

Apps and sustainable diets: what role can apps play in influencing individuals to eat sustainably

MSC Sustainability and Adaption

Abstract

The global food system and its emissions present a major challenge to achieving UN mandated climate goals. Animal agriculture is a significant contributor to greenhouse gas emissions and biodiversity loss, and as the world gets richer and our population grows, the consumption of meat and dairy, in line with a western diet, increases. The need to transition towards a sustainable diet, which reduces an individual's meat and dairy consumption is therefore urgent.

Behaviour change support systems (BCSS), otherwise known as mobile apps, offer a promising avenue for influencing behaviour at scale. Apps have been used successfully in influencing weight loss, to stop smoking, reduce alcohol consumption and more. However, the impact of apps on promoting sustainable diets remains underexplored.

This study explores this research gap, assessing the impact an existing app called Fork Ranger can have on influencing individuals to eating more sustainably, as well as analysing the strengths and weakness apps have. Utilising a mixed-methods approach, this study consists of a quantitative survey (n=180) and qualitative interviews (n=10), and provides deep insights into how apps can influence the uptake of sustainable diets.

The results show how the user interface and design of BCSS can combine information provision and skills development in a unique way which promotes user engagement and learning through features such as interactive quizzes, daily infographics, streak building, recipe rewards and knowledge building. 45% of users reported a change towards a more sustainable diet as a result of using the app, while nearly all users reported an increase in knowledge about the carbon footprint of the food they eat (91.1%) what a sustainable diet is (86.7%), the food industry's impact on climate change (86.1%), and the role of their diet in taking action on the climate (83.3%).

The research concludes that apps can be an effective means with which to help support behaviour change towards the consumption of more sustainable diets, while also making further suggestions about the strengths and weaknesses of apps, while building knowledge is a positive, the qualitative interview phase revealed that if the users physical environment provides obstacles such as lack of availability, price of sustainability and conflicting messages around health benefits. Suggestions for further research are also shared, which focus on exploring this research area further through observational studies, and trials with users who don't exhibit existing sustainable behaviours.

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1. Introduction

1.1. Context

The UN's Paris agreement goals set out plans to limit global temperature rise to 2°C or less. This will require rapid and ambitious reductions in global greenhouse gas (GHG) emissions, which can only be achieved with drastic reductions of GHG emissions from high emitting sectors such as energy, industry, transport, construction, and agriculture and forestry (IPCC 2022)

While fossil fuel emissions, from transport and energy, have quite rightly been a critical focus for governments and organisations, studies have shown that even if these emissions were halted immediately, current trends in the global food system, where emissions continue to rise, would prevent the achievement of the Paris goals (Clark et al., 2020).

These high emissions within the food system are being driven by a growing global population which is getting wealthier, estimates say by 2050 there could be up to 10 billion people on the planet, and as populations get richer, they are adopting western diets rich in meat and dairy consumption (Godfray et al., 2018, Clark et al., 2021)

This diet is unsustainable, with data presented in this paper's literature review revealing the stark impact animal and industrial agriculture has on the world's resources, such as land and water, and our biodiversity.

The issue is that our food system operates in a world of finite resources, and research shows that demand is continuing to rise. It is estimated the world will need to increase food production by between 70 to 100% by 2050, with the supply of energy dense foods needing to increase by more than 25% for meat and dairy, and eggs by more than 50% (Alexandratos et al. 2012). Animal agriculture, including animal feed, accounts for up to 20% of total GHG emissions, while it is responsible for nearly 60% of the food systems' emissions. (Xu et al. 2021)

Changing diets towards ones which are more plant-based will be critical in meeting GHG emission targets. For example, the UK's Net-Zero by 2050 commitments in the UK, outlines how the population needs to be eating 30% less meat, as advised by the government's independent climate advisory board The Climate Change Committee (The CCC, 2019). But in a recent progress report by the CCC it was revealed that the UK government isn't fulfilling its obligations to encourage meat reduction within individual consumer behaviour (The CCC, 2023).

Changing eating behaviours is a difficult challenge not least when it comes to changing diets from one focused on meat and dairy, such as the Western diet, to one which is one which is majority plant-based and sustainable, as recommended by the EAT-Lancet commission (Willet et al., 2019). There are several reasons for this, which this study will unpack in the literature review, ranging from cultural connections and identity, or for health reasons, taste preferences, or a lack of knowledge about how to shop, eat and cook sustainably (Kwasny et al. 2022). People are also less likely to understand, or make a connection, to the impacts on climate change their diets may have. (de Boer et al., 2013)

With temperatures rising at an unprecedented rate, this issue becomes more urgent. While behaviour change interventions have been modelled to encourage consumers to make more sustainable choices, from performing nudge experiments in cafeterias (Zhou et al. 2019), to climate labelling on meat products (Vanclay et al. 2011). The change isn't happening quick enough. In the UK, while meat eating has fallen, UK consumers now eat an average of 854g of meat a week, down

by 14% since 2012 (Flockhart, 2023), but according to the Eat Lancet Commission (Willet et al., 2019), which this paper uses to define what a sustainable diet is, people must eat, on average, no more than 300g of meat a week.

1.2. The research gap

From this perspective, the issue of tackling the rise of unsustainable diets requires a large-scale behaviour change intervention, but UK and European governments are reluctant to introduce drastic measures such as a meat tax (Simmonds and Vallgarda, 2021). However, there is one area in which a large-scale nudge-based behaviour change has shown promise: digital platforms such as mobile apps, where the proliferation of smartphones over the last two decades has opened up the possibility of delivering persuasive techniques to influence sustainable behaviours at scale (Lathia, 2013).

Behaviour change interventions delivered through mobile or web based platforms such as apps have emerged over the past 15 years as a way to form, alter or reinforce attitudes and behaviour at a large scale (Oinas-Kukkonen, 2013). These interventions, known as either behaviour change support systems (BCSS) or digital behaviour change interventions (DBCI), have been trialled and shown to be successful in influencing behaviours within other areas such as healthcare and wellbeing, where they have been used to help improve physical health (Hamari and Koavisto, 2015) manage obesity and weight-loss (Kassim et al. 2023) and even reduce alcohol consumption (Mubin et al. 2021). Within sustainability, apps and digital interfaces have been used to help manage and improve their energy and water usage, or to learn about transportation and energy quality (Douglas et al., 2021).

However, research and studies into the impacts of these digital interventions to inform and change sustainable diets is an underexplored area. This paper explores this research gap and looks into the impact a BCSS in the form of a mobile app could have in encouraging the uptake of sustainable diets.

1.3. Research aims, objectives and strategy

To explore this research gap in more detail, the research question and objectives proposed, are:

What role can mobile apps play in influencing the adoption of sustainable diets?

1. *Evaluate the influence a BCSS has in encouraging people to eat more sustainably*
2. *Examine the strengths and weaknesses of BCSS' in influencing sustainable diets*
3. *Highlight the implications of this study for action on sustainable diets*

Creating a custom-made behaviour change support system to test its effectiveness on sustainable diets would require a lot of resource and expertise before this study was then able measure its effectiveness with users, as such, the research will use an existing app called Fork Ranger, which focuses on educating and inspiring its users to eat more sustainably.

The app utilises presents information about the food system through several BCSS features, including a well-designed user experience, as well as gamification elements such as quizzes, streak-building and rewards. The app is used by over 10,000 people from across the UK, Europe and North America. A brief description about Fork Ranger and how it works can be found further in this paper within the methodology, but

To evaluate the influence the app has on users choosing to eat more sustainably, as well as to examine the strengths and weaknesses of apps in influencing sustainable diets, the research takes a

mixed-methods approach, utilising a quantitative survey of existing Fork Ranger users (n=180), supported by qualitative interviews (n=10) to provide a complete understanding of how apps could be an effective way in enacting behaviour changes around sustainable diets (Denscombe, 2021).

