties of usage, and barriers to its take-up.

Ultimately, the research aims to inform policymakers on how to boost adoption of satellite-enabled agri-tech in the UK, enabling farmers to reap the benefits of greater efficiency, higher yields, increased sustainability, and reduced environmental impact.

1.3 Report structure

This section (**Section 1**) introduces the scope and objectives of the research, whilst noting the limitations of the analysis. **Section 2** presents a review of previous studies, providing a solid foundation in the drivers and barriers for the adoption of satellite-enabled agri-tech, as well as guidance of methodological issues in relation to the survey design and sampling. **Section 3** outlines the survey methodology and characteristics of the achieved sample. **Sections 4 to 7** present the new evidence from our survey of UK farmers on the current usage pattern of satellite-enabled agri-tech, the benefits that users are experiencing, and the difficulties they presently face, as well as the barriers to adoption for non-users. **Section 8** concludes, with lessons for future research.

1.4   Caveats and limitations

Despite the research having been conducted using best practise and executed without any technical difficulties, we list below a range of important limitations to the analysis, and associated caveats attached to the results, that should be borne in mind throughout. These equally represent improvements that could be made for future iterations of this research.

- The response rate was low, with only 50 complete responses received.
    - Though this sample permits basic analysis to reveal some interesting insights on patterns and messages from respondents, it is not large enough to extrapolate to produce a nationally representative sample with representative findings. Thus the observed patterns may be specific to the respondent sample.
- The achieved sample is also almost certainly biased.
    - The sample is comprised of a high proportion of users of satellite-enabled agri-tech, who tend (based on the observed responses) to be highly educated and technologically literate. Therefore this cannot be taken as a broad adoption rate.

2   Review of relevant literature and previous studies

Farmers' *ex ante* attitude towards precision agriculture can be understood using the **Technology Acceptance Model** (TAM) (Davis, 1989), which is a theoretical model that is used to explain adoption of new technologies. Farmers' attitudes are most influenced by the **Perceived Usefulness** (PU) such as potential increases in profitability and the **Perceived Ease of Use** (PEU), which can be influenced by other factors such as education, previous experience, support availability, etc (Pierpaoli et al., 2013). Some research suggests that PU and PEU could be equally important in driving precision agriculture technology adoption (Folorunso and Ogunseye, 2008; Rezaei-Moghaddam and Salehi, 2010; Aubert et al., 2012). This means that **both the potential benefits of precision agriculture and ease of using the technology should be concurrently addressed to drive adoption.**

Some studies also find that a positive attitude to adopt precision agriculture technologies is positively correlated to the quality of soil and farm size (Hudson and Hite, 2003; Adrian et al., 2005; Marra et al., 2010).

Turning to the *ex post* reasons why farmers who adopted precision agriculture did so, the most important **drivers of adoption** identified in the literature were **farm size**, **net benefits**, **total farm income**, **land tenure**, **farmers' education and familiarity with computers**, and **location of the farm** (Pierpaoli et al., 2013). Of these factors, **farm size** was most frequently cited and the **farmer's confidence with computers** is cited as the second most important driver of adoption.

The other side of the same coin are the **barriers to adoption** of precision agriculture. **High machinery costs**, **time requirements** and **lack of compatibility between different products** were identified as key barriers for German farmers (Reichardt and Jurgens, 2009). These reasons, along with a **lack of technical knowledge** were also cited by farmers in the UK, USA and Denmark (Fountas et al., 2005; Pedersen et al., 2004).

Our desk research also revealed **three** recent surveys on adoption of space technologies in agriculture in Europe, which are summarised overleaf. The questionnaires from these surveys were the starting point for our survey design.

Table 1   Summary of recent surveys on adoption of precision agriculture in Europe

