FAIRWAY
Farm System Management and Governance
for Good Water Quality and Drinking Water Supplies

FAIRWAY REPORT series

Development of the SprayDay mobile app - assissting best practice amongst infrequent pesticide users

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1. EXECUTIVE SUMMARY

Pesticides are an important tool in modern agricultural practice, but it is recognised that their use can have significant negative ecological impacts and pose risks for human health if not removed from drinking water sources. Whilst there are technological solutions available to remove the majority of pesticides from drinking water, these approaches are expensive and may not always be effective. Consequently the use of professional pesticide products is strictly controlled, with usage limited to holders of, or those supervised by holders of, appropriate certification.

One challenge that is becoming increasingly apparent is that the infrequent use of pesticide products by many users means that adherence to best practice can be problematic. In addition the best source of information is not always clear, or easily accessible. This problem is further exacerbated by the fact that pesticide usage is a practical process meaning that notes taken in training sessions are unlikely to be to hand when questions arise in the farmyard or the field. Modern tools such as mobile telephones and the internet provide a theoretical solution to this problem, but connectivity in rural areas, is often poor and many individual users still prefer a more traditional method for gaining information.

The aim of deliverable 5.5 (Work Package 5) of the FAIRWAY project (https://fairway-project.eu/) was the development of a phone app that would provide guidance to users on the application, disposal and environmental risks associated with the use of different pesticides for weed and pest control.

The work has been undertaken in a number of stages;

1. **Market Research:** Market research was carried out in two steps. A review of the currently available online resources showed that there were a small number of resources available that specialised in providing information on specific factors relating to pesticide usage, but none sought to act as a centralised hub for all issues. Further, provision tended to target more frequent users and those who have recently purchased new equipment.

   The second step was a series of structured interviews with 83 farmers who used professional pesticide products. The purpose of these interviews was to determine the specific mix of features that would increase the appeal of the app to potential users.

2. **App Design and Development:** Building on the outcomes of the market research, the app development team, which consisted of scientists and software developers, determined that the most appropriate target audience for this app would be:

   - Users who apply pesticides infrequently (1-2 times a year).
   - Users who would like assistance with calibration and dilution calculations
   - Users who want access to easy-to-use, straightforward decision support tools

   The development team then used a number of MoSCoW meetings (**M**ust have, **S**hould have, **C**ould have, **W**on't have) meetings to determine the content of the app. These are:

   - A local weather forecast and an assessment of the suitability of conditions for planned pesticide application.
   - Sprayer details, to include calibration and dilution of pesticide guides
   - The ability to photograph and archive any aspect of pesticide usage that users wish to document and

- A brief exploration of the regulations on the disposal of pesticide-contaminated items (e.g. containers, PPE, foil caps) as well as links to more in-depth sources of information (websites and organisations).

A series of wire-frame visualisations were then developed and presented to stakeholders representing agricultural interests, civil servants, academics and professional training bodies from across the island of Ireland, Great Britain and Europe in order to gain their feedback on content and presentation.

Following a final MoSCoW meeting, the app was developed to operate under the Android mobile phone software platform, which holds approximately 72% of mobile phone operating system market share. The working prototype was developed following industry standard software development lifecycle processes in line with internal best practices and procedures and using the Xamarin Open-source mobile app platform for .NET. An object oriented approach to coding was taken where the different elements of the system were designed, coded and tested individually and then brought together to form the completed system. System testing was carried out using Android OS emulation software before the first round of user-acceptance testing. The App was named “Sprayday”.

3. **User review and testing:** The app was presented to 64 stakeholders from across the island of Ireland, the United Kingdom and Europe. Individuals represented a range of interest groups, ranging from civil servants to agricultural advisory service employees and from water utility employees to farmers. Several participants who had participated in the initial market research survey were included in this group. Overall feedback received was positive with more than 94% of respondents stating that they believed that the app was suitable for the target user groups. A number of respondents made it clear that they would prefer to see a more richly featured app that would provide users with the ability to generate the documentation associated with pesticide application, as well as storeroom records, as they felt this would improve the appeal of the app to the community. However, other respondents took exactly the opposite view, indicating that they felt that a simple app would be more appealing to the target audience.

Restrictions in 2020/21 due to Covid-19 meant that it was not possible to carry out a field trial of the app and there is a clear need for this work to be undertaken. In addition future works should include the following components.

- Explore alternative weather data suppliers other than the UK Meteorological Office (e.g. Met Eireann, Meteo Weather). This would enable the user to select their preferred data provider and would broaden the appeal to non-UK users
- The complexity of handling weather data at this scale meant that it was not possible, within the current project timescale, to develop the protocols necessary to assess the suitability of the weather for spraying on the day that the user consults the app. This is a clear limitation of the app that needs to be addressed in the next phase of development
- The app currently provides a basic suite of services to all users. The utility of the app may be increased by the addition of login facilities where more advanced functionality can be accessed. This could include record management and interfacing with existing commercially available farm management software.
- At present the app is written solely within the Android environment. Further work, within the Xamarin Open-source mobile app platform, would allow expansion onto the Apple platform. The possibility and benefits of expanding onto the Linux and Windows mobile operating systems could also be considered.

In conclusion the SprayDay app is a Decision Support Tool designed to target low-frequency users of professional pesticide products and assist with their adoption of best practice. There is a particular focus on providing information on the planning and execution of pesticide application. The app has been developed to approximately TL6 (Technology demonstrated in relevant environment) or TL7 (System prototype demonstration in operational environment) and has primarily targeted the Northern Irish/UK market, but could be adapted for the international market as part of a programme of further developments focused on developing the app to TL9 (Actual system proven in operational environment). Reviews suggest that the app has successfully been designed to appeal to infrequent users (1 – 2 applications per annum) of professional pesticide products from both agricultural backgrounds and other business sectors, such as groundskeepers managing amenity spaces.

2. ACKNOWLEDGMENTS

The authors of this report would like to acknowledge that the work presented here was made possible by the funding provided by the EU's Horizon 2020 programme (Grant No. 727984). We would also like to thank colleagues from throughout the FAIRWAY project, members of the Water Catchment Partnership, the National Pesticides and Drinking Water Action Group, the Source to Tap project and members of the Business Support (Crops) group at the College of Agriculture, Food and Rural Enterprise (CAFRE) for their comments and suggestions throughout the design and evaluation stages of the app's development. The gathering of opinions from potential users of the app would have been much more challenging without the assistance of the Source to Tap field officers and AFBI staff who gathered the opinions of today's farmers, as well as Andrew Gracey (Ulster Wildlife) who introduced the survey to tomorrow's farmers taking part in the "Grassroots challenge", which they ran in association with the Young Farmers' Clubs of Ulster. Finally we would also like to thank all who gave their time to take part in the market research stage and/or the prototype review meetings at the end of the project.

3. INTRODUCTION

Pesticides are widely used in modern agriculture to control the distribution and density of pest organisms in crops. However they also pose a significant environmental risk with a proportion of the applied pesticides migrating into surface or ground water bodies (Sandin *et al.* 2018) where they can have negative impacts on both ecology (Mensah *et al.* 2015, Morrissey *et al.* 2015) and drinking water (Pretty *et al.* 2000, Benner *et al.* 2013). The proportion of applied pesticide that is lost to water may be influenced by a variety of user practices and biophysical environmental characteristics and so many countries now have strict rules and regulations to control both the purchase and use of pesticides in a professional setting. For example, the EU requires, through the Sustainable Use Directive (European Comission 2009), that individuals wishing to purchase or use professional pesticide products have attained a specified level of training, or are supervised by someone with that training. Professional users are expected to be familiar with a number of considerations, including the weather and soil conditions that would permit use of pesticides, the correct way to calibrate spray equipment and calculate dilution ratios, as well as record keeping, storage and disposal requirements.

There are currently a small number of online resources available to professional pesticide users that refresh their technical knowledge (e.g. the British Crop Protection Council (UK) - https://www.bcpc.org/, Landwirtshaftskammer Neidersachsen (Lower Saxony, Germany) - https://www.lwk-niedersachsen.de/, SEGES (Denmark) - https://www.landbrugsinfo.dk/) or that will provide weather forecasts (e.g. Meteorological Office (UK) - https://www.metoffice.gov.uk/, Met Eireann (Ireland) - https://www.metoffice.gov.uk/ or Meteorologisk Institutt (Norway) - https://www.yr.no/en). Alternatively users may use the WaterAware mobile app (http://www.adama.com/uk/en/wateraware/) which combines weather forecasts with soil moisture deficit forecasts in order to predict the risk of selected pesticides migrating through the soil. Dilution calculations can be gained online from Ohio State University (https://ohioline.osu.edu/factsheet/fabe-530 or in mobile apps such as "Calibrate my sprayer (https://www.farms.com/agriculture-apps/spraying/calibrate-my-sprayer) or "Mix my Sprayer" (https://www.farms.com/agriculture-apps/spraying/mix-my-sprayer) from Clemson University. Owners of recently manufactured Hardy sprayers may also visit the company website (https://hardi-international.com/about-hardi/media/myhardi) for a range of product support.

Overall these resources are fragmented, mostly available solely online and not optimised for access in rural areas where internet and mobile signal availability may be poor. As such the aim of this task (Deliverable 5.5) within the FAIRWAY project was to develop a mobile telephone app that would act as a pocket-sized source of information for infrequent (1 – 2 times per year) professional pesticide users. An electronic approach was favoured as smartphones are widespread in society and allow the information provided to be kept current with little effort expended on the part of the user.

Whilst it is recognised that earlier studies from the FAIRWAY project (Nicholson *et al.* 2020) have highlighted that many Decision Support Tools do not work well in countries other than the one(s) for which they were initially designed, it was necessary to select a jurisdiction for the initial development. Section 3.1 explores why Northern Ireland was selected.

3.1 BACKGROUND CONTEXT – NORTHERN IRELAND

Traditionally the potential of grassland-applied herbicides to pollute waterbodies has been considered to be low, relative to the threats associated with nutrients (Hooda *et al.* 2000, Richards K.G. *et al.* 2009) as the variety and masses of pesticides used are relatively small (e.g. (Lavery *et al.*

2018, Lavery *et al.* 2019), but awareness is now growing in countries such as Northern Ireland (Morton *et al.* 2021) where 79% of agricultural land area is dedicated to livestock and grassland (DAERA 2020). In 2017, for example, it was calculated that 45.1 tonnes of MCPA (2-methyl-4-chlorophenoxyacetic acid) were applied to 33,573 ha of Northern Irish grassland and fodder crops (Lavery *et al.* 2018).

Grassland farmers use MCPA for the control of broadleaf species including common rush (*Juncus effusus*) and dock (*Rumex obtusifolius*). In silage crops and fields for intensive grazing these plants are undesirable because they are of low nutritional value, and outcompete the grass species, whilst in extensively grazed fields with lower grass quality, the extent to which these weeds are present is used as a measure of the extent to which the field is under active agricultural management, and thus the area of land that is eligible for the Basic Payment Scheme. MCPA sorbs weakly to the organic matter in soil, and is moderately persistent in the environment (Morton *et al.* 2020) which means, when applied to parts of the landscape that are hydrologically connected to the surface water network, the herbicide may be flushed into surface waterbodies. In one year of a long-term study it was found that MCPA concentrations exceeded the 0.1 µg/L threshold set within the Drinking Water Directive (European Commission 1998) for potable water in 25% of samples and thus would require significant treatment prior to supply (Morton *et al.* 2021). Across the island of Ireland MCPA has been flagged as a concern for drinking water supply with elevated concentrations detected in many surface water source catchments.

This is a significant challenge for water utilities, such as Northern Ireland Water and Irish Water and adds cost to the water treatment process. There are a number of technological approaches available for treatment, such as passing water through granular activated carbon or exposure of the water to chemical oxidation processes (Ahmed *et al.* 2017)), but these fail to address the larger problem of poor surface water quality. Clearly a better approach would be to prevent pesticides entering water courses in the first place and application at the right levels, in the right place and at the right time is a crucial step towards mitigating the risk of such losses. This requires efforts to raise farmers' awareness of these issues and their role in both the problem and solutions through projects such as Source to Tap (https://www.sourcetotap.eu/) as well as making resources more freely and easily available that will assist pesticide users to adopt best practice.