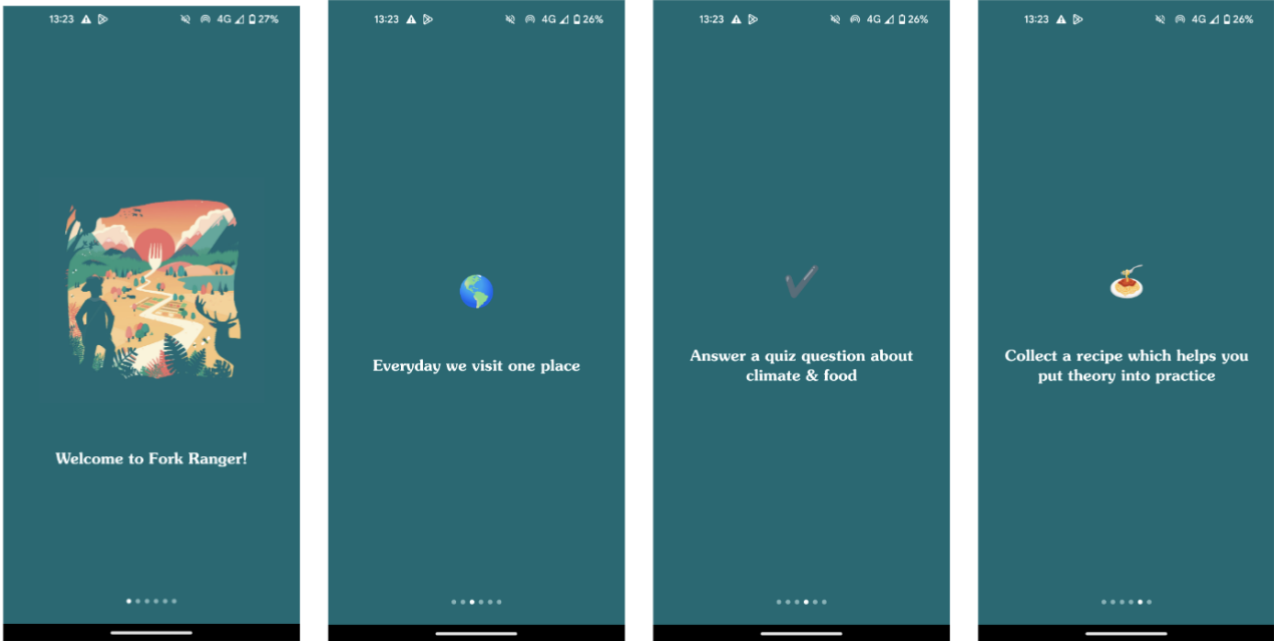


Figure 1: Example images of the welcome screen on the Fork Ranger app (Source: Fork Ranger, 2024)

1.4. Limitations and scope of this study

There are a few limitations to this approach. The study uses online surveys to gather self-reported data from participants, as opposed to physical observation or reporting on how respondents eat and buy their food. Due to this, the reported behaviour could be at risk of social desirability bias, a common issue within studies into sustainability (Fadnes et al 2009).

However, given the exploratory nature of the research, into an area in which hasn't been widely researched, the findings from this research should provide useful results for future research which utilise in-person observational research of an individual's eating and shopping behaviour after using a BCSS.

The Fork Ranger app is used across the UK, US and Europe, and to achieve a robust survey sample in the timeline required the research was unable to be targeted to one specific region. This research simply investigates the impact of the BCSS on a user base who typically consume a Western Diet high in meat and dairy.

It is also noted that there may be an issue of sampling bias within both the quantitative survey responses and qualitative interviews, which may have favoured those who have a positive experience of the app, and therefore excluded those who engaged with the app and didn't find it useful, and therefore did not receive the prompt to take part in the survey. Additional research may be needed in the effectiveness of the BCSS in a survey sample who are new to Fork Ranger and unaware of, or do not practice, sustainable behaviours.

Further limitations and challenges of specific methods used within this study can be found within the research methods and conclusion of this paper.

2. Literature Review

The following literature review covers discourse around sustainable diets, the environmental impacts of the current food system and consumption behaviours, the behavioural drivers behind the consumption of meat and dairy, and an analysis of the effectiveness of behavioural change support systems in influencing positive behaviour change, as well as discuss the theory of planned behaviour.

2.1. The case for a sustainable diet

The global food system causes one-third of all worldwide emissions (Crippa et al., 2021), and these emissions will continue to rise as a growing population continues to follow the trend of eating more meat and dairy as they become richer (Godfray et al., 2018, Clark et al., 2021).

Not only is the food system damaging to the planet, but it is also failing to keep the global population healthy, 800 million people remain undernourished (Polleau et al. 2019), and an estimated two billion people suffer from micronutrient diseases, while many mortalities in humans could be avoided with healthier diets which don't lead to issues such as obesity, diabetes, heart disease and some cancers (WHO, 2019).

The need for a win-win diet, one which is sustainable and good for the environment and good for human health has never been more important (Willet et al., 2019, Clark et al., 2020).

What constitutes a sustainable diet is a complex discussion. In a review of national sustainable dietary guidelines by the FAO (2016) it found recommendations ranging from consuming a mostly plant-based diet, focusing on seasonal and local foods, reducing food waste, ensuring consumption of fish from sustainable stocks only, and a reduction of red or processed meat, highly-processed foods and sugar-sweetened drinks.

The EAT-Lancet commission makes more specific and recent in-depth recommendations of the quantities of each different type of food we can eat to stay within safe planetary guidelines (Willet et al., 2019). This "planetary healthy diet", advocates for a doubling in average consumption of plant foods such as fruits, vegetables, legumes and nuts, a moderate consumption of poultry, fish and eggs, while recommending reducing or eliminating the consumption of red meat and added sugars (Willet et al., 2019).

The commission's recommendations were not intended to be a one-sized fits-all approach, but serve as a guide for policymakers, food producers and individuals. This reduction in meat, and moderate intake of dairy, is supported by a broad consensus of researchers who are clear about the environmental benefits of eating less animal based food (Garnett, 2011, Tukker et al, 2011, Westhoek et al, 2011, Clark et al, 2020).

This is further supported by a systematic review of studies measuring the environmental impacts of shifting diets to proposed sustainable dietary patterns, highlighted in figure 3. Aleksandrowicz et al. (2016) provides findings which showcase which diets can have the the most impact and make the most relative difference. These are diets which remove, or seriously limit, meat and other animal based foods such as dairy.

Global adoption of diets which are win-win, in both health and environmental benefits, such as a mediterranean, low-meat/flexitarian, pescetarian, vegetarian or vegan diet has been estimated to have substantial impacts on diet-related GHG emissions by between 25-60% relative to projected future dietary patterns as shown in Figure 2 (Aleksandrowicz et al. 2016)

An increase in consumption of animal products is a problem, because of the impact it has on the climate. Animal agriculture specifically has been found to be one of the biggest contributors to global greenhouse gases accounting for between 12-20% of global emissions and 60% of the entire food systems GHG emissions are produced by animal livestock and its feed (Xu et al. 2021), 70% of the world’s arable land is used for animal livestock whether to grow food to give to animals, or used as grazing, and this is a major driver of biodiversity loss (Grossi et al. 2019).

Reducing the production of ruminant meat i.e. cows, sheep and other grazing animals, as well as dairy products, will have the highest impact on GHG emissions compared to reducing the production of other foods (Gerber et al., 2013; Hedenus et al. 2014).