Title and Author	Key findings	Methodology
"Farm Practices Survey Autumn 2012 – England" by the Department for Environment, Food and Rural Affairs (DEFRA)[1]	■ Proportion of farms surveyed using the following precision farming techniques: GPS (22%), soil mapping (20%), variable rate application (16%), yield mapping (11%), telemetry (2%). ■ The proportion of farms using precision farming increased in 2012 compared to 2009, which GPS technology seeing the largest increase. ■ The two most common reasons for using precision farming were to improve accuracy (76%) and reduce input costs (63%). ■ Of those who did not use precision farming, 47% said they did not because it was not cost effective and/or initial setup costs were too high.	■ Sample size of 2,731 farms in 2012 ■ DEFRA regularly conducts its Farm Practices Survey (FPS) to collect information on a diverse range of topics. In autumn 2012, the FPS contained a section on precision farming (3 questions). ■ The FPS is a voluntary postal survey, and stratified random sampling is used to invite a representative sample of farms to do the survey.
"Uptake of GNSS technology amongst Danish farmers" by Jens Peter Hansen, Knowledge Centre of Agriculture (2013)[2]	■ 18% of farmers use some form of GNSS technology on their machines. ■ Of those who use GNSS technology, the largest group (41%) use RTK, followed by EGNOS (29%) ■ Of those who do not use GNSS technology, 51% said their "farm was too small", and 38% said they "don't think it will pay off".	■ Sample size of more than 6,000 farms ■ As part of a survey about mobile phones (4 questions on space technologies in agriculture) ■ E-mail with link sent to 14,000 Danish farmers; all respondents were registered users of main portal for Danish farmers.
"Identified user requirements for precision farming in Germany, Finland and Denmark" by Jens Bligaard, Knowledge Centre of Agriculture (2012)[3]	■ 36% of farmers surveyed had previous experience in using precision farming techniques and 27% said they planned to invest in precision farming in the next 1-2 years ■ 55% of farmers surveyed were using a desktop farm management system ■ In terms of possible barriers, only 59% of farmers surveyed often or always had reliable mobile Internet access in the field. 27% often or always experienced difficulties due to 'language problems' between different farm equipment or between their farm equipment and a software program. ■ In terms of needs, no more than 18% of farmers surveyed would be willing to wait 3 or more minutes extra per field task (e.g. for typing in information or waiting for a GPS signal).	■ Sample size of 194 farmers (from Germany, Finland and Denmark), out of a total of 257 respondents ■ Online survey of 21 questions ■ Publicised via agricultural portals in each country

Source: Various, see corresponding footnotes

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[1] Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/181719/defra-stats-foodfarm-environ-fps-statsrelease-autumn2012edition-130328.pdf
[2] Available at: http://www.project-unifarm.eu/News/Newsarticle/tabid/225/ArticleId/81/18-of-Danish-farmers-use-GNSS.aspx
[3] Available at: https://www.landbrugsinfo.dk/Planteavl/Praecisionsjordbrug-og-GIS/Sider/identified-user-requirements-for-precision-farming_pl_13_1369.aspx

3   Research methodology and sample

This section contains a technical description of the work performed. An overview of the survey design is provided, followed by a description of the survey sampling.

3.1   Survey design

The survey was designed such that respondents were asked questions relevant to their **current awareness and use** of satellite technologies in agriculture. Based on his/her answers, a respondent would be classified into the following groups (based on Gumpertsberger and Jürgens, 2003; Reichardt and Jürgens, 2009):

- **Uninformed farmers:** farmers who were unaware of satellite-enabled agri-tech and currently do not use any of these technologies.
- **Informed farmers:** farmers who are aware of satellite-enabled agri-tech .
  - □ **Informed users:** famers who are aware of and currently use satellite technologies at their farms.
  - □ **Informed non-users:** farmers who are aware of but do not currently use satellite technologies at their farms.
    - – **Informed potential users:** farmers who plan to use satellite technologies at their farms within the next 3 years.
    - – **Informed long-term non-users:** farmers who are not intending to use satellite technologies within the next 3 years.
    - – **Informed abandoners:** farmers who previously used satellite technologies but stopped using them.

All respondents were also asked about their farm characteristics (e.g. hectares farmed, type of crop/livestock), demographic variables (e.g. education level, computer literacy), and other circumstances (e.g. availability of mobile Internet in the field). In order to inform education and engagement policies, all respondents were also asked how they currently learn about new technologies and farming practices.

3.2   Survey administration

We collected primary data about satellite-services adoption trends and preferences from the UK's agriculture sector via an **online survey**. We adopted a robust and user-friendly survey design methodology as follows:

- **Content:** The survey questions were modelled after the UNIFARM and Danish studies. As examples, these included questions about current level of satellite technologies adopted (e.g. soil condition mapping, variable rate application) and the benefits experienced, the systems installed, ranking of importance of various satellite services, and the main barriers to adoption. The survey also studied the extent of use of various Earth Observation (EO) technologies (e.g. optical data, infrared images, Synthetic Aperture Radar (SAR) maps) and identified the most frequently used products and services.
  - □ A copy of the survey questionnaire is available on request from London Economics.
- **Sampling:** Adoption of and attitudes towards Global Navigation Satellite System (GNSS) technologies (commonly known as Sat Nav) tend to be correlated with farm size (early

adopters of GNSS technologies tend to be larger farms) and crop type. We hoped that our survey sample would be representative of the national distribution along these parameters (and others discovered during our desk research). Based on initial contact with associations and bodies we were confident of achieving a survey sample that is large enough for the required sample-wide and sub-group analysis. However, a noted limitation of the research is a small sample size: the response rate to the survey was considerably lower than anticipated at 50 responses – precluding representative analysis.