3.2 MARKET RESEARCH

In modern farming practice both the frequency with which pesticides are used, and the technical sophistication of application equipment can vary widely as a result of a number of personal and business factors. It is generally accepted that grassland-dominated farming systems tend to use smaller quantities of pesticides per annum, and to utilise less advanced application machinery. The first step in the development of the app was to gather some basic information about the farmers, and to gain their input on what app features and functions would best suit Northern Irish farms. The survey explored what information farmers would be most interested in seeing in a mobile app, and what barriers they would perceive as preventing their engagement with such a product.

The questionnaire was developed through engagement with experts in pesticides use and farming in Northern Ireland with the aim of developing a broad understanding of the farming community's opinions of pesticide regulations, mobile phones and decision support tools. This understanding allowed for the development of a long-list of potential questions. A prototype questionnaire was developed that was suitable for use and this was tested in face-to-face conversations with AFBI colleagues. Following a number of iterations of the questionnaire, a small

number of farmers known to AFBI were approached and asked to first complete the questionnaire and then comment on all aspects of the experience. Of particular concern was whether the respondents felt the questions were understandable, phrased in a balanced manner and permitted them to share their opinions fully. Reviews received were very positive and changes made to the questionnaire were minor. A copy of the questionnaire used can be found in Appendix A.

A combination of approaches were used to gain access to interviewees in the farming community. Interviewers attending marts (livestock markets) were given a brief outline of the project and the purpose of the questionnaire to help to recruit participants. Interviewers were not given selection criteria to use in their identification of participants as it was expected that the majority of attendees at a livestock market would be farmers and those that were not would be expected to be eliminated during the introductory conversation. Interviewers also attended National Register of Sprayer Operator (NROSO) roadshows organised by the College of Agriculture, Food and Rural Enterprise (CAFRE), which is the main agricultural education and training provider in Northern Ireland. Younger members of the farming community were approached through the Ulster Wildlife co-ordinated "Grassroots Challenge" which was run in association with the Young Farmers' Clubs of Ulster.

3.3 RESULTS

In total 83 farmers from Northern Ireland were interviewed. These individuals ranged from "Under 20" to "80+" with 26% of respondents in the 40 – 60 age band, and representing a diverse range of farm types (Figure 1). Whilst 77 respondents stated that they owned a smart phone, only 2 currently used any app to assist them in planning their pesticide usage or container disposal, but 43 individuals did say that they were prepared to consider using a mobile app in future. Of the individuals who were not interested in a mobile app three indicated that they lived in an area where mobile reception was too poor, four felt that the training they had already received was sufficient and six preferred to receive training/information via a different medium.

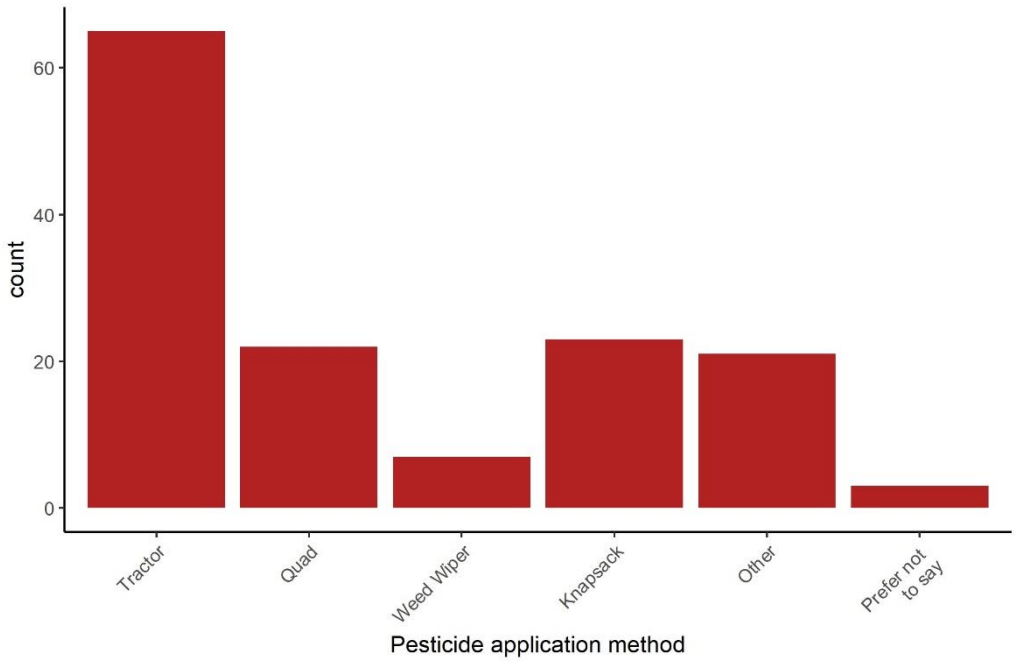

Figure 1: Respondents were asked to identify all business sector(s) within which the farm they were associated with operated.

In order to increase the appeal of the app to users it was important to determine the pesticide application methods used as this would strongly influence the information content of the final app. Whilst the vast majority of respondents used boom sprayers (Figure 2), there were also a number of individuals who used knapsacks and/or weed wipers. The extent to which farmers felt that they were aware of current best practice when planning for disposal of empty pesticide containers was also gauged as this would also influence the presentation of information in the app. 82% of respondents felt that they were at least "somewhat familiar" with the correct protocols.

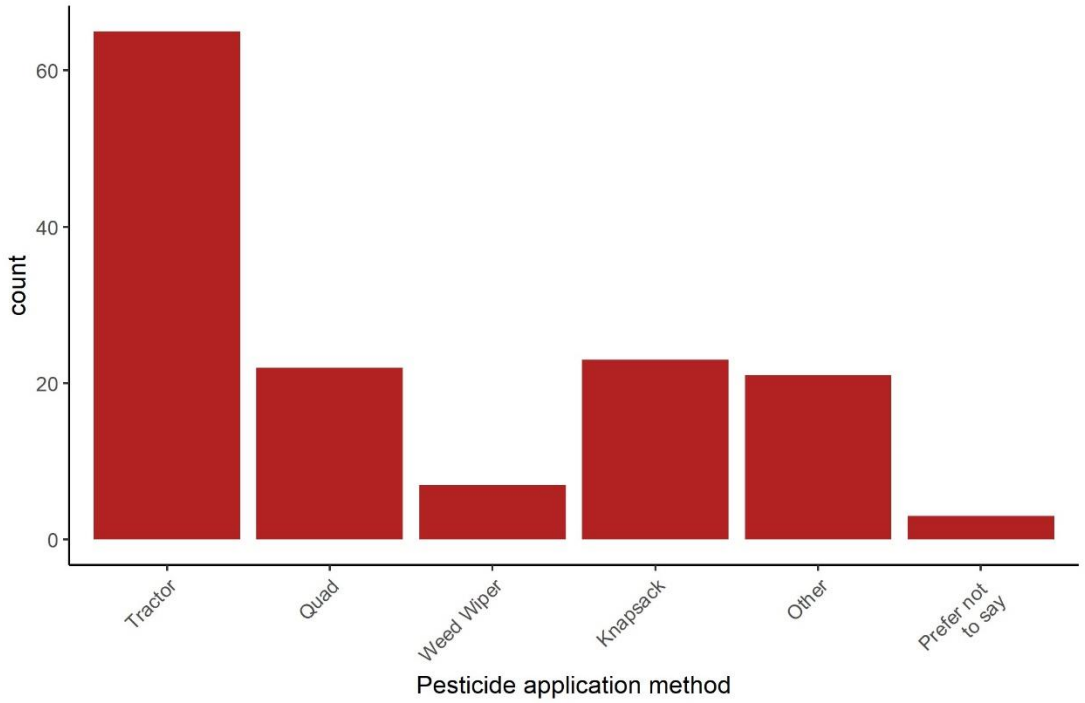

Figure 2: Respondents were asked to identify all pesticide application techniques used on the farm that they were associated with.

Those respondents who were interested in a mobile app were offered a list of features that could be included and were asked to identify those that they would find useful (Figure 3). In the grassland sector of Northern Ireland farmers frequently select the most appropriate herbicides based on their own understanding of the active ingredients in individual products and so it is perhaps not surprising that further information on this matter was the most popular option (81% of respondents), followed by tips on best practice related to the application of the pesticides (the correct concentrations of pesticide to use (61%), correct ground conditions when spraying (63%), correct weather conditions (61%) and the correct buffer layout (65%)). There was less interest in aspects of pesticide usage that did not have such obvious financial implications (safe use of PPE and correct wash-down procedures both interested 42% of respondents). Respondents were also allowed to add their own suggestions and seven respondents requested that the app include record keeping functionality whilst another asked for more information on pesticide usage that arable farmers would tend to gain from their agronomist.

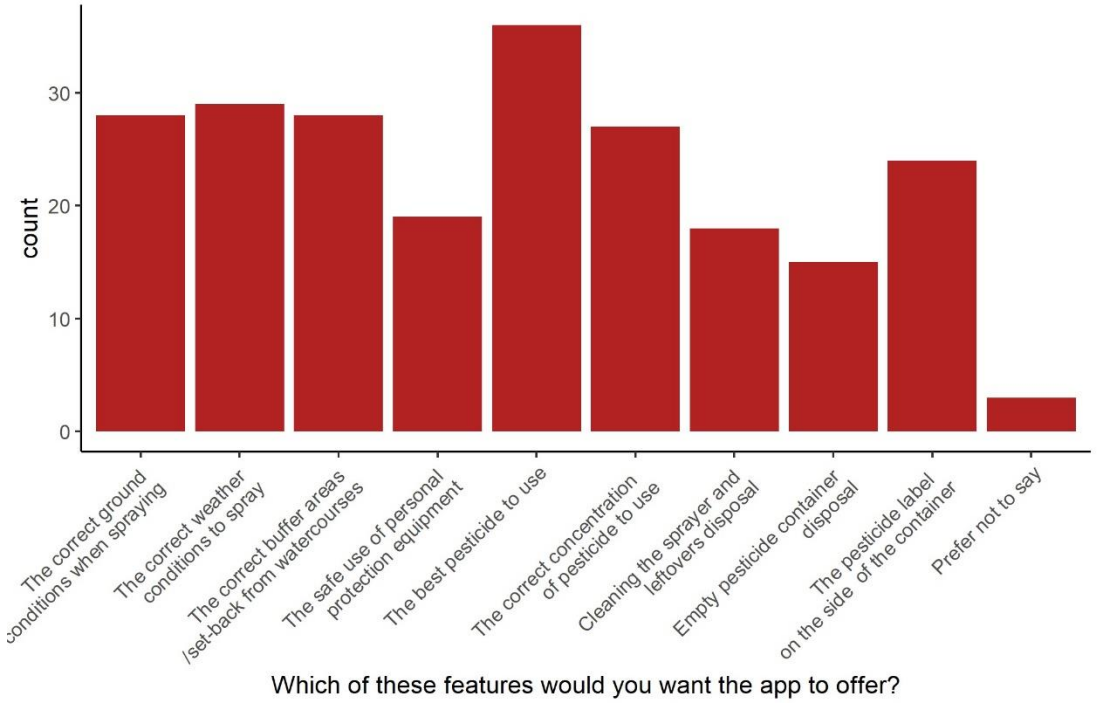

Figure 3: Respondent were offered a list of features that the app could contain and were asked to select those that were of interest. Respondents were allowed to select as many features as they wished.