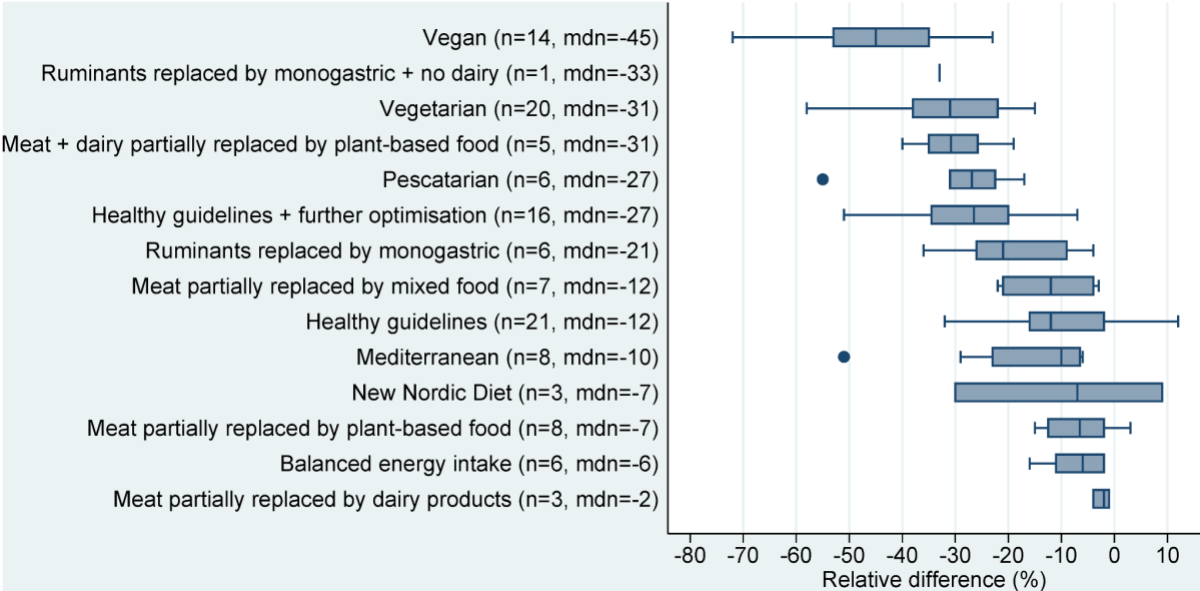


Figure 2: Aleksandrowicz et al., 2016 “Relative differences in GHG emissions (kg CO2eq/capita/year) between current average diets and sustainable dietary patterns.

2.2. Challenges to adopting sustainable diets

For the purpose of this study, when referring to sustainable diets we will use the EAT recommendations and focus on the need to limit dairy consumption and reduce meat intake to no more than 300 grams per week (Willet et al., 2019)

This focus on animal products is for the fact that even with small increases in the consumption of red meat or dairy foods, the goals to feed 10 billion people by 2050 sustainably will be hard to reach (Willet et al., 2019). While a holistic approach to adapting and improving our food systems will be critical, what is clear is that tackling environmental issues on the production side of the food system, which is out of this dissertation focus, will be difficult to achieve without influencing dietary behaviours which limit the intake of animal products (Martini et al. 2021, Garnett 2011.)

But consumer awareness of how reducing consumption of animal-based foods or going meat-free can impact the environment is still relatively low (Polleau et al., 2019). Surveys of populations

around the world have shown a lack of awareness of animal products' impacts on climate change: In the USA, 51% of respondents disagreed with the statement that eating less meat can help the environment (Campell-Arvai 2015), 36% disagreed in the UK with the statement that it is better to eat less animal foods to help reduce the impact of climate change, with 46% unsure (Clonan et al., 2015) and in Australia 56% disagreed with a similar statement (Lea et al., 2008). Further studies in the Netherlands yielded similar responses where 41% of respondents disagreed, and 36% were unsure with the statement of agriculture and animal husbandry being one of the major causes of climate change (De Boer et al., 2013).

This lack of awareness and connection between food choices and climate change is a concern, given that national climate targets, such as the aim of the UK's The Climate Change Committee (CCC) (2019) to reduce meat consumption by 30% by 2030 have been mandated. While meat consumption has dropped by 14% from 2012 to 2022 in the UK (Stewart et al. 2021), analysis suggests that the UK will fail to reach this target, and that the UK government is failing in its obligations to encourage this meat reduction by avoiding direct campaigns which address reducing meat consumption (The CCC, 2023). Similarly, in the recent FAO roadmap for food systems report, academics were critical in its omission of meat-eating reductions from the UN's plans. (Verkuijl et al., 2024)

Indeed, governments have been shown to be unwilling or extremely reluctant to address calls to reduce meat consumption (Westhoek et al., 2011), and even less so to bring in harder policy measures such as a meat tax (Ammann et al., 2023). This is because meat consumption has played an important role in western societies and cultures for centuries, with meat "hard-wired" into human behaviour (Graça et al., 2015). Further analyses support this notion, with research papers showing how meat can become ingrained in a person's identity, heritage, and values (Dibb et al., 2014, Graham and Abrahamse, 2017).

There are also several other key challenges to individuals eating a more plant-based diet, from enjoying the taste of meat, to the convenience in purchasing and cooking behaviours (Stoll-Kleeman et al., 2017, Culliford et al. 2020), or price and availability of sustainable options (Dibb et al., 2014), as well as meat eating being a habitual behaviour (Allès et al., 2017).

All of these challenges and barriers show that across a number of high-income countries, people's willingness to reduce their meat consumption is low (Kenny 2023), and many view non-dietary related changes to take action on climate change as more acceptable than reducing or replacing meat in their meals (Macdiarmid et al. 2016), such as limiting food-waste or buying foods with more sustainable packaging (Culliford et al., 2020).

But there are studies that have found that increased knowledge about the links between climate change and sustainable food choices were associated with a greater willingness to change meat consumption behaviour (De Boer et al, 2014, Verain et al., 2015). Within demographics, it's also shown that females are more likely to be willing to reduce their meat consumption, compared to males, and younger generations are also most willing to reduce their meat consumption (Hartmann et al., 2020)

However, while this provides a promising opportunity for a behavioural change intervention which educates consumers about the impact of their food choices, with the aim of helping them to eat more sustainably, an "attitude-behaviour gap" is commonly observed within sustainability contexts too, where, although consumers may report favourable attitudes toward sustainable behaviours, they may often not take action on them, such as in the food they eat (Varela et al., 2022)

An additional difficult challenge is if individuals have an emotional or cultural attachment to meat. Even if these people are presented with information around the negative climate impacts of meat consumption, they are still less receptive to reducing their consumption (Graca et al., 2015).

2.3. Behaviour change interventions

From the evidence in the previous section, changing food consumption behaviours is a challenge, with people reluctant to give up food, such as meat and dairy for several reasons, ranging from cultural identity, to lack of awareness to taste and price. As a result, there is a rich pool of research studies and behaviour change interventions and studies which have explored how to influence human behaviour to make more sustainable choices.

One popular way in which interventions have been designed have been around the concept of nudging, which seeks to alter the choice architecture in people's decision making process i.e the food environment, so that people's automatic, quick mode of decision making is activated (Thaler et al., 2009) These actions seek to alter people's behaviour in a predictable way, without putting restrictions on options or offering economic incentives, such as placement of healthy foods or sustainable foods in a more prominent position (Romero et al., 2016). In a mini-review of behaviour change interventions Abrahamse (2020) identified how nudging such as labelling foods with their climate impacts (Vanclay et al. 2011) or increasing the availability of sustainable options in cafes (Garnett et al. 2019) have some effect on making consumer choose a more sustainable. Interestingly, Abrahamse also identified how, while providing information about food and their climate impacts isn't effective on its own, when combined with a motivational goal, as in a study by Monroe et al. (2015) or when it emphasises social norms (Sparkman et al. 2017), information provision has a positive impact.