- **Administration:** The survey was administered online, open from 10 June 2015 to 14 August 2015. Invitations to participate were distributed using a 'push' approach, published via the following channels:

  □ Organisations who piloted/reviewed the survey: *Aerovision, SEGES (merger of Knowledge Centre for Agriculture/Danish Pig Research Centre), Velcourt.*

  □ Organisations who promoted the survey to members: *Agriculture and Horticulture Development Board , Agri-tech East, AGspace, Duchy College, Home Grown Cereals Association, National Farmers' Union Scotland, National Sheep Association, Reed Business Information (Farmers Weekly), Scottish Agricultural Organisation Society, Scottish Association of Young Farmers Clubs, Tenant Farmers Association, The Plant and Crops Sector of the Knowledge Transfer Network of Innovate UK, UKTI Agri-Tech Precision Agriculture Specialist, Yorkshire Agricultural Society.*

- **Strategy:** To encourage participation, we ensured that the survey was short (approximately 10 minutes) and user-friendly. Wherever possible, we adopted terminology commonly used in the agriculture business so that respondents could quickly relate to the survey. Our desk research and research objectives were key in designing the content of the survey. We also developed a well-communicated invitation to the survey, highlighting the importance of participation. In addition, our collaborator, Satellite Applications Catapult, has strong relationships with a number of agricultural associations and DEFRA, who were important stakeholders in helping us disseminate our survey. Finally, a cash prize of £250 was offered for respondents completing the survey to incentivise participation.

- **Cost-effectiveness:** An online survey is the most cost-effective way to reach farms throughout the UK. We are mindful that an online survey may have introduced a selection bias against farms that do not have Internet access, but we believe this to be a small percentage. Furthermore, the previous UNIFARM and Danish studies have shown online surveys to be a viable research tool in the agriculture sector.

- **Analysis:** Once the primary data was collected and cleaned, we conducted an Excel-based analysis and charting of findings.

3.3   Achieved sample

In total, a disappointingly low **total of 50 respondents** completed the survey. Of these 50 respondents 48 were aware of applications of satellite-enabled agri-tech, and of these 48 aware farmers, 42 were users of the technologies. Of the 50 farmer respondents, 31 were arable farmers, and the remaining 19 were livestock farmers. In the subsequent paragraphs we summarise in detail the key demographic characteristics of this small sample.

As noted in the 'Caveats and limitations' (Section 1.4), all findings should be interpreted with the small size of the sample in mind.

3.3.1 Respondent demographics

Age

The demographics of **all** survey respondents are representative of farmers in the UK; the overall distribution closely matches census data from DEFRA[4]. A third of the farmers are aged between 40 and 54, another third between 55 and 64, and the remainder are split above and below this range.

Looking just at **users** of satellite-enabled agri-tech, the demographic profile is very similar to that of the whole sample; showing that adoption occurs across the age spectrum of farmers surveyed and is not confined to a particular (e.g. younger) generation.

Figure 1   Age profile of respondents

N=50
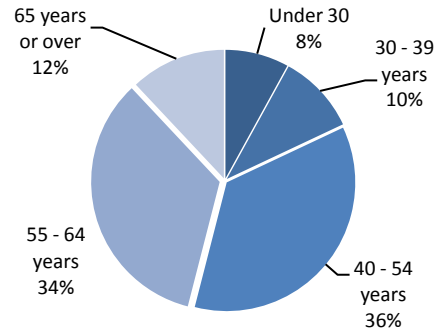
Educational attainment

The farmers that completed the survey are **highly educated**: over half (54%) have at least A-levels or equivalent, including 34% holding a degree or equivalent and 10% holding a higher degree/postgraduate degree. A further 30% have received formal courses in agriculture. This is above the average for the industry quoted in the agricultural census[5].

Figure 2   Educational attainment of farmers in the sample
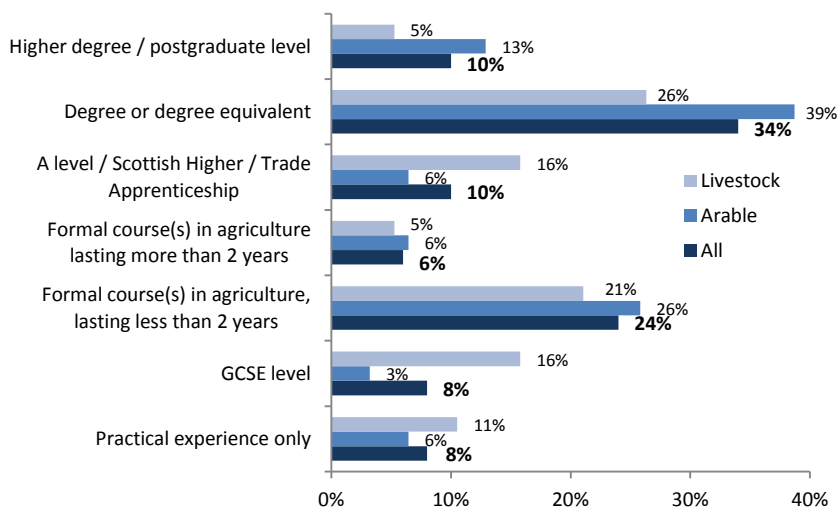
N=50

Again, there is little difference in attainment between users and non-users, but there is a difference between the different farmer types. Arable farmer respondents, who make up almost two thirds of the sample, are more highly educated (58% holding at least A-levels or equivalent) than livestock farmers (47%).