4. MOBILE APP DEVELOPMENT

The app development team, which included both scientists and software developers, first reviewed the data that was gathered in the market research stage in order to define the target audience for the app. Although interviewees were not specifically asked to comment on the suitability of the app to other business sectors, such as the amenity sector, a number of individuals commented that farmers were not the only users of professional pesticide products. As such the target audience were defined as:-

- Users who apply pesticides infrequently (1-2 times a year)
- Users who would like assistance with calibration and dilution calculations
- Users who want access to easy-to-use, straightforward decision support tools

In a Northern Irish context, the main target audience were small, lower intensity livestock farmers who often own older pesticide application machinery. Non-agricultural users would be predominantly drawn from the amenity sector, such as groundskeepers for sports pitches and golf courses, as well as environmental bodies and local councils who are responsible for the management of green spaces.

The development team then used the MoSCoW method (Must have, Should have, Could have or Won't have) to determine which features were to be included in the early prototype app. The market research showed that there was interest in a better understanding of best practice surrounding weather and the correct concentration of pesticides to use as well as the opportunity to integrate pesticide usage and record management tools into one piece of software. As such four sections were defined – Weather, Calibration and dilution calculations, Records and Best practice tips.

At this point it was decided that it would be inappropriate for the app to offer agronomic advice, e.g. on the best pesticide to use as this would require site and pesticide-specific information that was not available to the app development team. In addition, the record keeping facility to be offered would be considerably simpler than that requested by some respondents.

4.1 DEVELOPMENT OF APP INTERFACE

Prior to coding of the App interactive mock-ups and wireframes were created in Adobe XD and this imagery was presented to individuals working in agricultural industry support roles (e.g. staff in the Source to Tap project and representatives of the College of Agriculture, Food and Rural Enterprise (CAFRE)), Government and industry bodies (e.g. the Water Catchment Partnership, the National Pesticides and Drinking Water Action Group (NPDWAG)) and agricultural researchers in meetings where there opinions were sought.

Feedback from this process showed that:

- All parties were positive about the proposed product,
- Members of the FAIRWAY project and staff at CAFRE were concerned that the app needed to find its place in the market – it must either develop into a wide-ranging product that considers all aspects of pesticide use or it must focus in on the basics and seek to engage individuals who are often not keen to adopt technological solutions.

A further round of MoSCoW meetings identified those features that were to be included in the prototype version of the app, as well as a number of features that may increase the appeal of the app in later versions (Future developments, Section 6.4). The app development team elected to develop a simple app with little requirement for mobile or Wi-Fi connectivity in order to operate successfully and a diagrammatic representation of the highest levels of the menu system can be seen in Figure 4. Infrequent professional pesticide users, such as are commonly found in rural Northern Ireland were also confirmed as the primary target audience for this version of the app.

4.2 PROCESS OF CODING THE APP

A Business Requirements Specification was developed and then a small in-house team of software developers followed an industry standard software development lifecycle process in line with internal best practices and procedures.

To leverage existing skills in AFBI, the system was developed using the Xamarin Open-source mobile app platform for .NET. As well as allowing the developers to code in the widely used C# language, using this platform provides the option to port the application to iOS at a later date with relatively little resource investment.

An object oriented approach to coding was taken using the recommended “Model – View – ViewModel” (MVVM) design pattern. As such, the different elements of the system were designed, coded and tested individually and then brought together to form the completed system. Weekly team meetings were held to review progress and resolve any impediments/issues. System testing was carried out using Android OS emulation software before being passed to AFBI scientists for the first round of user-acceptance testing.

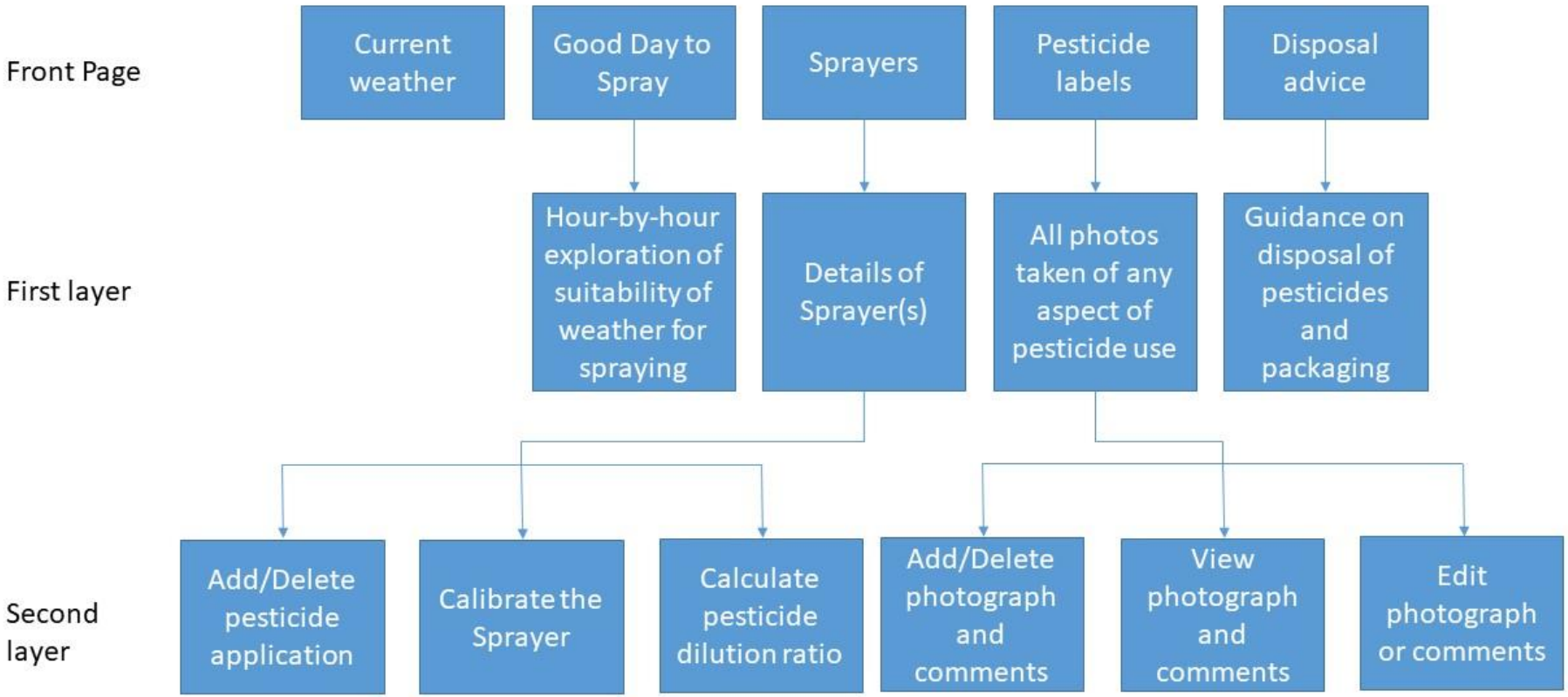

Figure 4: Diagrammatic demonstration of the highest levels of the menu system within the SprayDay app.

5. THE "SPRAYDAY" APP

The app consists of a front page as well as four themed areas and all are introduced below.

5.1 FRONT PAGE

Figure 5**Error! Reference source not found.** illustrates the first screen that the user sees when the app opens and it offers them information on the current weather conditions and access to the four sections of the app. Along the bottom there is a navigation strip that also allows the user to move between sections. This strip is present in all screens and so it is not necessary for the user to return to the main screen in order to navigate between sections.

As a current weather forecast is vital information when planning pesticide applications the app attempts to contact AFBI, where the current weather forecast is held, when the app is opened. When contact is made, the latest forecast data is downloaded and displayed. Where a connection cannot be made data from the last forecast received is displayed. The user is able to check the age of the forecast as the last line in this section shows the date and time when the forecast was last updated. If necessary, the user may use the update button located to the right of the temperature to download the latest forecast.

Figure 5: Front screen on the app showing the four options and the current weather conditions.

5.2 WEATHER

This section of the app provides the user with a more detailed description of weather conditions for spraying over the next five days at their location (Figure 6). The UK Meteorological Office previously developed the "Good Day to Spray" protocol that categorises the suitability of each hour for spraying (returning the result "Suitable" or "Unsuitable"), based on the parameters outlined in **Error! Reference source not found.**. When opened the app requests the GPS location of the mobile phone (where the user has permitted this information to be shared) and shares this information with the AFBI servers where weather data is held. The GPS location is used to identify the most spatially appropriate weather forecast and this information is returned to the app. The GPS data is then deleted. The weather data held by AFBI is updated every six hours.

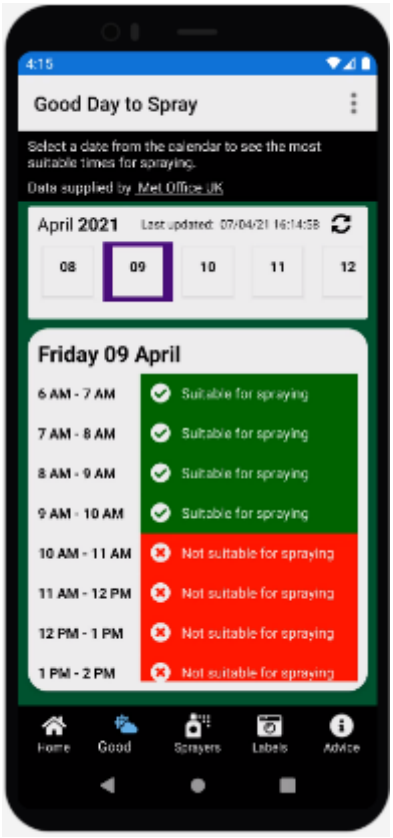

Figure 6: The weather section advices users of which periods of time over the next five days are suitable for undertaking spray actives.

The output of the protocol is presented to the user for each hour between 6am and 10pm for each of the next five days (**Error! Reference source not found.**) and, again there is a timestamp at the top right of the screen showing when the data was last updated. If the app has been unable to contact the AFBI servers for more than 6 hours a message appears informing the user of this, and suggesting they should update the weather data. If no connection is made for more than 48 hours this section of the app will cease to function until such time as new data is received.

In the prototype app it is not possible to provide information on today's spray periods. It is recognised that this is a weakness and the steps required to resolve this are known, however addressing this required more time than was available in the current project. This will be considered in future development of the app.

Table 1: Parameters used by the "Good Day to Spray" protocol to determine if weather conditions are suitable for spraying activities.

Parameter	Conditions
Time	Values are returned for the period between 0600 and 2200
Precipitation	No precipitation should be expected in the previous or current hour
Wind speed	Wind speeds should be less than 10 mph at 10m above ground level
Temperature	Average temperature should be greater than 1^{o}C in the current hour
	Temperatures should exceed 7^{o}C at some point during the day of interest

5.3 CALIBRATION AND DILUTION CALCULATIONS

The calibration of a sprayer and dilution of pesticides both require mathematical calculations to be performed. If, as is often the case on grassland-dominated farms, these steps are performed infrequently and so can be a major source of error and expense for the user.

The app records details of each sprayer and reminds the user when it is more than one year since calibration was last undertaken (Figure 7). Sprayer types supported are boom sprayer (tractor-mounted and quad-mounted), knapsack and weed wiper.

The app uses the workflow outlined in the CAFRE-presented training courses (validated by City and Guilds) that all professional pesticide users in the UK are required to attend (See Appendix B for details of the training courses and links). The app asks simple questions and performs the calculations for the user (Figure 8). Details of the calculations undertaken in this section can be found in Appendix C.

No information from this section of the app is shared with third parties

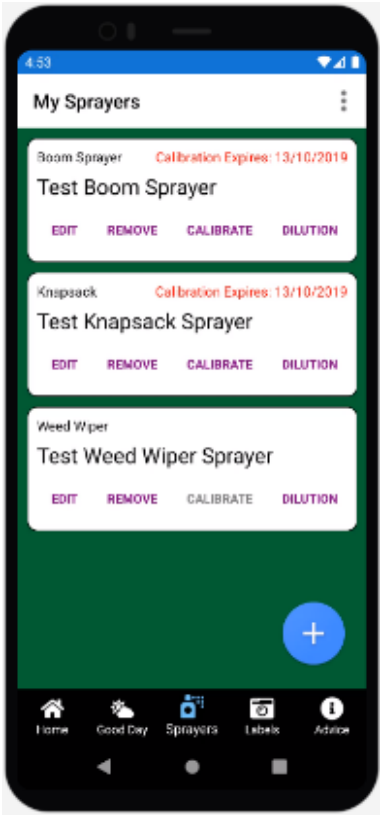

Figure 7: The area of the app where users can store the details of all the spray application devices that they use.