In a systemic review of interventions aimed specifically towards reducing the consumption of meat, Kwasny et al. (2022) reviewed 67 journal articles to recommend future interventions, these focus on 1) informing users about negative side effects of meat, with a focus on health, 2) trigger emotions with images of animals, either suffering, or alongside meat, 3) provide competence training and support habit change, such as providing cooking courses or information on how to cook sustainable meals, or combine the intervention with goal-setting, and 4) increase the visibility of vegetarian (or sustainable) food

However, a critique of these interventions by both Abrahamse (2020) and Kwasny et al. (2022) is that many of these studies have been small scale, and understandably haven't been amplified or tested at a larger scale. This leads to an opportunity to explore the role digital interventions can play in persuading and changing consumer behaviours.

2.4. Behaviour change support systems

Over the past few decades the world has undergone a technological revolution, with mobile phones becoming a method of communication that the majority use in our daily lives. The proliferation of mobile phones amongst modern society, has opened the possibility to deliver persuasive techniques to influence consumer behaviours at scale (Lathia, 2013).

This has led to the rise of Persuasive Technology (PT) (Fogg, 2002) and persuasive system designs, which are digital platforms designed to reinforce or shape attitudes or behaviours in a desirable way. This technology does not itself seek to influence behaviour, but through services built on top of the technology, it can facilitate behaviour change (Lockton 2012).

This behaviour change method can also be defined as Behaviour Change Support systems (BCSS), and Digital Behaviour Change Interventions (DBCI), two very similar terms which involve enacting and influencing behaviour through digital technology, such as mobile apps, smart-technology such as wearable devices or web-based information and communications (Yardley et al. 2016, Oinas-Kukkonen, 2010). Importantly, these systems encourage behaviour change without using coercion or deception, which has been a critique of other digital technologies built on the concept of Persuasive systems design (Oinas-Kukkonen, 2013).

Mobile phones and apps offer particular promise for supporting behaviour change as they are with us at most times and often present in daily situations where we must make decisions (Chang et al. 2013). Digital interventions are popular because they're convenient, often low-cost, available across a large geographical area and can be engaged with over a long-term period (Chen et al., 2020).

These methods in particular have become ubiquitous within the healthcare environment, offering medical practitioners the ability to administer advice and to help patients improve and change behaviour remotely and at scale. Over the past decade persuasive technology applications have been shown to be effective in enacting changes within individual health related behaviours, from improving physical health (Hamari and Koavisto, 2015), managing obesity and weight-loss (Kassim et al. 2023) and reducing alcohol consumption (Mubin et al. 2021)

Within sustainability, BCSS' have had an impact within helping individuals manage energy shows promising results; in a study of digital based apps which use a BCSS method in gamification, Johnson et al. (2017) found that outcomes achieved included improved energy consumption behaviours, cognitive outcomes such as improved energy-related attitudes and knowledge of energy consumption and sustainability.

A review of sustainability oriented mobile apps by Douglas & Brauer (2021) found a positive adoption of pro-environmental behaviours in categories such as sustainability education, energy reduction, transportation, air quality, waste management, and water conservation. The findings noted that gamified apps can lead to longer-term psychological engagement than other behavioural change methods such as nudging. Apps that used elements of gamification, such as providing feedback or earning points or rewards for a behaviour were also viewed more positively than ones simply attempting to change behaviour by solely providing information (Beck et al., 2019). Improved knowledge has also been noted from findings from a number of PT interventions, which can be linked to a change in behaviour (Adaji et al., 2022).

Influencing diets is of particular interest to this study, and it's encouraging to see digital behaviour change interventions having a positive impact on healthy eating (Chen et al. 2020). Across a number of studies as part of a review of different methods of DBI's by Chen et al, a main critique was noted that while DBI's can be effective in enacting change, the long term effect of them will not happen if wider environmental barriers aren't dealt with such as the availability and affordability of healthy food, which has similarities to barriers facing adopting sustainable diets (Alles et al., 2017). Further critiques of the few studies that have analysed PT in sustainability, is that a lot of reported positive impacts have been based on self-reported findings from users, which may indicate a gap between intention and actual behaviour change (Adaji et al., 2022).

2.5. The Theory of Planned Behaviour

One way in which a research study can counter, to some extent, the critique of self-reported behaviour and to measure longer-term behaviour change is by analysing the impacts through a theoretical framework known as the Theory of Planned Behaviour (TPB) (Ajzen, 1991), which can help self-reported findings to be more accurate.

The TPB is a framework used to explain, predict and understand human behaviour, by explaining an individual's intention to enact a behaviour. The theory identifies three key components that shape a person's behavioural intentions: 1) Attitude, which refers to a person's individual evaluation of the target behaviour, 2) Subjective norm, which captures the perceived social pressure to perform the behaviour, and 3) Perceived behavioural control (PBC), which reflects a person's belief in their ability to perform the behaviour, and whether they have the necessary resources, skills and opportunities to engage in that behaviour (Ajzen 1992)

This theory has been used in over 2000 empirical studies across various topics ranging from healthy eating to fitness, as well as food consumption decisions (Ajzen 2020). In sustainability, it is a measure which has been used to analyse sustainable behaviours such as green product purchasing behaviours (Setyawan et al., 2018) and sustainable tourism decisions (Al Fahmawee et al., 2023). This makes it an appropriate measure to review sustainable diet decisions.

However, there are limitations to this theory, with the main critique being that intention is not the only driver of behaviour, which means the TPB fails to consider other key factors that can explain an individual's decision-making process. This can result in an intention-decision gap, where people's intended decisions can be driven by emotions instead (Juvan and Dolnicar, 2014), in the context of sustainable diets this is very relevant; people could be concerned about making the sustainable choice, but at the last moment, make an impulse to eat meat.

Another critique lies in the view that the theory does not consider habits and other underlying identities that influence decisions (Bamberg and Schmidt, 2003), for example, if a person sees meat eating as their identity, a challenge identified earlier in this literature review, or a person eats meat consistently as a habit.

However, both of these critiques on impulse and emotions and habit and identity, can be challenged by parts of the TPB itself; impulse and emotions can be explained to some degree within the attitude measure of the TPB which can be influenced by emotions, while habit and identity it could be argued are a result of repeated behaviours that influence attitudes.

While the TPB has some flaws, it is felt, combined with other quantitative survey questions and the qualitative interviews, this research should produce useful data in which we can use to answer the research question.

3. Research Strategy & Methods

3.1. Methodology

As covered in the literature review, changing how people shop and eat is a difficult task, and even more so when it comes to getting them to reduce or remove meat and dairy from their diets. Therefore, analysing the impact of a potential solution requires a rich analysis of user behaviour and impact. To achieve the aims of this study and to obtain this rich analysis, the research utilised a mixed-methods approach, consisting of a quantitative survey and qualitative interviews within a pragmatist paradigm. This enabled the researcher to properly assess the potential impact a behaviour change support system (BCSS) can have in influencing the consumption of a more sustainable diet. The following section explains the research strategy as well as the methods chosen in more detail.

A pragmatist, mixed-methods approach

The Pragmatist paradigm is a problem-focused approach, which emphasises the value of using strategies and methods which work best in practice (Denscombe, 2021). This approach prioritises the research question and sidelines epistemological and ontological arguments inherent in other paradigms such as in positivist or interpretivist paradigms (Teddlie and Tashakkori, 2009, Denscombe, 2021.)

The study utilises a mixed-methods approach using an exploratory quantitative survey to establish initial findings around how users may have been influenced by the BCSS, with a series of in-depth qualitative interviews to identify and reveal a richer analysis (Cresswell, 2017).