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[4] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/430205/auk-chapter02-28may15.xls
[5] ONS census data (2011) on industry by highest level of qualification shows that 50% of those employed in Agriculture, energy and water have A-level or equivalent and above (level 3 qualifications in the table relate to A levels) http://www.nomisweb.co.uk/census/2011/wp6503ew

Farm characteristics

We asked farmers about their farms and about their role in the relation to the technologies used on their farms. The majority (82%) of respondents' farms are **full-time commercial holdings**, with 16% being part-time commercial holdings, and the remaining 2% are a hobby/lifestyle choice. Eight out of ten of these farms are **owner-operated**.

94% (47) of the respondents in the survey help **decide which technology is being used on their farms**, ensuring that responses come from people with direct experience using the technology.

There are two types of farmers in the sample: **arable** farmers and **livestock** farmers. The farmers in the survey cultivate a range of crops/livestock, with the most popular categories being wheat (36%), cattle and calves (30%), and cereals (18%). The livestock farmers in the sample predominantly rear cattle and calves – perhaps unsurprising, as the more valuable livestock, given the investment costs associated with certain satellite-enabled agri-tech.
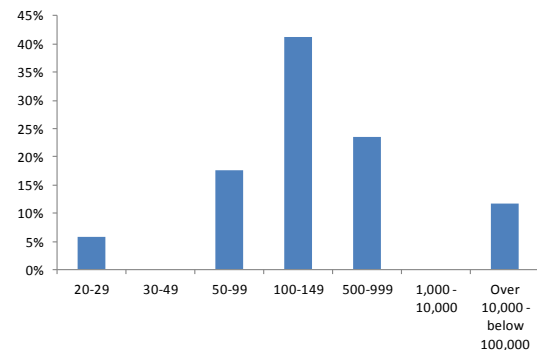
The distributions of farm sizes (arable: hectares; livestock: number of livestock) are as follows:

Figure 3   Farm sizes of respondents
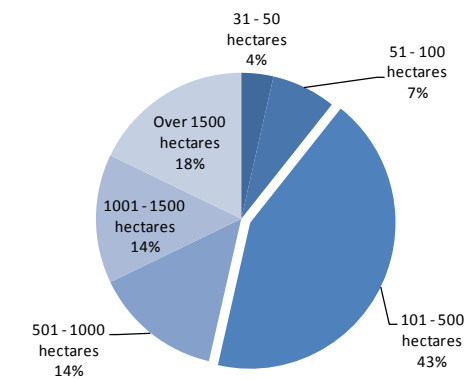
N=31

Figure 4   Number of livestock

N=19

Geographical distribution

Figure 5   Mapping of respondents

The survey respondents are dispersed widely across the UK, highlighting that the survey was pushed out across all of the country by the organisations involved.

# 4 Usage

4.1 Awareness and usage

Respondents were asked whether they were aware of satellite technologies used in agriculture, giving examples of technologies such as satellite navigation and applications such as machinery guidance within the question. **96% (48) of farmers were aware of the technologies**, and **84% (42) currently use the technologies**.

Of those who are aware but not currently using satellite technology *(6 out of 8 non-users in the 50 respondent sample)*, 3 have plans to use it in the next 3 years, and the remaining 3 have no plans for use of satellite technology in that same period. 5 of the 6 nonusers of the technology are livestock farmers.

4.1.1 Technological awareness dissemination channels

The channels through which farmers find out about new technologies and techniques being used in agriculture are varied. **Vendors**, **distributors**, **suppliers**, and **agronomists** are the most popular suppliers of new information to farmers, as are **farming media and newsletters** such as *Farmers Weekly*, and **conferences** and **exhibitions**. Information from formal sources such as training and education, and government agencies such as DEFRA is more limited. Word of mouth is also an uncommon way of receiving new information among the sample.

Figure 6   Sources of information about new technologies
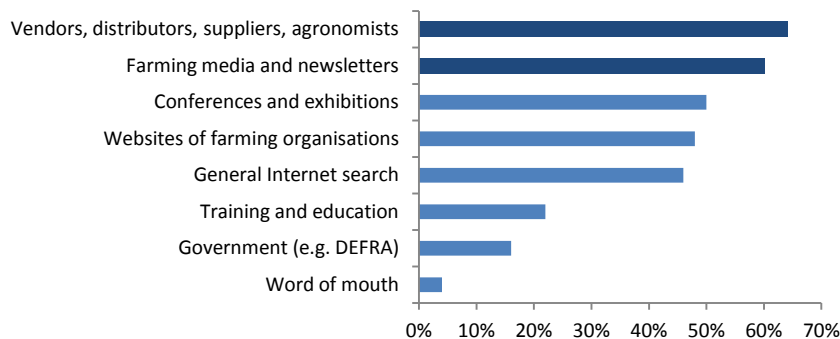
N=31

The information channels used for both users and non-users is very similar, with the vendor and farming media categories remaining the most popular for both groups.