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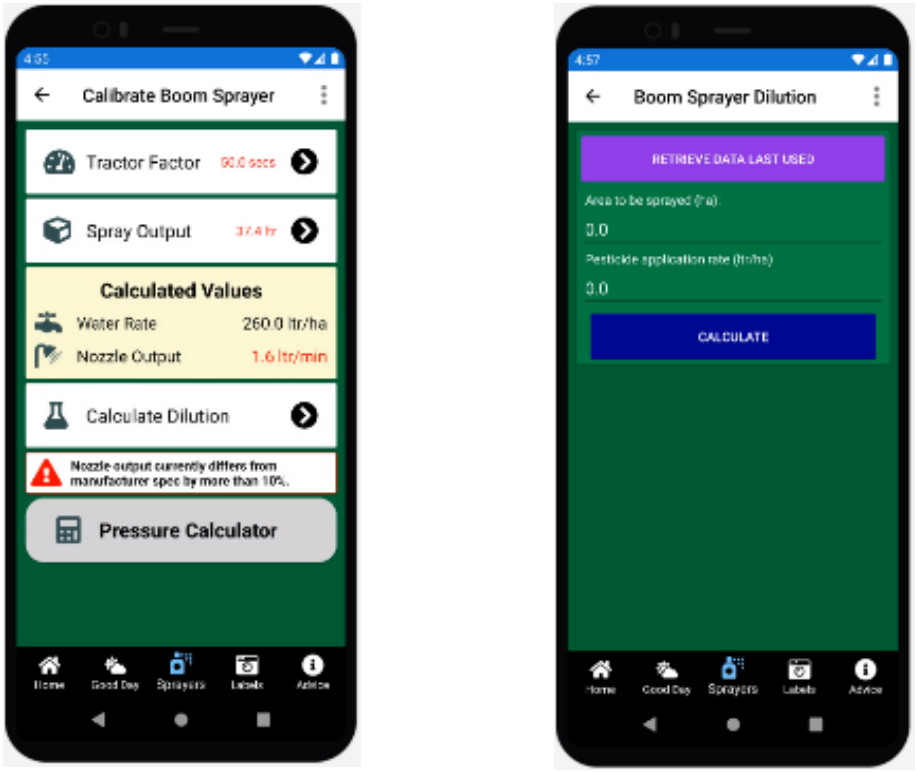


Figure 4: Once the user has entered the Sprayer area of the app they can either calibrate the sprayer (A) or calculate the volume of concentrated pesticide and water needed to treat the specified area of land (B).

5.4 PESTICIDE LABELS

An area where app users keep images of any aspect of the pesticide containers or sprayer(s) for future reference. (No information is shared with third parties). The capacity of the app to store photographs is limited by the same hardware constraints as apply to other photograph storage on the device. The user is able to "View", "Edit" or "Delete" any entry (Figure 5a) and each record includes a section for the user to records comments (Figure 5**Error! Reference source not found.**b).

A) B)

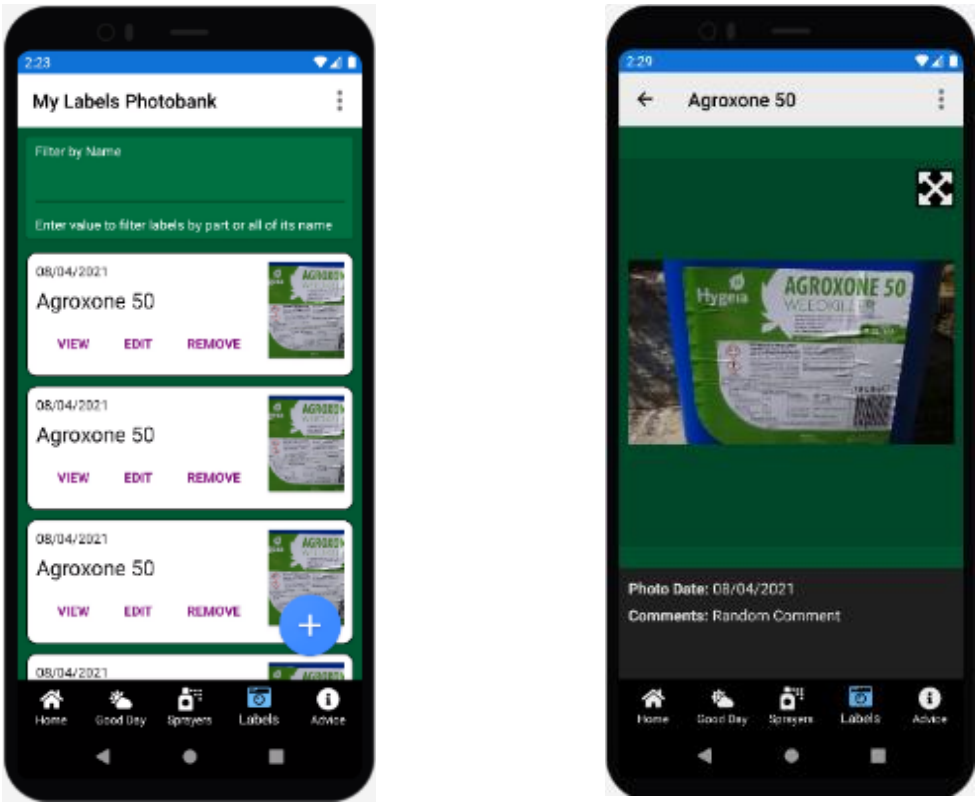


Figure 5: Users are free to photograph any aspect of the pesticide container or sprayer(s) that they wish to. Screen A shows the entry page where all items are listed. Users may choose to "View", "Edit" or "Delete" entries. Screen B shows the "View" screen. Comments may be updated in the "Edit" screen

5.5 BEST PRACTICE TIPS

This is intended to act as a quick reference section that either provides a brief answer to a user's questions around pesticide usage and storage best practice or guides them to more extensive resources on the internet. The focus of the text is on encouraging best practice disposal of pesticides (diluted as well as undiluted), bottles, foil seals, contaminated Personal Protective Equipment and materials used to deal with a spill (Figure 10).

When this section of the app is opened, the app contacts the server at AFBI and declares the issue number of the text currently held. The server compares this value with the document number of the latest version of the document. When the number is the same, no further action is taken, but where the numbers are different the new version of the text is downloaded to the app. This ensures that links and content remain current and accurate. If the app is unable to contact the AFBI server, a message will appear warning the user that the document may be out of date.

Figure 6: Information is provided as a series of headed sections allowing the user to rapidly navigate to the area of interest.

6. USER REVIEW OF THE PROTOTYPE APP

Legal restrictions on travel and meeting with individuals within Northern Ireland in early 2021, associated with the ongoing coronavirus pandemic, meant that it was not possible to arrange face-to-face meetings during the period of time when feedback on the app was being gathered. This meant that it was necessary to present the final prototype app to all respondents in web-based meetings. The benefit of this was that it allowed for an expanded range of professional bodies to be consulted, particularly within continental Europe. However, it is recognised that is has made it more difficult to reach the core target audience of this app.

6.1 STAKEHOLDER FEEDBACK COLLECTION– PROTOTYPE APP

A series of six online meetings were scheduled for late March 2021 and details of these meetings were released in the first week of March via email (Appendix D) and Twitter. Recipients of the email were encouraged to share the information with colleagues and contacts whom they believed would be interested. As a result there were a total of 64 attendees at the webinars.

Each presentation started with a brief introduction to the FAIRWAY project and the purpose of the app before a live demonstration was given. A version of the presentation that included screenshots of the app only was also prepared, in case of technical difficulties being experienced and this can be seen in Appendix E, alongside a list of key points to be discussed in each slide. Attendee feedback was gathered through use of the web service Mentimeter (www.mentimeter.com). In addition a Word document version of the questions (Appendix F) was distributed to all attendees after the event as it was recognised that not all participants would be willing to share their opinions online. Response to all/any questions was optional.

6.2 THE RESPONDENTS

In total 50 individuals' shared their opinions and these individuals represented a variety of professional backgrounds (Figure 7) from across the UK, the Republic of Ireland and Europe (Table 2). 43% of respondents (n = 47) had undertaken some form of professional pesticide user training course during their career, whilst only 21% (n = 47) had used pesticides in the last year.

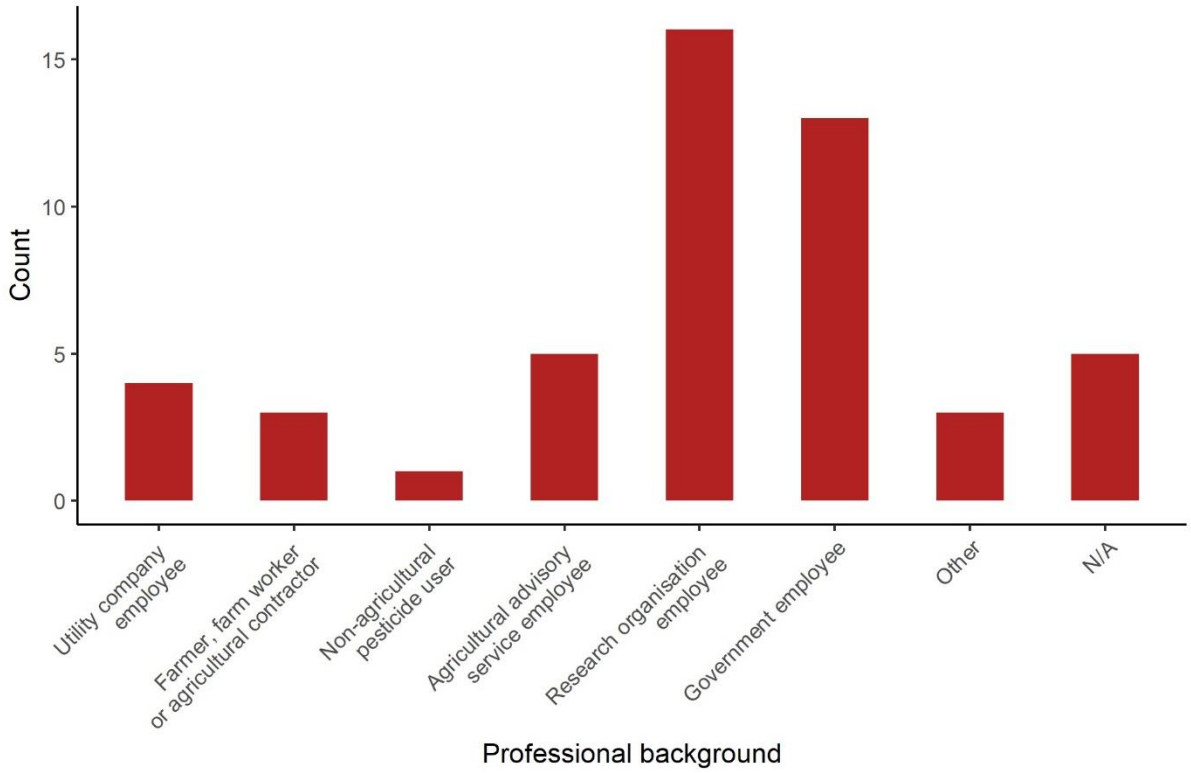


Figure 7: The profession(s) of the individuals who took part in the app review process in March 2021.

Table 2: The country within which respondents worked. Individuals operating within the United Kingdom were asked to clarify which of the constituent countries of the United Kingdom they worked within.

Country	Number of individuals
UK	
UK (England, Scotland, Wales & Northern Ireland)	1
Great Britain (England, Wales and Scotland)	1
Northern Ireland	16
England	10
Wales	1
Republic of Ireland	13
Netherlands	1
Denmark	1
Norway	1
Germany	1
Portugal	1

Market research at the start of the project had made it clear that the infrequent professional pesticide user market was actually much wider than just the farmers originally envisaged as the target

audience. The amenity sector (e.g. golf courses and sports grounds), as well as organisations such as councils would potentially be interested in this app and so the rest of the questions were written with this in mind.