Conducting this research via a mixed methods approach overcomes the disadvantages that are inherent when adopting a single method of research (Teddlie and Tashakkori, 2009). Disadvantages of a solely quantitative approach include the issues of reductionist research models which could overlook or fail to consider important constructs that could be identified by qualitative research, or studies which only consider qualitative data may fail to reveal data which can be generalised within a wider setting. (Heba 2019).

Adopting both a quantitative and qualitative approach combines them in a way that improves the quality of the research by providing balance (Sale et al., 2002). This can then enable triangulation in a research analysis, which can enrich and strengthen the research results by using different methods to study the same hypothesis or research question in order to gain a complete understanding of the issue at hand (Glogowska, 2011).

The study followed a quan-qual approach with both findings having equal weight within the analysis. The quantitative survey came first and was used to identify patterns of use of the app, gauged opinions on whether user knowledge had increased or decreased, provided initial insights into the features of the BCSS users engaged with the most, as well as gave initial quantifiable data on whether the app had changed user diets, across a larger sample.

The qualitative interviews provided greater depth into why and how the app had influenced users, why certain features had resonated most with them, and what other influences had potentially led to a change in behaviours. These elements will be explained further within the methods section. Utilising this ordering of the study moved the analysis forward with the aim of revealing greater insights into the user experience and impact of the app (Denscombe, 2021)

3.2. Data Collection

180 respondents took part in an 18-question online survey distributed to users of the Fork Ranger app. Following this phase, 10 participants took part in online interviews as part of the qualitative stage.

3.3. Methods

Choosing a behaviour change support system.

To explore the proposed question of the effectiveness of a BCSS, rather than create a new app, which would have required skills and resource which the researcher does not have, the study chose to focus on an existing app, called Fork Ranger, which has already been used and developed with many BCSS features, as outlined by the likes of Yardley et al. (2016) and Oinas-Kukkonen (2010). Features of the Fork Ranger app include goal setting and tracking, education resources including daily recipes and infographics and information on sustainable food and impacts of the food system, gamification mechanics such as streak building and a daily quiz, a reminder notification, and progress tracking.

The Fork Ranger app is used by 10,000 people across the world. The app works based on a daily interaction, users can either load up the app at their convenience, or they are served a notification to continue their Fork Ranger journey. The user is then given a daily story about a certain part of the food system, and they are then quizzed on the information they have learnt. Once they're notified if they are right or wrong, they are then served a detailed infographic with the answer explained in further detail, before rewarding users with a daily recipe, all with a focus on educating users about how to make sustainable choices (Fork Ranger, 2024).. Examples of what this journey looks like can be found below in figure 3 below, as well as in Appendix 1.

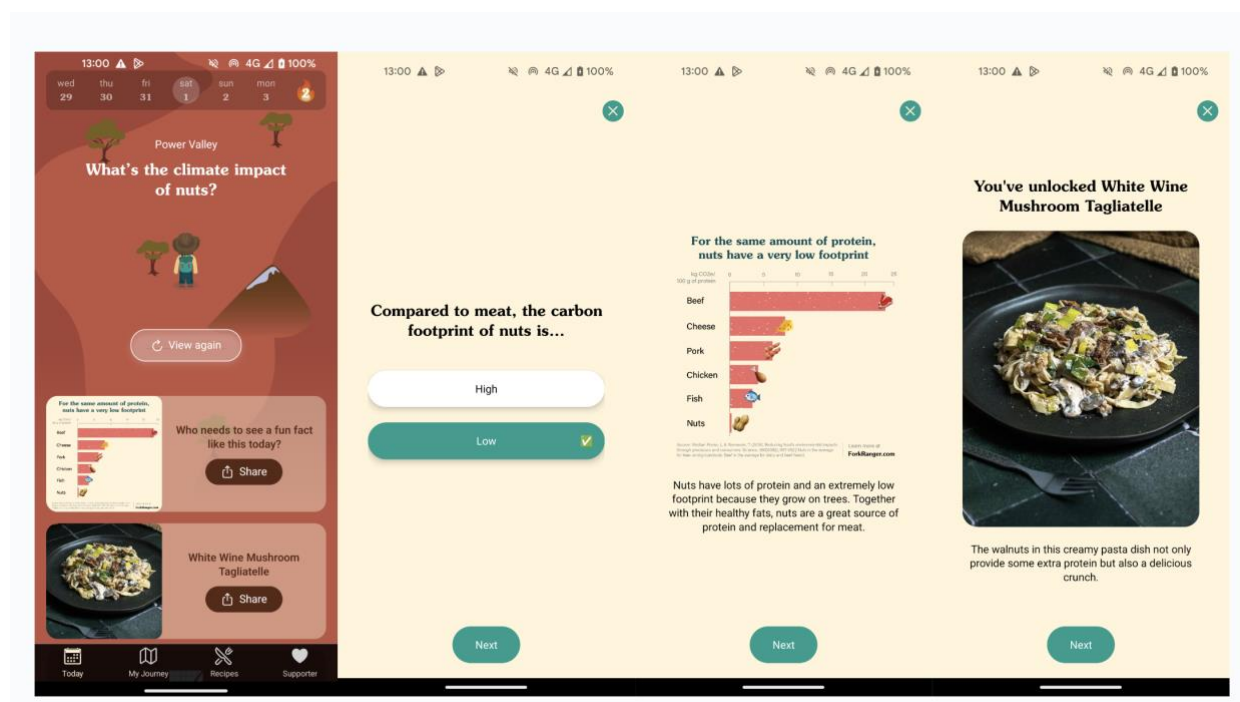


Figure 3: Screenshots of the Fork Ranger App, its daily quiz, recipe reward and infographic (Source: Fork Ranger)

3.4. Sampling

Quantitative survey

For the quantitative survey, the research took a non-probability approach to sampling, as it concerned the users of the Fork Ranger app, so therefore needed to be targeted (Denscombe, 2021). This surveyed a targeted sample of Fork Rangers userbase via an online survey delivered hosted on Microsoft Forms.

An online survey was chosen as the app is mobile-phone based, and the survey link could be shared with users of the app, this also enabled easier data processing at the point of analysis, greater accessibility, and the delivery of the questions could be standardised, limiting the effect of interpersonal effects or how the questions are delivered (Denscombe, 2021, Leonard et al., 2018)

Respondents to the survey were recruited via a push notification delivered through the Fork Ranger app to existing users (Figure 4). Respondents were also recruited via Fork Ranger's social media channels, such as LinkedIn, and the Fork Ranger newsletter. To motivate respondents to take part, the message was written in a way to highlight how respondents could make a difference by taking part (Denscombe, 2021). A disadvantage of questionnaires is survey fatigue, to limit this, the questions were written clearly and concisely and written in a way to make it as accessible and easy to understand (Leonard et al., 2018). At the beginning of the survey it was also made clear how much time (5-10 minutes) it would take for respondents to complete the survey.

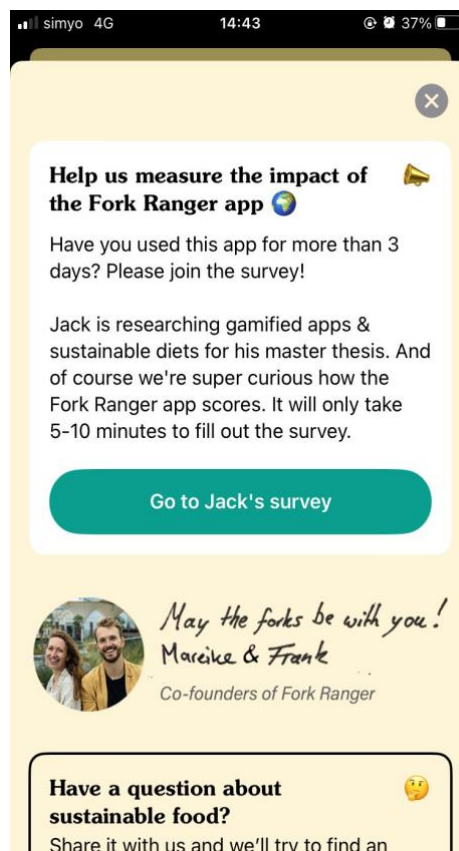


Figure 4: The survey notification delivered to users (Source: Fork Ranger)

3.5. Survey design and analysis

Quantitative survey

The quantitative survey consisted of a consent form, followed by 18 questions which are listed in Table 1. The full survey questions, including the options within each question can be found within Appendix B.