There is higher use of government channels and word of mouth amongst the non-users in the sample.

Figure 7   Sources of information about new technologies in agriculture by farmer type
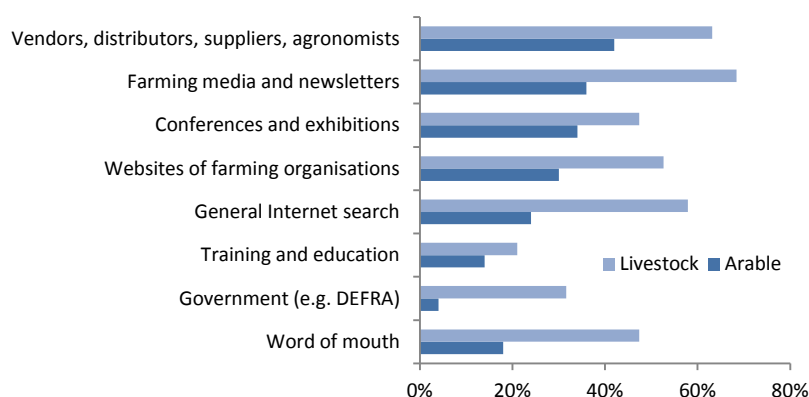

N=50

4.2   Applications of the technologies

There is a broad range of applications of satellite technologies used by farmers in the sample. The most popular use of the technology is **machinery guidance**, used by 80% of the sample. Approximately 5 in 10 farms use the technology for **weather information**, **variable rate application**, and **land parcel measurement**. Applications with very limited take up include automated agriculture (e.g. weed control robots), geo-traceability, livestock tracking, and virtual fencing.

"We are contractors as well as farmers and find that field mapping is particularly useful because it helps us to accurately quantify what our charges should be for any given job".

Across farmer groups, **arable land farmers use a wider variety of applications** due to more monitoring of the ground conditions for crops. **Machinery guidance remains the most popular application across both groups**, though the use of satellite technology for **weather information is more prevalent amongst livestock farmers**.

**Figure 8   Applications of the technologies**
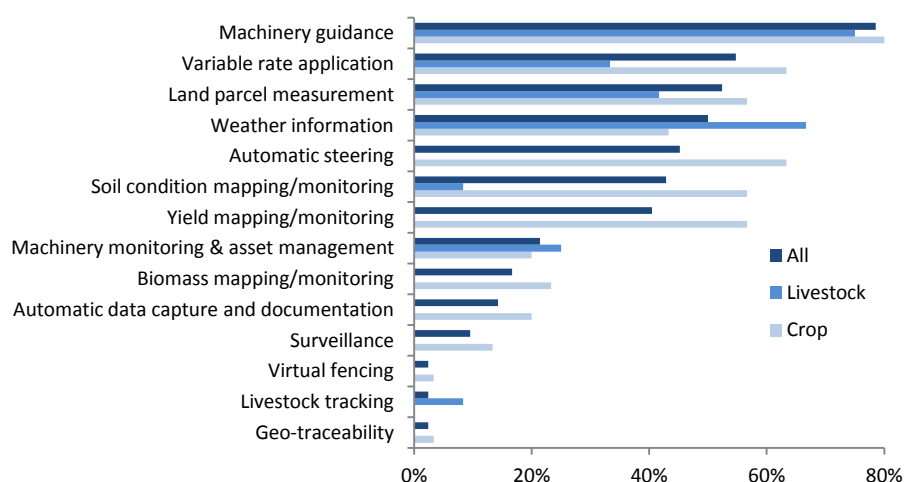
N=42

5   Benefits

The farmers surveyed are on the whole **very positive** about the use of satellite-enabled agri-tech. The primary benefits relate to **increased productivity** on their farms, in the form of **reduced input costs**, and **higher yield** and **better quality output**. **Environmental benefits** are frequently noted, but our analysis suggests that the importance of these benefits relative to productivity benefits is low.

5.1   Experienced benefits and their importance

**Figure 9   Benefits from using space technologies in agriculture**
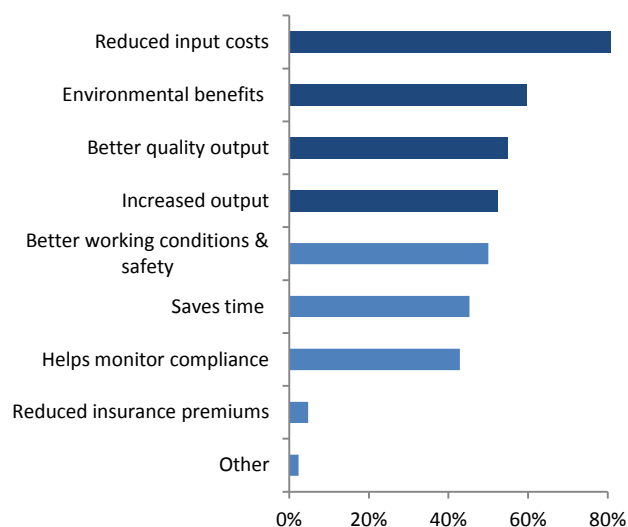
N=42

The most commonly reported benefit is **reduced input costs** (e.g. fertiliser, seeds, fuel, water, fuel), which has been experienced by 8 out of 10 farmers surveyed. There are also output benefits from using satellite-enabled agri-tech; 5 in 10 report **increased output**, as well as **better quality output**.