6.3 RESULTS

Overall reviewers were very positive with 84% (n = 45) of respondents stating that they believed that the app delivered the key information required by the users in order to manage their pesticide usage. Reviewers were also asked to assess how suitable the app was for each of three identified sub-groups of users. 94% (n = 47) of reviews felt that the app was suitable for infrequent users of pesticides, 96% (n = 47) felt that the app was suitable for users who would like assistance with calibration and dilution calculations and 92% (n = 47) of respondents felt that the app was suitable for users who wanted access to an easy-to-use, straightforward decision support tool.

The pre-development market research exercise (section 3.3) also made it clear that there were differing views about the breadth of issues that the app should seek to address. There were those who were keen to see a very simple and paired down app and there were those who wanted a much more diverse app that would centralise a number of functions currently offered by a mixture of apps. As such the reviewers were asked to assess whether the decision to keep the app simple was the correct one, in their opinion. This was achieved by asking respondents to rate how strongly they agreed with four statements on a scale of 1 (Strongly disagree) to 10 (Strongly agree). The weighted average of responses is shown in Table 3.

Table 3: Weighted average of respondent's evaluation of whether specific changes in the app would improve the appeal of the tool to users.

Would the app benefit from…	Weighted average of the responses
An area for pesticide store record management	7.1
An area for record keeping	7.7
An expanded feature set	5.5
Staying simple. No more features	7.2

Reviewers were also given the opportunity to suggest any other changes that they felt the app needed and the answers showed a strong signal for the inclusion of more information and support materials in the "Disposal Advice" section, perhaps converting it to a "Hints and Tips" section instead. A number of respondents suggested that information on the correct placement and use of buffer strips as well as Local Environment Risk Assessment for Pesticides (LERAPs) would be beneficial. Several respondents suggested that the app should include some basic agronomic information (pesticide label dilution rates, target weed species, limits on usage, etc.) and a small number suggested including a QR code reader to allow users to access the manufacturers' information directly. One respondent also suggested that the app should carry information about the help and support the local water utility is currently providing, for example details of planned pesticide

amnesties or awareness raising days. There were also a number of individuals who suggested that non-pesticide approaches to weed management should be presented.

Updates to existing, and new features that were suggested included the expansion of the "SprayDay" output to specify why particular hours were unsuitable for spraying as this would make good use of a learning opportunity. Also suggested was the expansion of the targeted sprayer devices to include Controlled Droplet application (CDA) sprayers that are popular in the amenity sector, air assisted boom sprayers and drone sprayers. Finally the development of a version of the app that would record and return data to a centralised administration, whether that be for government records or as part of a catchment-scale scientific research project was proposed.

There were also a number of comments around the potential of the app to assist users in completion of the paperwork associated with the application of professional pesticide products. The facility to record the weather, as reported in the "Good Day to Spray" section of the app at the time of spraying was requested, as was the ability to integrate some form of mapping tool that would allow users to graphically determine the area of land that they intend to spray.

6.4 FUTURE DEVELOPMENTS

Whilst the work undertaken to date completes the work required within the FAIRWAY project it is recognised that there are a number of steps needed to bring the app to TRL9. In addition the original market research (section 3.3) and the reviewer feedback (section 6.3) shows that there are a number of potential future developments which would increase the utility and appeal of the app to potential users.

Development to bring the app to TRL9

- Field Trials: The ongoing Covid-19 regulations meant that it was not possible to trial this product in the field and there is a clear need for this work to be undertaken.
- Updates to the existing app functionality highlighted in the above trials.
- Update of weather data predictions: As previously discussed the way in which weather data is handled currently means that it is not possible to provide a "Good Day to Day Spray" review for today, which is clearly a significant weakness in the app. The current approach was adopted at this stage because of the complexity of handling weather data at this scale. That said, the protocols necessary to address this problem already exist and the development team have begun to investigate the work that would need to be undertaken to address this problem. This work should be continued.

Additional features/functions that could be included

- Update of weather data source: As previously discussed the current version of the app only uses weather data from the UK Meteorological Office. It has already been noted that this would potentially limit the appeal of the product to non-UK residents, but it should also be noted that individuals within the UK often have clear preferences around meteorological service providers they believe to be reliable. Future development could be to integrate other weather data suppliers into the app which the user could choose from (e.g. Met Eireann, or Meteo Weather).

- Expansion of App Functions: The app currently provides a basic suite of services to all users. As such there is the potential for further development of the product by the inclusion of a login facility and further tiers of support.
    - Tier 1 (Entry level) – app presented as is with no log in required
    - Tier 2 (Advanced user) – Log in required. Professional use of pesticides requires the generation of a number of documents each time pesticides are purchased, applied or disposed of (e.g. Pesticide store management and spray activity records). This tier of membership would allow users to perform much of this through their app and documentation could then be exported to a device attached to a printer when the user is in the office.
    - Tier 3 (Research catchment) – customisable services and information gathering tools that allow farmers participating within a research project to share specific items of data with research scientists without repeated completion of paperwork, e.g. sprayer calibration parameters, spray activity records, other parameters defined by the research project. The research project would provide users with an activation code.
- Operation System: At present the app is written solely within the Android environment and there is the need to adjust the app such that it will also operate on the Apple platform. The benefit of targeting the Linux and Windows mobile operating systems should also be explored.

6.5 SUITABILITY OF THE APP FOR USE IN JURISDICTIONS OUTSIDE THE UK

A major finding of earlier parts of Work Package 5 of the Fairway Project (Nicholson *et al.* 2020) was that the majority of Decision Support Tools are not suitable for adoption outside the country that they were initially developed for. It is recognised that this version of the app has been developed predominantly for the UK/Irish market, but it is suggested that key developments from TL6 to TL9 could include customisation for other countries as well. Specifically:

- Weather data - Currently the UK Meteorological Office provides the weather data for the app. The resolution of this data is much higher for locations within the UK than elsewhere, but international data is available. The data is provided to AFBI in an industry standard format and so supply contracts could be negotiated with other suppliers.
- Language – the apps native language is English, but could be translated into other languages.

7. CONCLUSIONS

The SprayDay app is a Decision Support Tool designed to assist infrequent users of professional pesticide products with adoption of best practice and there is a particular focus on providing information on the planning and execution of pesticide application. The app has been developed to approximately TL6 and has primarily targeted the Northern Irish/UK market, but could be adapted for the international market as part of a programme of further developments focused on developing the app to TL9. Reviews suggest that the app has successfully been designed to appeal to infrequent users of pesticides from agricultural backgrounds, as well as non-agricultural users, such as, groundskeepers for sports pitches and golf courses, environmental bodies and local councils who are responsible for the management of green spaces

APPENDIX A – QUESTIONNAIRE - MOBILE PHONE APP DEVELOPMENT

Thank you for your time today. The purpose of this five minute questionnaire is to explore the ways in which farmers use IT tools to plan their pesticide usage in Northern Ireland. The research project that I represent is developing an easy-to-use telephone app that will offer practical tips and advice to sprayer operators. We are currently at the design stage and so we are seeking the input of individuals we hope will be the apps users. This questionnaire is completely anonymous and there will be no follow-up questions or contact from ourselves. Would you be willing to answer a few questions?

1. Do you currently use online computer resources or mobile apps for any aspect of farm management?
    a. Yes – Please name
    b. No
    c. Prefer not to answer

2. Do you currently use online computer resources to assist with your planning for pesticide usage and container disposal?
    a. Yes – Please state particular website used…….
    b. No
    c. Prefer not to answer

3. Which category do you feel best describes your mobile phone (See back page for a hint if you're not sure)
    a. Smart phone
        i. Android
        ii. iPhone
        iii. Windows
    b. Traditional – go to question 7
    c. None – go to question 7
    d. Prefer not to answer

4. Would you be interested in using a mobile telephone app to assist with your planning for pesticide usage and container disposal?
    a. Yes. Go to Q. 5
    b. No – Please select the reasons that most closely match the respondents answer. Go to Q. 7
        i. Do not own a smartphone
        ii. Telephone network does not support fast enough browsing
        iii. Other forms of training already received
        iv. Other ways of gathering information preferred
        v. Other

5. Would you like an app to offer you information on any of these items when you are planning spraying activities? (select all that are appropriate)
    a. The correct ground conditions when spraying
    b. The correct weather conditions to spray
    c. The correct buffer areas/set-back from watercourses
    d. The safe use of personal protection equipment
    e. The best pesticide to use
    f. The correct concentration of pesticide to use
    g. Cleaning the sprayer and leftovers disposal
    h. Empty pesticide container disposal
    i. The pesticide label on the side of the container
    j. None of the above

6. Is there any other information that you would like the mobile telephone app to offer you?
    a. Yes – please specify
    b. No

I would now like to ask a few questions about the type of farm you are involved with and, in particular some of the challenges you face with weed management.

7. Which of the following sectors would you say that the farm that you are involved with is part of?
    a. Arable
    b. Beef
    c. Dairy
    d. Suckler
    e. Sheep
    f. Poultry
    g. Pigs
    h. Goats
    i. Other (please specify)
    j. Prefer not to answer

8. What plants are you most commonly trying to control through use of herbicides?
    a. Docks
    b. Rushes
    c. Thistles
    d. Ragwort/Benweed
    e. Other - please specify
    f. Prefer not to answer

9. Do you use any of the following herbicides on the farm that you are involved with?
    a. Mecoprop
    b. Glyphosate
    c. Fluroxypyr/triclopyr
    d. Aminopyralid/triclopyr,

e. Diflufenican
f. Metsulfuron-methyl
g. MCPA
h. Don’t know
i. Prefer not to answer

10. Which methods are currently used for herbicide application on the farm you are involved with?
    a. Tractor-mounted boom sprayer
    b. Quad mounted Lance/ boom sprayer
    c. Weed-Wiper /Weed-licker
    d. Knapsack Spraying
    e. Other
    f. Prefer not to answer

11. Are you familiar with the approved way to dispose of empty pesticide containers?
    a. Very
    b. Somewhat
    c. No
    d. Don’t know
    e. Prefer not to answer

12. Which age bracket do you feel best describes yourself?
    a. Under 20
    b. 21 – 40
    c. 41 – 60
    d. 61 – 80
    e. 80+

13. Which river catchment(s) does the farm you are involved in lie in?
    (E.g. Derg, Erne, Finn).

Thank you for your time answering these questions today. Your answers will form an important part of the mobile telephone app development process.

SMART

TRADITIONAL

APPENDIX B – SOURCES OF PROFESSIONAL PESTICIDE USAGE TRAINING IN NORTHERN IRELAND

The College of Agriculture, Food and Rural Enterprise (CAFRE) offers a range of City and Guilds validated courses that allow individuals to gain a Certificate of Competence in the safe use of pesticides. The certificate is a legal requirement for anyone wishing to use pesticides approved for use in agriculture, horticulture and forestry.

Pesticide Training – Foundation Unit (PA1) - Pesticide training - Foundation Unit PA1 | Safe use of pesticides | CAFRE

Pesticide Training – Boom sprayer (tractor mounted) (PA2A) - Pesticide training – PA2A -Boom Sprayer (tractor mounted) | CAFRE

Pesticide Training – Weed wiper (PA2F) - Pesticide training – PA2F – Weed Wiper | Pesticides | CAFRE

Pesticide Training – Weed wiper (PA6AF) - Pesticide training – PA6A – Knapsack Sprayer | CAFRE

APPENDIX C – CALCULATIONS USED WITHIN THE SPRAYDAY APP.