The questions were drafted in line with research during the literature review, for example, section 2 of the survey asks questions regarding frequency of use to ascertain whether using Fork Ranger had become a daily task for some users, which can be an indication of developing a new habit. The question about whether users started using Fork Ranger with a goal in mind also served to provide a link between the systematic literature review by Kwasny (2022) which highlighted how interventions which incorporate goals can help users to reduce their meat consumption.

Other questions asked during this stage were designed to identify changes in self-reported behaviour, as well as frequency and engagement with the app. This survey also incorporates a section on the TPB, which would help to counter the issue of self-reported behaviour, while also showcase any behaviour changes from using the app. Within Table 1, the questions for attitude, subjective norms, perceived behavioural control and intention are broken down.

The survey also utilised Likert scales to assist in data collection, which enabled the researcher to measure attitudes to sustainable diets and the app experience. (Denscombe, 2021)

Table 1: Questions asked in the quantitative survey

Survey section	Questions asked
1) User demographics	<ul style="list-style-type: none"> - What is your gender? - How old are you? - How would you describe your ethnicity or ethnic background?
2) Use of Fork Ranger and users' diets	<ul style="list-style-type: none"> - How long have you been using the Fork Ranger app? - How often do you use the Fork Ranger app? (i.e. daily, every other day, weekly, fortnightly etc.) - Before you started using Fork Ranger which of the following best describes your diet? - After using Fork Ranger which of the following best describes your diet? - Before using Fork Ranger how much meat do you estimate you ate on average each week? - After using Fork Ranger how much meat do you estimate you now eat on average each week? - How do you see your diet changing in the next year? - Did you start using Fork Ranger with a specific goal in mind?

<p>3) Likert Scale questions</p>	<ul style="list-style-type: none"> - While using and interacting with the Fork Ranger app, how would you estimate your knowledge of the following topics have changed? 5=Decreased a lot, 1=Increased a lot (topics revealed in the results section of this paper) - <u>AFTER</u> using the Fork Ranger app - what's the likelihood of you taking the following actions? 5= Very Unlikely, 1= Very Likely
<p>4) Theory of Planned Behaviour</p>	<p>The questions in this part of the survey about sustainable diets make use of a rating scale where 1 is strongly disagree, and 7 is strongly agree. Please select the number that best describes how you feel.</p> <p>A) Attitude:</p> <ul style="list-style-type: none"> - Eating a sustainable diet will be good for me and my health - Eating a sustainable diet will be good for the environment <p>B) Subjective norms</p> <ul style="list-style-type: none"> - Most people who are important to me would approve of me eating a sustainable diet - People who I admire, or who influence me, would think that I should buy sustainable food - Eating a sustainable diet is a popular or fashionable thing to do <p>C) Perceived behavioural control</p> <ul style="list-style-type: none"> - It is easy for me to find sustainable food options - Sustainable food options are affordable to me - I am confident I will be able to eat a sustainable diet <p>D) Intention</p> <ul style="list-style-type: none"> - I plan to eat a sustainable diet regularly - I will actively seek out sustainable food options when I buy my food in future
<p>5) Features of the app and challenges of eating sustainably</p>	<ul style="list-style-type: none"> - Which part of the Fork Ranger app do you find most useful? - Which barriers or challenges do you face when it comes to eating sustainably?

Qualitative interviews

After taking part in the quantitative survey, respondents were asked whether they were willing to take part in a follow-up qualitative interview, 57 participants left their email addresses for follow-up interviews. Using a purposive sample approach (Denscombe, 2021), the next stage involved choosing 10 participants for in-depth qualitative interviews. The selection of participants for this stage were chosen to, as much as possible, represent the initial findings from the quantitative survey, which focused on frequency of use of the app, any reported changes to diets, meat consumption, plans to change diets or if there were no changes to examine why there wasn't. The final respondents can be seen within the results section in Table 12.

The interviews during this stage were conducted online via Microsoft Teams and were held one-to-one, with the aim of producing detailed, rich and personal responses from participants (Braun &

Clarke, 2013). The interviews took 30 minutes, and were based on semi-structured questions, a sample of these questions can be seen below in Table 2. This semi-structured approach allowed for greater flexibility and analytical discussions during the interview stages, based on the responses to each question (Kajornboon, 2005). The interviews were conducted in a formal way, to limit interviewer bias and avoiding leading questions (Denscombe, 2021).

Table 2: Semi-structured interview questions

Semi-structured interview example questions
<ol style="list-style-type: none"> 1. So firstly, I wondered if you could just describe your experience with the Fork Ranger app, how long have you been using it for? Are you still using it? 2. Why did you start using the app? 3. Has it had any influence on your diet? 4. What else do you think has an influence on your diet? 5. I noted you reported a reduction in meat consumption, can you tell me more about that? 6. While using Fork Ranger, how would you describe how your knowledge about sustainable diets have changed? 7. Do you think eating sustainable diets are a popular or a normal thing to do in your peer group? 8. What challenges in your life do you face in eating a sustainable diet? 9. How would you describe the role meat plays in your diet? 10. Do you ever envisage a future where you no longer consume animal products such as meat and dairy? 11. Are there any features from the app which you favoured? If so, why? 12. Do you use any other apps similar to Fork Ranger? 13. Will you keep on using the fork ranger app?

3.6. Data analysis

To analyse the quantitative data collected from the 180 respondents, descriptive statistics were utilised to summarise the participant demographics and responses to individual questions. This provided a clear picture of the sample characteristics and the prevalence of particular viewpoints, by calculating percentages, mean average and mode. This data is presented within the results section as bar charts, pie charts and tables. This data was analysed via Microsoft Excel.

For the Theory of Planned Behaviour, the study also utilised a data analytics tool called SPSS Statistics to test the findings for statistical significance, and to test for a positive significant correlation between attitude and intention, subjective norms and intention and perceived behavioural control and intention. This calculated a value using a Pearson correlation coefficient to identify the statistically significant correlation. This would then help to explain the relationships between the findings of the research.

However, variables in social science are rarely if ever correlated, or if they are, the reason is more nuanced (Denscombe, 2021), which is why the next stage - the qualitative interviews - were seen as crucial to allow the researcher to explore the topic further and add extra detail to answer the studies three research objectives.

Interviews were transcribed from recordings and the research then utilised a thematic analysis which employed Braun and Clarke's (2006) six-stage thematic analysis to identify themes and patterns within the qualitative data. The process is summarised as: 1) The analysis began with familiarization, achieved through repeated readings of the transcripts. 2) This immersion allowed for the initial coding process 3) A further review of these codes then helped the research identify and generate themes. 4) these themes were then reviewed further before they were 5) defined and named into themes, this was then used to 6) produce the report to help tell a concise, coherent and logical story. To facilitate this process, the research utilised an online thematic analytics software tool called Delve.

There are of course weaknesses in using thematic analyses, as they are subjective and based on how the researcher interprets the data. However, combining this with the quantitative data means these findings can have greater reliability. (Denscombe, 2021).

3.7. Ethical considerations

In academic research, following ethical processes are important in producing valuable insights and fair research (Vanclay et al., 2013). The paper followed the standard procedures set by the Centre for Alternative Technology (CAT) and completed and passed an ethics assessment by CAT's supervisors.