Environmental benefits (e.g. less agri-chemical run-off; lower greenhouse gas emissions) have been reported by 6 in 10 farmers, but a follow up question in the survey which asked respondents to rank in order of importance their top 3 benefits shows that its importance is very low when compared to the other benefits.

Figure 10   Relative importance of the benefits
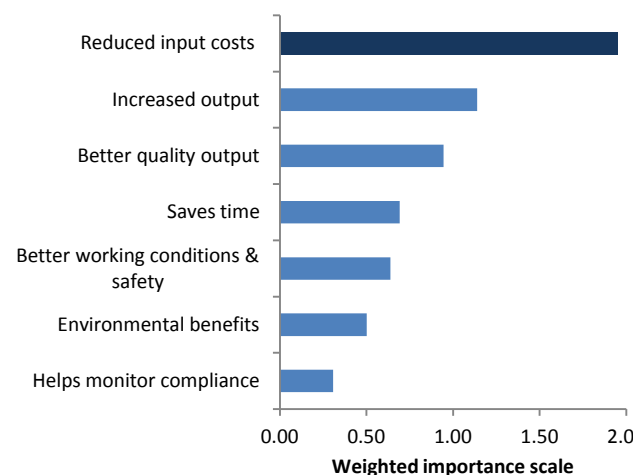
N=42

A ranking system was designed to produce a **weighted 'importance' scale**[6]. The most important benefits to farmers from using satellite-enabled agri-tech are **productivity-related** – these are all factors which are quantifiable and monetisable, providing an avenue for further research. It is interesting that despite environmental benefits being the second most popular reported benefit, their ranking relative to the other benefits is low.

Although the whole range of benefits are experienced by both farmer groups, for **livestock farmers the reduced input cost benefits** are more prevalent than the

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[6] A ranking methodology has been established, whereby a benefit ranked most important receives a 3, a benefit ranked second a 2, down to a reported benefit which is not ranked in the top 3 being given a score of 0. The scores for each benefit are then averaged.

output benefits; 8 in 10 have experienced input cost reductions which compares to 3 in 10 and 4 in 10 for increased output and better quality output respectively.

5.1.1 Perceived benefits from non-users

These productivity benefits are also **clearly understood by farmers who plan to use satellite-enabled agri-tech in the next 3 years** – all 3 farmers in this category indicated that they expected to experience reduced input costs, and 2 of the 3 also expected increased output.

5.2 Attitudes

Attitudes towards the technology by farmers have on the whole been very positive, with 5 in 10 users rating their experience as very positive, and **83% rating it positive or very positive**. There are **no farmers in the sample who have had a very negative experience**. The average satisfaction rating is **very similar between the different types of farmers** (4.4 for arable farmers, and 4.0 for livestock farmers).

Figure 11   Attitudes towards using space technology in agriculture
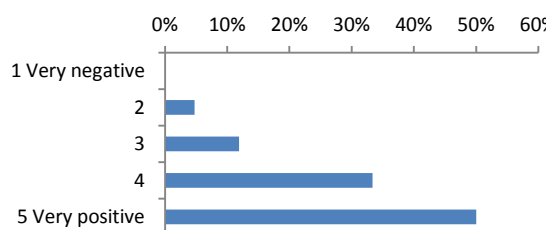
N=42

"It is the best way forward, young people understand it, it is greener, more efficient and could be cost effective on all farms if costs came down."
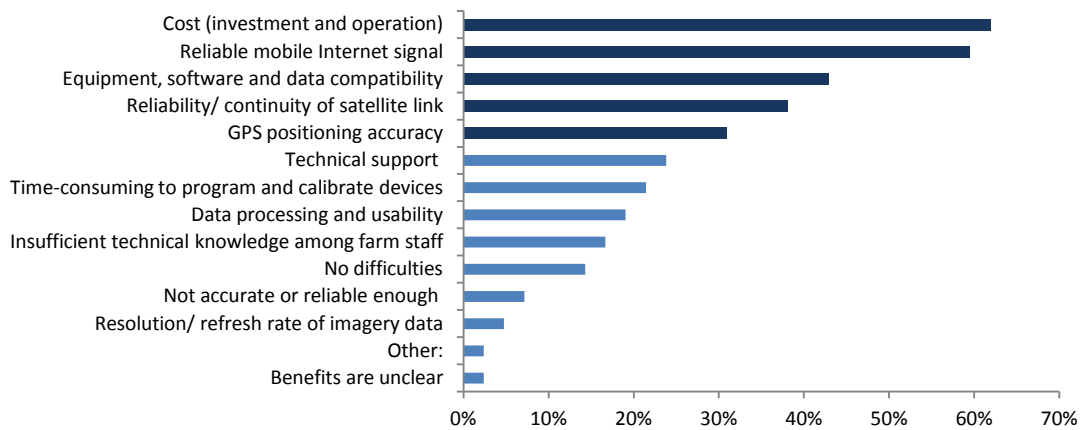
6 Difficulties

Despite consistently positive attitudes to the technology in general, there are some key difficulties for users. **Cost, reliability of mobile signals and compatibility** were the biggest issues. Almost all users surveyed would like to see the **cost of the systems reduced, more reliable mobile connectivity** and **better standardisation** of the technology in the future.