Boom-mounted Sprayer calculations

Calibration

Spray output

$$Spray\ output\ \left(\frac{l}{min}\right) = \left(\frac{\sum spray\ output\ volume\ recorded\ from\ test\ nozzles}{number\ of\ nozzles\ sampled}\right) * nozzle\ count$$

Tractor factor

$$Tractor\ factor\ (s) = \frac{(sum\ of\ journey\ times\ across\ the\ 100m\ course)}{number\ of\ times\ course\ was\ traversed}$$

Time taken to spray 1ha

$$Time\ it\ takes\ to\ spray\ 1ha\ (s) = \left(\frac{10000}{width\ of\ sprayer\ boom}\right) * Tractor\ Factor$$

Water rate

$$Water\ rate(l/ha) = Spray\ output * \left(\frac{Time\ it\ takes\ to\ spray\ 1ha}{60}\right)$$

Calculate the change in pressure needed in the sprayer to achieve the desired nozzle output.

Nozzle spacing (m)

$$Nozzle\ space(m) = nozzle\ spacing * 0.001$$

Nozzle output (l/min)

$$Nozzle\ output\ (l/min)\ = \frac{(Water\ rate * Tractor\ speed * nozzle\ space)}{600}$$

New sprayer pressure

$$New\ Pressure\ (bar) = \left(\frac{Desired\ nozzle\ output}{Nozzle\ output}\right)^2 * 2.4$$

Dilution calculations

Do you need a full tank?

$$Areal\ capability\ of\ tank\ (Ha) = \frac{capacity\ of\ tank\ (l)}{Water\ rate\ (l/Ha)}$$

Yes, I need a full tank calculation

Volume of pesticide formulation to use (l)

$$Vol\ of\ pesticide\ formulation\ to\ use\ (l) = \frac{(capacity\ of\ sprayer\ tank * pestcide\ application\ rate)}{Water\ rate}$$

No, I need a part tank calculation

Volume of water needed in the tank (l)

$$Volume\ of\ water\ needed\ in\ the\ tank(l) = area\ of\ field\ (Ha) *\ water\ rate\ (l/Ha)$$

Volume of chemical formulation to add to the sprayer (l)

$$Volume\ of\ chemical\ formulation\ to\ add\ to\ the\ sprayer\ (l) = \frac{(Volume\ of\ water\ needed\ in\ the\ tank\ (l) * application\ rate\ of\ pesticide(l/Ha))}{water\ rate(l/Ha)}$$

Knapsack sub-page

Sprayer calibration

Walking speed (km/h)

$$Walking\ speed\ (km/h) = \frac{360}{average\ walking\ speeds\ (m/s)}$$

Water rate (l/ha)

$$Water\ rate\ (l/ha) = \frac{\left(\frac{(600 * spray\ rate\ (l))}{Spray\ width\ (m)}\right)}{walking\ speed\ (km/h}$$

Dilution calculations

Do you need a full tank?

$$Areal\ capability\ of\ tank\ (ha) = \left(\frac{capacity\ of\ tank\ (l)}{Water\ rate\ \left(\frac{l}{Ha}\right)}\right)$$

Yes, I need a full tank (Label gives dose rate in l/Ha)

Volume of pesticide to use (l)

$$Vol\ of\ pesticide\ to\ use\ (l) = \left(\frac{areal\ capacity\ of\ tank\ (m^2)}{10000m^2}\right) * application\ rate\ (l/Ha)$$

I need a full tank (Label gives dose rate as a concentration)

Volume of pesticide to use (l)

$$Vol\ of\ pesticide\ to\ use\ (l) = \left(\frac{Dose\ (l\ per\ 100l) * Tank\ size\ (l)}{100}\right)$$

I need a part tank calculation (Label gives dose rate in L/ha)

Volume of water to use (l)

$$Volume\ of\ water\ to\ use\ (l) = \left(\frac{area\ of\ field\ (m^2)}{10000}\right) * water\ rate\ (l/ha)$$

Volume of pesticide to use (l)

$$Litres\ of\ chemical\ formulation\ to\ add\ to\ the\ sprayer = \left(\frac{(area\ of\ field\ (m^2))}{10000}\right) * application\ rate\ (l/Ha)$$

I need a part tank calculation (Label gives dose rate as a concentration)

Volume of water to use (l)

$$Volume\ of\ water\ to\ use\ (l) = \left(\frac{area\ of\ field\ (m^2)}{10000}\right) * water\ rate\ (l/Ha)$$

Volume of pesticide to use (l)

$$Vol\ of\ pesticide\ to\ use\ (l) = \left(\frac{Dose\ \left(\frac{l}{100l}\right) * Volume\ of\ water\ needed\ in\ the\ tank\ (l)}{100}\right)$$

Weed-wiper sub-page

Dilution calculations

Enter dilution ratio advised into the two text boxes below. For example if the dilution ratio is 1:2.75 dilution with water, enter 1 in the left box and 2.75 in the right box

TEXT BOX: TEXT BOX

Volume of pesticide to use (l)

$$Vol\ of\ pesticide\ to\ use\ (l) = \left(\frac{Dose\ \left(\frac{l}{100l}\right) * Volume\ of\ water\ needed\ in\ the\ tank\ (l)}{100} \right)$$

Volume of water to use (l)

$$Vol\ of\ water\ to\ use\ (L) = \ vol\ of\ pesticide\ to\ use\ (l) * right - hand\ text\ box$$

APPENDIX D – EMAIL SENT OUT TO RECRUIT ATTENDEES TO THE PROTOTYPE APP REVIEW SESSIONS.

Dear X,

As partners in the EU-funded FAIRWAY project (www.fairway-project.eu)), the Agri-Food and Bioscience Institute (AFBI) are involved in investigating the different ways in which countries manage and mitigate the risk of agricultural contamination of waterbodies used for drinking water supplies. In Northern Ireland we are particularly interested in the threat of losses of grassland herbicides, such as MCPA.

Within the project, AFBI has developed a mobile phone app that will provide farmers who are using professional herbicide products with guidance on current best practice in all aspects of pesticide use. We have now reached a stage where we have a working prototype and are seeking feedback from both potential users of the app and other professional stakeholders whose work relates to pesticide use or impact on water quality.

We would appreciate the opportunity to present the app to you and/or your colleagues and so would like to invite you attend one of the free-to-register webinar sessions detailed below. Please also feel free to forward this email on to anyone else that you think may be interested as we are keen to present this work to as wide a variety of individuals and organisations as possible and in particular farmers groups.

Should you have further questions, please do not hesitate to contact me.

Webinar times and dates

https://www.eventbrite.co.uk/e/sprayday-mobile-app-for-infrequent-pesticide-users-tickets-143696559277

Monday 22nd March 2021 - 2pm

Thursday 25th March 2021 – 10am

Friday 26th March 2021 – 11am

Monday 29th March 2021 – 11am

Tuesday 30th March 2021 – 3pm

Wednesday 31st March 2021 – 2pm

Please note all times are correct for the UK's time zone.

Yours sincerely

Dr. Luke Farrow

Higher Scientific Officer – Spatial analyst – Catchment Management

Sustainable Agri-Food Sciences Division

Agri-Food & Biosciences Institute

18a Newforge Lane

Malone Upper

Belfast

BT9 5PX

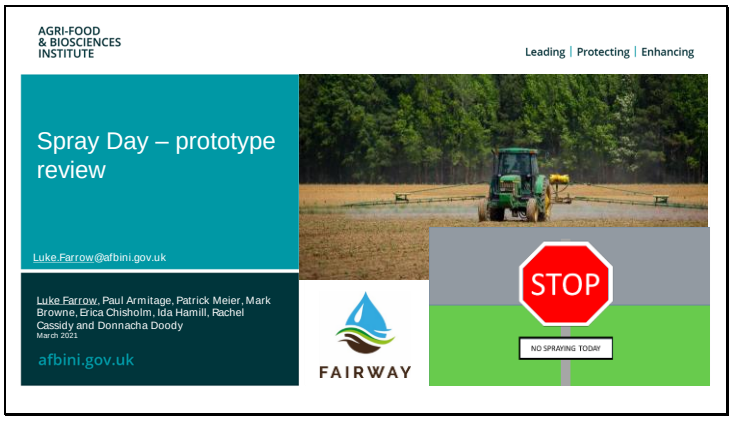
Northern Ireland

Tel: 028 9025 5442

e-mail: luke.farrow@afbini.gov.uk

APPENDIX E – POWERPOINT PRESENTATION OF THE PROTOTYPE APP

Slide 1

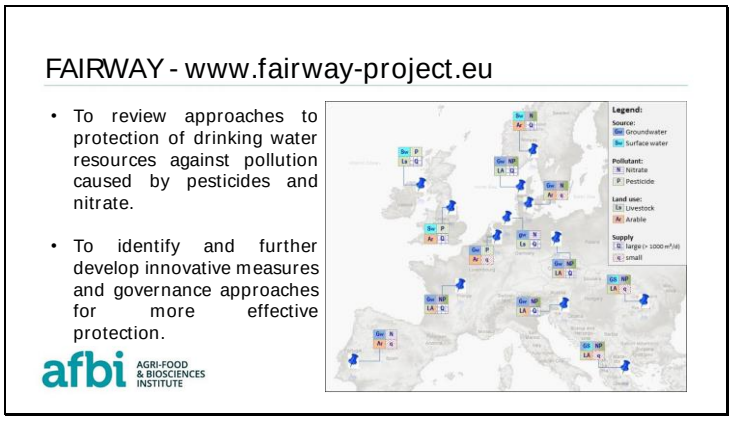


- Welcome to the Spray Day mobile app presentation. This is a piece of work undertaken by the Agri-Food and Biosciences Institute in Northern Ireland (AFBI) in Northern Ireland as part of the Fairway project.

Slide 2

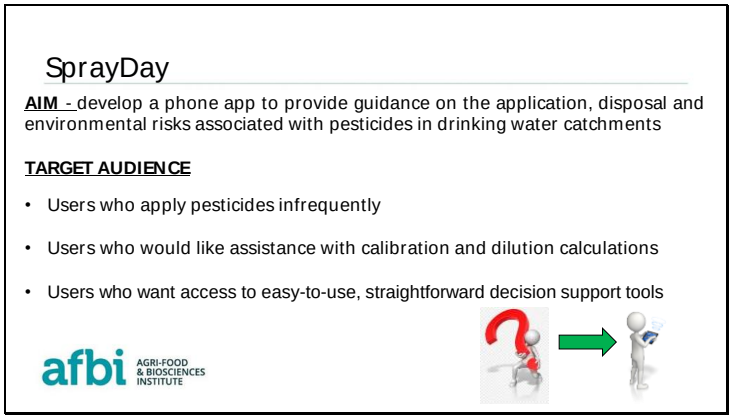
- Read out

Slide 3



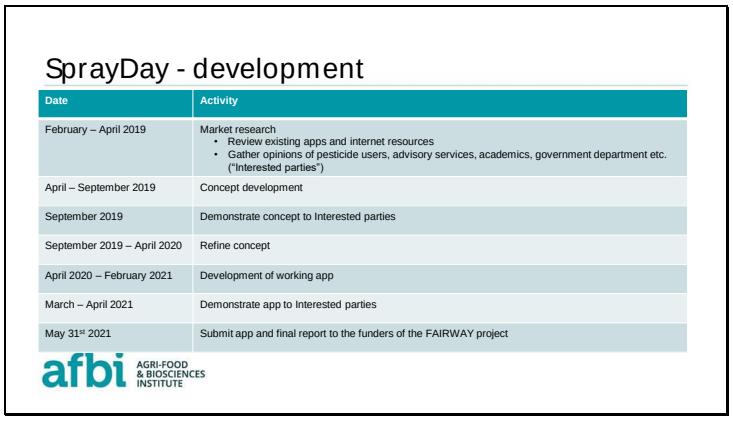
- The purpose of the FAIRWAY project is to review the way in which member states are protecting drinking water supplies from agricultural contaminants, specifically pesticides and nitrates.
- We are looking for innovative measures and governance approaches and reviewing how well, or poorly they have performed.
- This information is shared with other states so that the good ideas can be perpetuated and the less good ideas can be avoided in future.
- As the map on the right of the slide shows, we are covering a very wide area across Europe and each individual research site has chosen the most appropriate mixture of challenges