Before taking part in both stages of the research, participants were asked for their consent and informed about the purpose of the study, were assured of the anonymity of their responses and were informed of their ability to withdraw at any stage of the research. Participant's information was anonymised (i.e. personally identifiable information deleted) and collated with others. Permission was given by Fork Ranger to survey its user base, and respondents were also informed that after the completion of the study, the anonymised data would be shared with Fork Ranger.

3.8. Limitations

Unfortunately, due to the study utilising Fork Ranger's existing user base, and Fork Ranger indicating that issuing two surveys could disrupt the user experience outside of this study, the research was unable to carry out a pilot phase of the initial survey questions, however it was trialled with several Fork Ranger staff members first. Additionally, due to the small number of respondents who left their email addresses for the qualitative stage, and who responded to emails, the research was also unable to conduct a pilot qualitative interview at this stage as well.

This lack of pilot phase has been noted as a potential negative impact, but the author is confident that when it came to collecting the results, this didn't appear to present any issues.

The survey was an online form, and due to this, there was a risk of social desirability bias where respondents could be self-reporting changes which they have not actually performed, and, due to this being a self-completed questionnaire, the research is unable to check on the truthfulness of the answers. To reduce the influence of this social desirability bias, the questionnaire also incorporated a section of questions which utilised the Theory of Planned Behaviour (TPB) (Ajzen 1991).

This will be noted in the analysis, but given the exploratory nature of this study, it should provide data to indicate areas for further research which involves in-person observational research of a person's actual behaviour when interacting with a BCSS.

While the TPB itself is a self-reported questionnaire and, as discussed in the prior literature review, has some weaknesses, using this method weakens social desirability responses by focusing on

behaviour and intention rather than values. (Ajzen 1991). To further counteract social desirability bias, the survey was anonymised and privatised to encourage more honest responses (Denscombe, 2021)

In preparation for this survey, the original question about meat consumption was very specific, based on the EAT-Lancet commission’s (Willet et al., 2019) recommendation of consuming no more than 300g of meat a week, consisting of 98g of red meat and up to 202g of poultry. However, during the research design phase, this breakdown of meat consumption was deemed to be a potential difficult measure for respondents to quantify quickly, hence why the question now focuses on the frequency of days spent eating meat per week. This is marked as a limitation, as the findings do not reveal the type of meat respondents were consuming, with moderate consumption of poultry in some cases being found to be more sustainable than a vegetarian.

It is noted that there may be an issue of sampling bias in the study and some of its respondents (Denscombe 2021), which could have favoured those who have a positive experience of the app, and therefore excluded those who engaged with the app and didn’t find it useful, and therefore didn’t use the survey. Additional research may be needed in the effectiveness of the BCSS in a survey base who are new to Fork Ranger and unaware of, or do not practice sustainable behaviours.

The Fork Ranger app is used across the UK, US and Europe, so this data is unable to be targeted to one specific country, and simply looks into the impact of the BCSS on a user base within Western society.

4. Results

4.1. Demographics of respondents

In total 180 people completed the survey sent to Fork Ranger’s users. Of the participants, the females were represented significantly higher than males comprising 69% of the sample.

As shown in Table 3, half of the respondents were aged 25-34, with the next most common age range of 45-54. while there was a smaller proportion of 55-64, 65-74 representation, and one person who was under 18.

Nearly all the respondents were of White European descent, with smaller percentages provided from other ethnic groups.

Table 3: Demographic overview of the sample

Characteristics	Category	Quantity	Percent (%)
Gender	Female	124	68.9
	Male	52	28.9
	Non-binary	2	1.1
	Prefer not to say	2	1.1
Age group	Under 18	1	0.6
	18-24	6	3.3
	25-34	62	34.4
	35-44	31	17.2
	45-54	44	24.4

	55-64	26	14.4
	65-74	10	5.6
Ethnicity	Prefer not to say	4	2.2
	Asian: Chinese or Chinese European	1	0.6
	Black: African or African European	2	1.1
	Black Caribbean, or Caribbean British/European	1	0.6
	Mixed: white or white European and Asian or Asian European	5	2.8
	Mixed: White or White European and Black African or Black African European	1	0.6
	Latino / Latin American	2	1.1
	Mixed: White or White European and Black Caribbean or Black Caribbean European	5	2.8
	White: European such as British, Dutch, German, French etc.	158	87.8
	White: South Spain	1	0.6

4.2. Frequency and duration of use

To analyse the impacts of prolonged use of the app, the next two questions asked: How long have you been using the Fork Ranger app? and how often do you use the Fork Ranger app?

The most popular usage period was between 2 weeks to a month (21.7%), followed by 2-3 months (17.2%) and between 1-2 months (16.7%). 69.5% of all users fit within the 3days – 3 months bracket, giving the survey a useful spread of timescales for analysis (Full data seen in Table 4). Note, that respondents were unable to progress with the study if they had been using Fork Ranger for less than 3 days.

Participants were then asked how often they engaged with the app. A large proportion reported frequent use of the app, 40.6% of respondents used it daily, 28.3% 4-6 times a week and 15% said they used it 2-3 times a week.

Table 4: Table showing the length and frequency of time spent using the Fork Ranger app

Characteristics	Time	Quantity	Percent (%)
Length of time using the Fork Ranger app	3 Days to 1 week	25	13.9
	2 weeks to a month	39	21.7
	between 1-2 months	30	16.7
	2-3 months	31	17.2
	3-4 months	15	8.3
	4-5 months	6	3.3

	5-6 months	8	4.4
	6 months - 1 year	16	8.9
	over 1 year	10	5.6
Frequency of using the Fork Ranger app			
Frequency of using the Fork Ranger app	Daily	73	40.6
	4-6 times a week	51	28.3
	2-3 times a week	27	15
	Weekly	20	11.1
	Monthly	8	4.4
	Fortnightly	1	0.6

4.3. Before and After

To analyse how using the app may have influenced or changed behaviour, the survey then asked participants to describe their diets before and after using the Fork Ranger app, with the results found in Figure 5.

The two most popular diets before using the app was Flexitarian (35.6%), and omnivore (33.3%). A smaller percentages of users were vegetarian, vegan, and pescetarian and a very small percentage who identified as carnivore (0.5%), and other diets which were grouped as a category called “flexi-vegan” (2.8% collectively)

After using the app the biggest decrease in diets was Omnivore, which declined by 15%, with the data showing that these respondents had taken up different, more sustainable diets. There was a 10.5% increase in participants who now said that they followed a flexitarian diet (which is defined as mostly vegetarian, with occasional consumption of meat and fish), there was also a small increase of 4.4% of respondents who reported they were vegetarian, and a slight increase of 0.6% to vegan, and 1.8% to flex-vegan.

Note that “Other” responses collated by the survey have been grouped within “flexitarian” or a new sub-category identified in responses as “flexi-vegan”, which covers responses such as “mostly vegan, but with cheese” or “mostly-vegan, less eggs”.

Collectively, the data revealed a 16.7% shift of the total research population towards more sustainable diets, with a decline in diets which consist of eating meat. In only one instance was there a change towards a more unsustainable diet, one person said that they had become a Carnivore. However, the respondent’s other answers later in the survey stated they only ate meat twice a week. So, the researcher suggests this could be an erroneous response (full data can be accessed via this paper’s appendix.)