"They are an amazingly positive addition to the machinery. I hope the cost of any new innovations do not mean the small farmer can not benefit from them also."

6.1 Experienced difficulties and their importance

Although reduced input costs are the main benefits experienced by farmers, the **cost in terms of investment and operation** is the most prevalent problem that farmers were found to have with satellite-enabled agri-tech, affecting 6 in 10 farmers. The second most common difficulty is **reliable mobile internet signal** on the farmland, a finding which will interest mobile satellite communication service providers. **Compatibility of equipment, software and data**, and the **accuracy of location services** are also notable drawbacks, although 10% of crop farmers, and 25% of livestock farmers report no difficulties when using satellite-enabled technology on their farms.

Figure 12   Difficulties faced when using space technologies in agriculture


N=42

Figure 13   Relative importance of difficulties
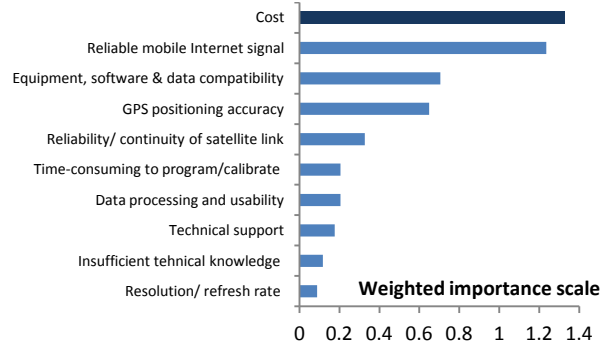
N=42

In a similar vein to the section on the benefits, we have created a **weighted importance scale** for the difficulties encountered[7]. The **cost** and **reliability of mobile internet** on farmland are the most significant difficulties faced by farmers taking part in the survey, with their importance being almost double that of the next two factors: **compatibility** and **accuracy of location services**.

Between farmer groups, **arable farmers experience a wider range of problems** when using satellite technologies. As well as encountering a smaller range of problems, livestock farmers also report each problem in a smaller proportion than arable farmers.

**Figure 14   Difficulties by farmer type**
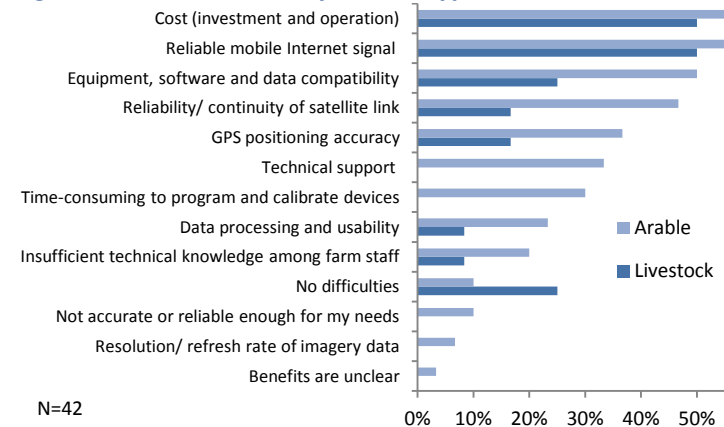
N=42

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[7] A ranking methodology has been established, whereby a difficulty ranked most important receives a 3, a difficulty ranked second a 2, down to a reported difficulty which is not ranked in the top 3 being given a score of 0. The scores for each difficulty are then averaged.

6.2   Improvements farmers would like to see

When asked about the improvements that farmers using satellite-enabled agri-tech would like to see in the future, almost all respondents (93%) stated **standardisation of the equipment, software, and data across vendors and systems**. **Better accuracy of the location services** was the second most frequently selected improvement in the survey.

"So much technology nowadays is just so easy to work with for example you just take an iPhone out the box turn it on and everything is ready to go. With a lot of the agricultural technology it is a very different story. Compatibility and ease of set up are real issues and prevent the easy uptake of the technology."