Slide 4



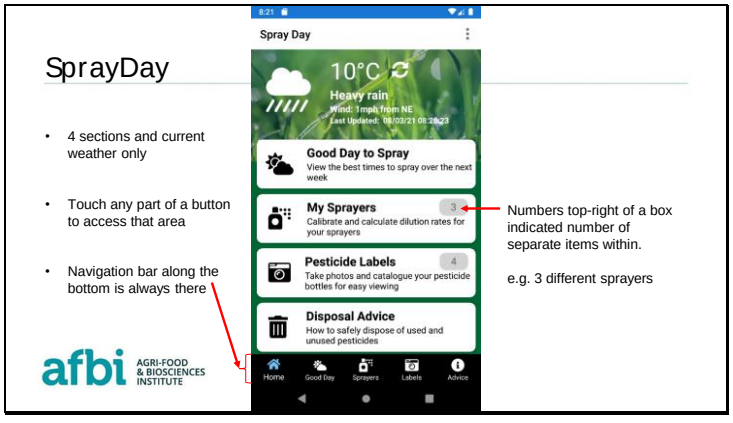
- AFBI was asked to design an app that provides guidance on the application, disposal and environmental risks associated with pesticides in drinking water catchments.
- Early market research showed us that farmers weren't the only potential target group. Other organisations, such as the amenity sector and Councils may also use pesticides in considerable quantities.
- We defined our target audience to represent
    - users who apply pesticides infrequently
    - users who would like assistance with calibration and dilution calculations
    - users who want access to easy to use straight forward decision support tools

Slide 5



- The work has been undertaken over the last three years starting with market research
    - Speaking to potential users of the app and also individuals and organisations that work to support agriculture, such as advisory services, academics and government departments - Finding out what really needs to be in the app
- In March and April 2021 we demonstrated the prototype app to the same groups as listed above
- In May 2021 the report final report will be written up and submitted as part of the Fairway projects deliverables.
- AFBI would like to see the project go further and we are actively looking for companies to collaborate with on this. As a research active organisation we are familiar with the processes around applying for, and gaining funding from research bodies, such as Innovate NI. If you would be interested in collaborating with us, please contact luke.farrow@afbini.gov.uk.

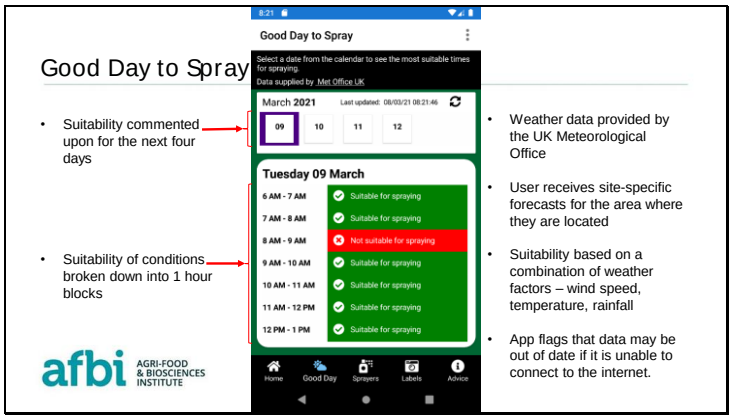
Slide 6



- This is the front page of the app.
- It deliberately only contains five pieces of information and the navigation bar along the bottom.
- At the top you have the current weather

    - A picture describing current weather conditions
    - A written description of temperature, weather and wind (direction and speed)
        - Data is currently provided by the UK Met Office and is accurate, if you are within the UK, to within about one kilometre of your location. Elsewhere in the world data resolution is lower.
    - A timestamp for the last time the weather data was updated
        - Reload button next to the temperature allows the user to reload weather data at will.
        - Feature is important as weather is a key factor in determining if now is a good time to go spraying.
- "Good Day to Spray button - a deeper dive into weather data
- "My sprayers" - The personal details of your sprayers
- "Pesticide labels" - an area where the user may photograph any aspect of pesticide usage that they wish to photograph
- "Disposal advice" - A hints and tips section offering advice on disposal of pesticide contaminated object (e.g. triple-rinsed foil caps, bottles and PPE) as well as dilute and undiluted pesticides.
- Although currently written in English, the app could easily be re-written to offer further languages

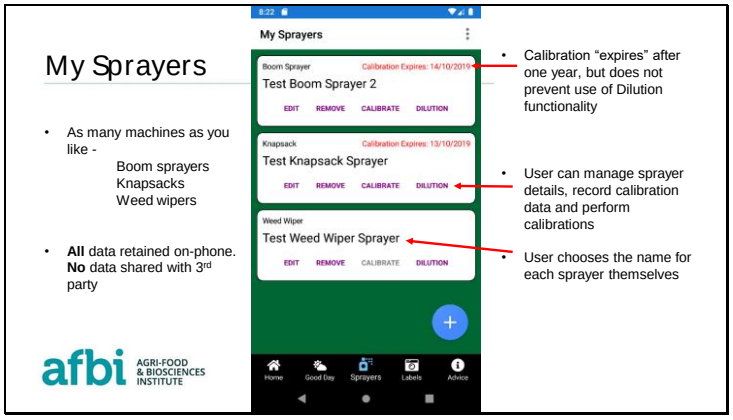
Slide 7



- "Good Day to Spray" is a deeper exploration of the weather conditions and their suitability for spraying
    - Divides next four days into hourly blocks between 6am and 10pm and determines whether each period is suitable for spraying or not, based on the "Good Day to Spray" protocol developed by the UK Met office
- Data currently provided by UK Met Office, but is provided in an industry standard format and so it would be relatively simple to replace with data from a different supplier in future
    - Increases the transferability of this app out of the UK
    - Recognises that everyone has their own view of which weather data suppliers are most reliable, so broadening the appeal of the app in the UK too
- Personal information security – when setting up a new mobile, users decide if the phone will be allowed to share GPS location data with third parties. If this is enabled the app shares the GPS location with AFBI. AFBI identifies the weather forecast that is appropriate for the location and returns it to the app. The GPS location is not retained by AFBI.
- To the right of the month there is a timestamp and reload button allowing the user to download updated weather data.

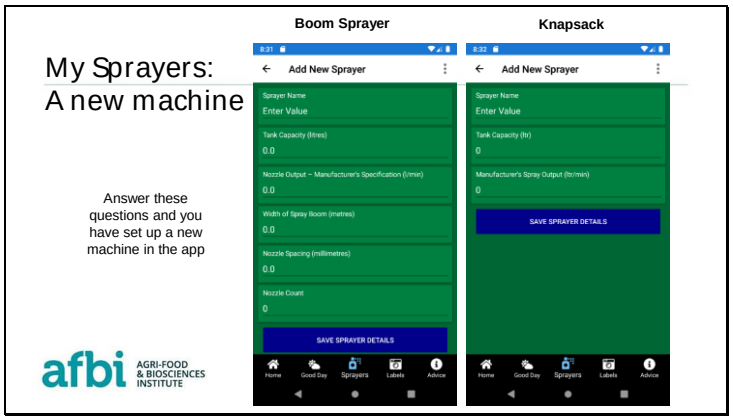
- AFBI receives updated weather data every 6 hours
- If the app has not made contact with AFBI for more than 6 hours a message appears beneath the date warning the user to download a newer forecast
- If the app has not made contact for more than 2 days, this section only displays a message suggesting the user downloads a new forecast.

Slide 8



- "My Sprayers" – Storage area for the personal details of all sprayers that the user owns
- Also home to the calibrate and dilution calculation functionality
- Sprayer types offered are currently "Boom", "Knapsack" and "weed wiper"
- No data from this area is shared with any third party.
- Also displayed is a visual reminder if calibration of a device happened more than one year ago. This does not disable functionality
- When new this screen is empty and new machines may be added by clicking on the blue plus symbol

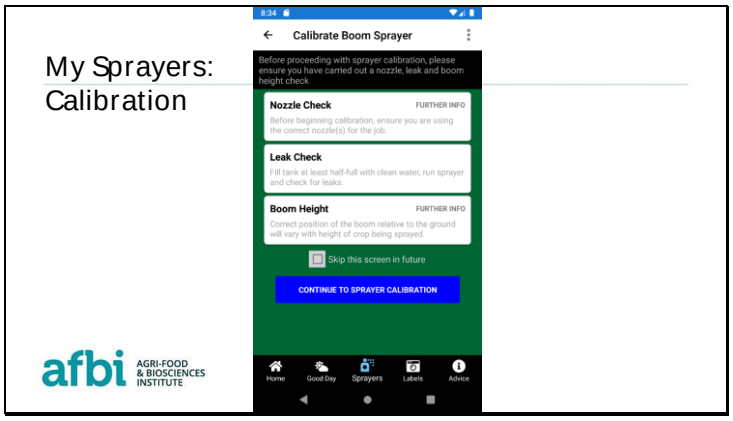
Slide 9



- Details of each sprayer are entered here.

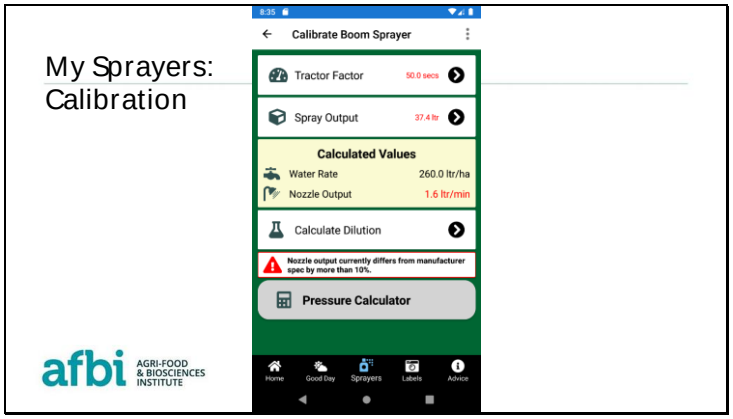
- On the left are the questions for a boom sprayer and on the right are the questions for a knapsack sprayer.
- Sprayer name: User selects the name for the sprayer
- Nozzle output – This value will need to be updated each time the user alters the nozzles on the sprayer. The app is not envisaged as being used by individuals with access to sprayers that carry multiple different nozzle types simultaneously.
- The three dots stacked atop each other at the top right of the app allow access to the Settings area. One of the features in here allows the user to determine if the app is to request data in imperial or metric measure.

Slide 10



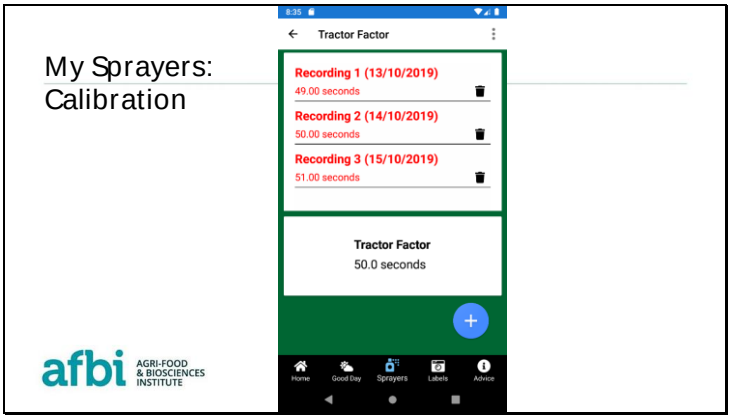
- Three reminders about best practice. Nozzle check and Boom height may be clicked on for more information
- If the app user doesn't want to see this screen again, they can select "Skip the screen in future" and this screen will not be seen again for this sprayer.

Slide 11



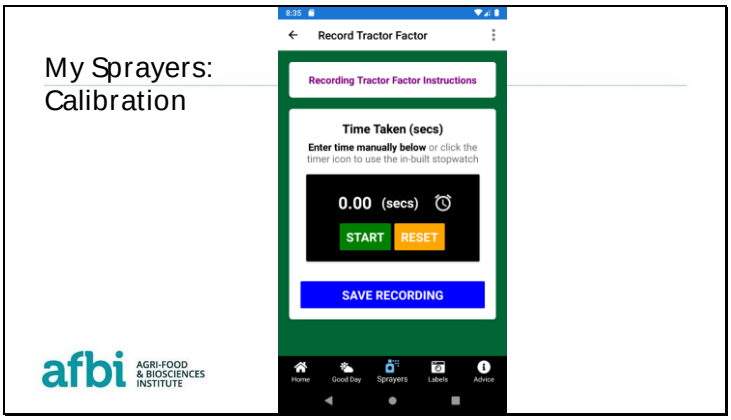
- "Tractor Factor" and "Spray Output" are the only buttons that require info from the user, so this screen is not as intimidating as it looks.
- In order to calibrate the sprayer the user first needs to click on "Tractor Factor"

Slide 12



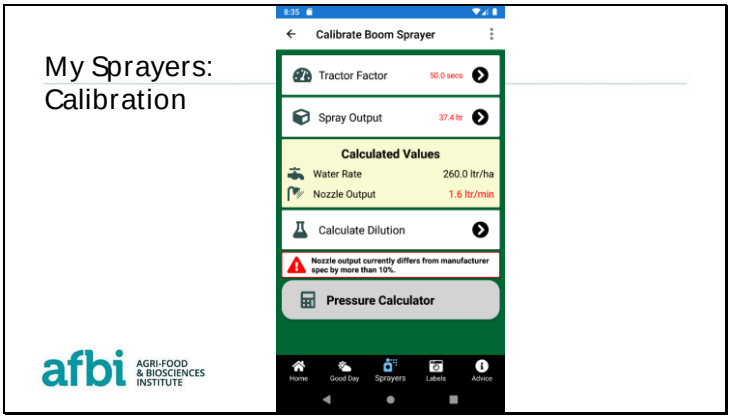
- "Tractor Factor" is a measure of the time taken for the tractor to cover 100m whilst spraying.
- The app requires 3 values to be entered in order for "Tractor Factor" to be calculated
- Old values can be deleted by clicking on the dustbin icons
- New values entered by clicking on the blue cross

Slide 13



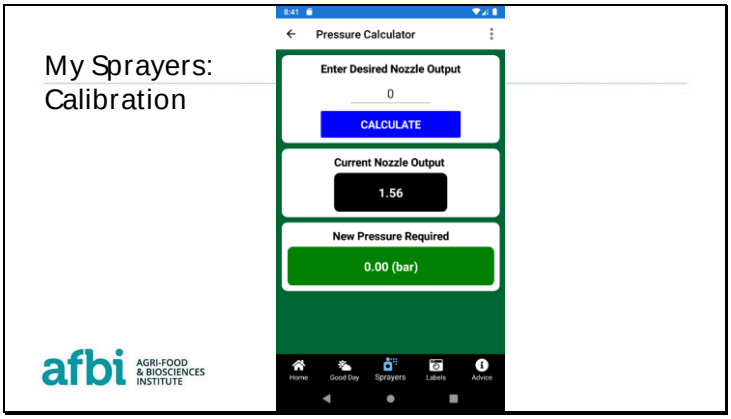
- The "Recording Tractor Factor Instructions" button contains a full set of instructions on how to complete this process
- The central section is a stop-watch allowing the users to record the time taken to drive 100m
- If the user already knows the answer to this question they can type the value in directly
- "Save recording" saves the result

Slide 14



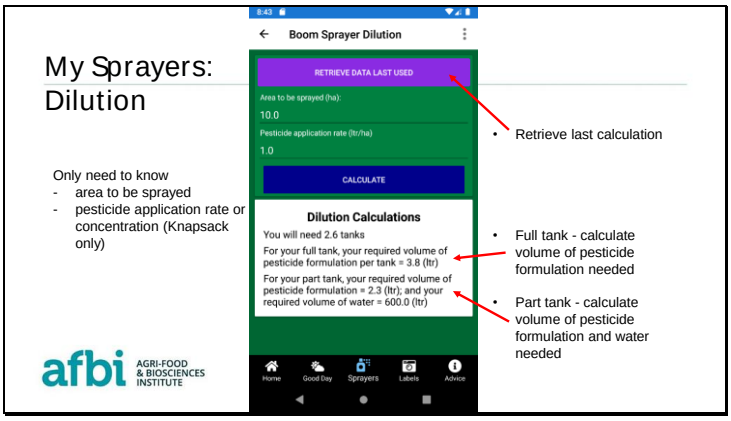
- "Spray Output" – A measure of the volume of water sprayed by selected nozzles across the sprayer during a period of 1 minute. As for "Tractor Factor" instructions, a stop watch and data entry function are provided.
- The "Calculated Values" box in the middle of the screen allows the user to check that the values calculated by the app match their expectations
    - "Water rate" – volume of water sprayed per ha
    - "Nozzle output" – the average output of each of the tested nozzles.
- In this case we set the sprayer up with 2ltr/min nozzles and so the app flags that there is potentially a problem – hence the exclamation mark and comment beneath "Calculate Dilution"
- Causes could be
    - Sprayer nozzles are worn out
    - Pressure in the sprayer is too low
- User is responsible for checking the first, but the app can help with the second – if the user presses on the "Pressure calculator" button.

Slide 15



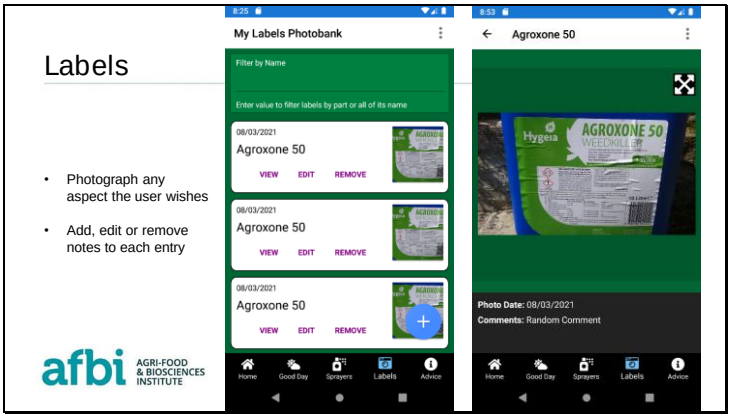
- User enters the desired pressure in the first box and presses the "Calculate" button
- "Current nozzle output" reminds the user of the current nozzle output
- "New pressure required" tells the user what pressure to raise the sprayer to in order to achieve the desired nozzle output.
- At this point the user must assess whether the value suggested is realistic for their machine
    - Yes – make the adjustments and re-run "Spray output"
    - No – evidence suggests that the problem is not with the pressure in the sprayer

Slide 16



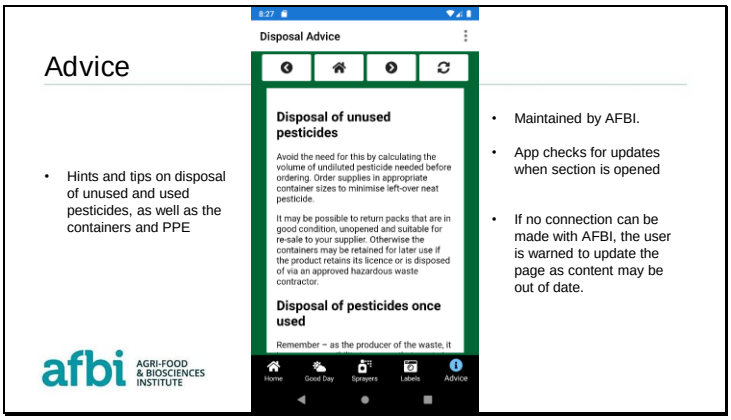
- When the user is ready to go spraying they navigate to this page and enter the area of land that they wish to spray and the pesticide application rate that they wish to use before pressing the "Calculate" button
- In this case the work requires 2.6 tanks of mixed pesticide
    - Full tank: 3.8 litres of pesticide formulation and fill the tank with water
    - Part tank: 2.3 litres of pesticide formulation and 600 litres of water
- This screen also allows users to "retrieve last data used"

Slide 17



- This area acts as a photo bank for any aspect of pesticide usage that the user wishes to photograph
- Image on the left shows the front screen of this area. When the app is new there are no entries.
- New entries are created by clicking on the blue plus sign
- "View" opens the image on the right of the screen. The arrows top-right opens the photograph in a new screen and this is fully zoomable
- "Photo Date" records the date the photograph was take
- "Comments" are entered by the user and may be amended through time by use of the "Edit" function.
- Once the photograph is no longer needed it can be removed by clicking on the "Remove" option.

Slide 18



- A hints and tips section that currently covers best practice around disposal of used and unused pesticides (both those with labels and the less easily identified), as well as PPE, absorbent materials used to tidy up pesticide spills and what to do with excess diluted pesticide.
- Section could easily be expanded to cover other information as well.
- As this section contains legal terms and information on best practice, the app checks back with AFBI every time it is opened. This ensure that the document in the app is the current version.
- Where it is not possible for the app to contact AFBI, a banner is displayed at the top of the page warning the user that the information may be out of date and suggesting that they either update the page or seek clarification from other sources.
- Where connection to AFBI has been successful and the current document on the app is found to be out of date, the new version is updated automatically.
- If the app were to be deployed in a country other than the UK, this page could be re-written (language and content) to reflect the local legal conditions.

Slide 19

- Thank you for your attention today
- If you have any questions, or would be interesting in future collaboration opportunities, please do not hesitate to contact me at luke.farrow@afbini.gov.uk

APPENDIX F - QUESTIONS ASKED OF ATTENDEES AT THE PROTOTYPE APP DEMONSTRATION EVENTS

Whilst working with the Agri-Food and Bioscience Institute (AFBI) here in Northern Ireland I have been part of the EU-funded FAIRWAY project (www.fairway-project.eu)) which is investigating the ways in which different countries are managing the threat of diffuse agricultural contamination of waterbodies used as sources of drinking water. In Northern Ireland we are particularly interested in the threat posed by diffuse losses of grassland herbicides, such as MCPA.

One of the project deliverables is a mobile phone app that will provide infrequent users of professional pesticide products, such as individuals associated with farms where pasture is the predominant land use with guidance on current best practice associated with all aspects of pesticide use. We have now reached a stage where we have a working prototype and we are seeking the opinions of both potential users of the app and from individuals whose professional roles bring them into contact either with potential users or pesticide-related drinking water quality issues.

Please be aware that your answers will be collated with all other responses we receive and analysed for trends and patterns. The results of this analysis will be used in the final report that we submit to our funders and may be included in a future scientific publication.

Overall

1. The designers of this app opted to develop a simple to use product that targeted. Do you feel that this app is suitable for these targeted groups?
    - Users who apply pesticide infrequently

      Yes No
    - Users who would like assistance with calibration and dilution calculations

      Yes No
    - Users who want access to easy-to-use, straightforward decision support tools

      Yes No

2. Overall the app would benefit from…

- An area for pesticide store record management?

Strongly disagree Strongly agree

1 2 3 4 5 6 7 8 9 10

- An area for record keeping?

Strongly disagree Strongly agree

1 2 3 4 5 6 7 8 9 10

- An expanded feature set

Strongly disagree Strongly agree

1 2 3 4 5 6 7 8 9 10

- Staying simple. No more features

Strongly disagree Strongly agree

1 2 3 4 5 6 7 8 9 10

3. Does the app deliver the key pieces of information required by farmers to manage their pesticide usage?

Yes No

4. Overall – what other features would the app benefit from?

About you

We are interested in gaining some understanding of the interested parties that we have gained feedback from.

1. Which category (or categories) do you feel best describes yourself?
    a. Utility Company employee
    b. Farmer, farm worker or agricultural contractor)
    c. Non-agricultural pesticide user

d. Agricultural advisory service employee
e. Research organisation employee
f. Government employee
g. Other

2. Have you, as part of your professional duties, used pesticides in the last year?

Yes No

3. Have you, at any time, undertaken any official training courses in the use of professional pesticide products?

Yes No

4. Which country/region do you work in?

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