Figure 15   Improvements farmers would like to see
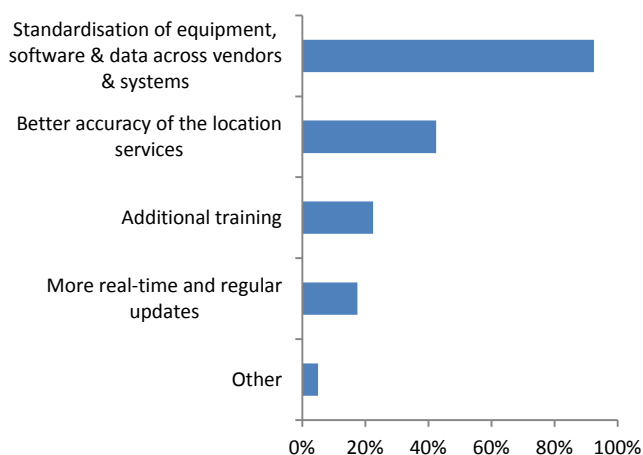
N=42

Corroborating the earlier finding that there is a larger proportion of livestock farmers than crop farmers who have experienced no difficulties using the technology, 17% of livestock farmers using satellite technologies on their farms did not report any improvements that they would like to see with the technology. There were no such reports in the arable farmers group of respondents.

7   Barriers to take-up

"I can see the advantages of the technology, but its cost on a small area is not justifiable, plus the thought of incompatibility/lack of agreed standards between different manufacturers of equipment would give me pause for thought even if I could easily afford it "

As well as asking current users about the difficulties they currently encounter, an important aspect when assessing the current environment for satellite-enabled technology in agriculture are the barriers which are preventing further take up of the technology.

7.1   Farmers with no plans for the technology

We asked those who do not use the technology currently, and had no plans for using it in the next 3 years about their reasons for this. Despite the sample being too small to draw inference from (3 farmers), it is nonetheless informative data.

In line with the difficulties faced by current users, **costs**, and **reliable mobile internet signal** on the farmland were the reasons given for not planning to, or having stopped using technology. **Insufficient technical knowledge** amongst staff was also stated. Lastly, and valuable from an information stand point, one farmer said that the **benefits of the technology are unclear**, and that he also needed to increase his knowledge of what was available.

"Cost is still a big barrier as is the availability of software to view edit and export data"

This point on information continued into a follow up question on the most important factor which may make farmers consider using applications of satellite technologies. Two of the farmers said that they might consider using it if the technology definitely resulted in **net benefits**, which may partly be explained by the fact that the three respondents are relatively small livestock farmers. When asked about the benefits that farmers perceived they would enjoy if they employed applications of satellite technology, the responses were consistent with the benefits enjoyed by current users, and non-users planning on using the technology in the next 3 years. This shows that farmers have an understanding of the technologies even if they are not currently using them.

7.2   Farmers planning to use the technology

For those not presently using applications of satellite-enabled agri-tech but planning on their use in the next 3 years, we asked about the reasons behind not using them sooner. The resounding reason has been the **cost of the technology**. Farmers have not been sure whether the technology was worth the investment, and been **waiting for the technology to become cheaper**. When asked about the difficulties they believe they will face, the farmers in this group gave very similar responses to the other groups discussed earlier.

8   Conclusions

8.1   Summary and conclusions

The research process of this study was **implemented successfully**: relevant previous survey-based studies were reviewed and insights employed in the research design; a robust survey questionnaire was prepared, piloted and coded online; participating respondents were able to complete the survey without impediment; and the questions and answers yielded relevant and meaningful findings.

Unfortunately the coverage of the achieved **sample was very limited** – precluding more detailed analysis and statistical inference based on a representative sample, as had been hoped, and restricting the significance of the results.

Nonetheless, this research has added to the evidence base on the current nature and extent of satellite technology application **usage**, underlying **drivers of demand**, and **adoption barriers** in the

UK's agricultural sector. Despite the disappointingly small sample size, the responses that have been received were completed thoroughly and thoughtfully by respondents – for which we are immensely grateful – and thus provide quality **UK-specific insights** to the key issues that policymakers need to understand in order to boost adoption of these important technologies amongst farmers in the UK.

8.2   Recommendations for future research

Though this research has returned a disappointingly small sample size, the overall research objective, the design and relevance of the questionnaire, the operation of the online survey, and the **insights that even a limited sample can provide to key policy-relevant questions** have been proven to be effective, and the process has proved to be educational – with many lessons learned.

There have been two core issues that would need to be solved:

1. **Season:** One of the limitations of the study which could be improved in another version of this study is the **timing** of the survey. The online survey ran from mid-June until mid-August, but expert input which was offered when the project was already underway was that October would have been a more suitable point in the year to survey farmers.

2. **Survey distribution:** Related to the above point is the achieved response rate. To improve participation in any future iteration, it would be recommended to adopt a different method to distribute the survey: for example, by incorporating the survey questions within the annual sample survey and decennial Census run by the Department for Environment, Food and Rural Affairs (Defra), which would yield a larger sample and enable the sample dataset to be linked to official farming statistics, balanced to be representative and scaled up to the national level – allowing for more complex analysis and tracking of users of satellite-enabled agri-tech over time.

Index of Tables, Figures and Boxes

Tables

Figures

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ANNEXES

Annex 1   Bibliography

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