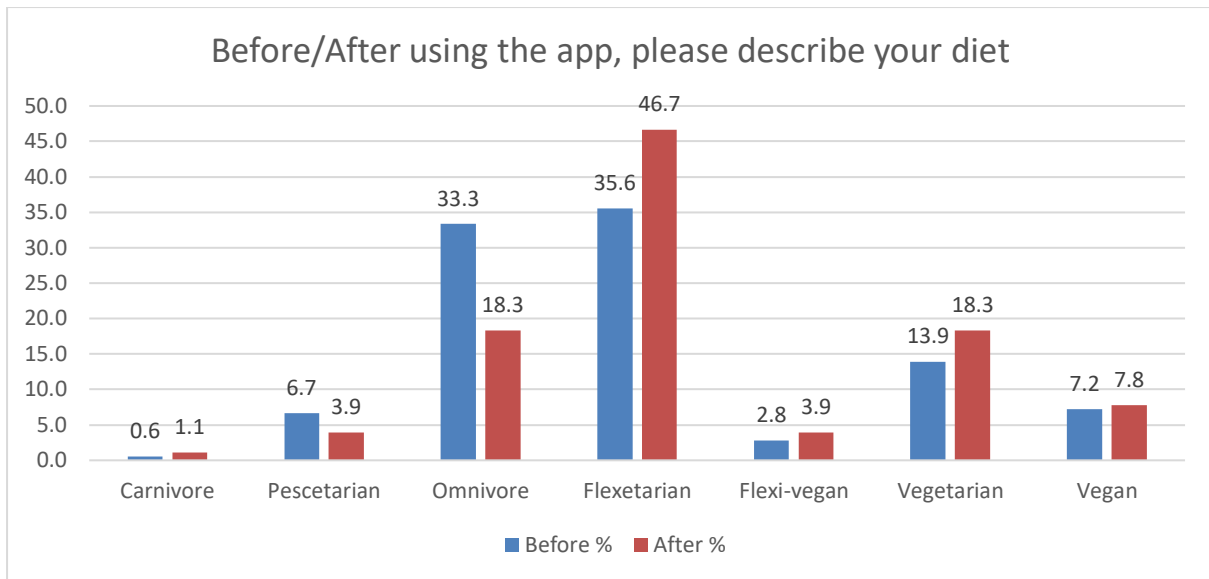


Figure 5: Bar graph showing responses to a question which asked: “1. BEFORE you started using Fork Ranger, which of the following best describes your diet? And 2. AFTER you started using Fork Ranger, which of the following best describes your diet? The data listed is in %

In question 12 of the survey, participants were then asked how often each week that they consumed meat, before and after using the Fork Ranger app (Figure 6). For context, before using the app, 36 people said that they ate meat every other day (20% of respondents), followed by 30 people who ate meat for “one meal a day” (16.7%).

After using the app, the number of people reporting that they ate meat for one meal a day dropped by 40% to 12 respondents, representing a 10% reduction across the total research population. So too did “for more than two meals a day”, which fell by 2.2%, or from 10 people to 6. Overall, the data revealed a shift towards eating less meat, with the total population of people reporting to be eating meat two times a week or less increasing by 12.8% of the total research population.

In total, 63 people (35%) reported a decrease in their meat consumption habits, an indicator of a switch to eating more sustainably. The biggest shift in diets, as shown in Table 5, came from participants eating meat every other day, 10.5% reduction, and one meal a day, 11.1% reduction.

In total, a combined 81 respondents (45%) in the study recorded a positive sustainable dietary change before and after using that app, whether it be a change in description of their diet, or a reduction in their meat intake.

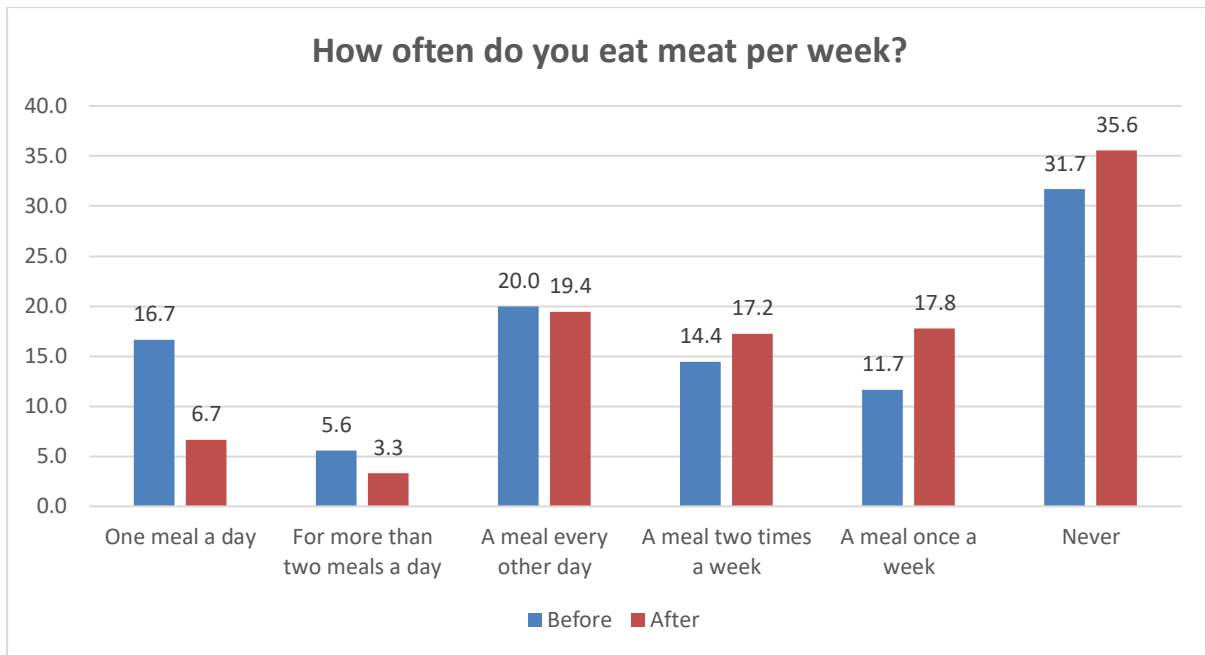


Figure 6: Bar graph showing responses to a question which asked: “1. BEFORE you started using Fork Ranger, how much meat did you eat per week? And 2. AFTER you started using Fork Ranger, how much meat did you eat per week? The data listed is in %.

Table 5: Table showing the dietary shifts towards consuming less meat, from two meals a day (the most), to once a week.

Before using Fork Ranger, how often each week do you consume meat?	Meat conception that participants moved to after using Fork Ranger	Total number of participants	Percentage shift
Two meals a day (5.6% of total participants)	One meal a day	3	2.2%
	Every other day	1	
One meal a day (16.7%)	Two times a week	5	11.1%
	One meal once a week	2	
	Every other day	13	
Every other day (20%)	Once a week	1	10.6%
	Never	1	
	Two times a week	15	
	Once a week	2	
Two Times a week (14.4%)	Every other day	1	7.8%
	Once a week	12	
	Never	1	
Once a week (11.7%)	Never	6	3.33%

How do you see your diet changing in the next year? (Please select up to 3 choices)

Participants were then asked about any planned changes to their diet over the next year. As seen in table 6, the top priority for over half (56.1%) of participants was to eat more sustainably, with close to a half of respondents (43.9%) equally planning to reduce their meat and dairy consumption. Other changes listed included reducing other animal products such as eggs and fish/seafood.

Very few respondents, 1.7%, planned to revert to the diet they were following. Within the data of those who reported a change in their diet before and after using Fork Ranger, only one participant – Participant #20 - said that they planned to revert to the diet they were following before using Fork Ranger, which was eating meat every other day, as opposed to eating meat twice a week.

Table 6: Ranked order of planned changes individual’s diets in the next year

How participants planned to change their diets in the next year (Ranked)	Number	Percentage %
1. Eat more seasonal food	101	56.1
2. Reduce meat consumption	79	43.9
3. Reduce dairy consumption	79	43.9
4. Make no changes	23	12.8
5. Reduce egg consumption	19	10.6
6. Reduce my fish/seafood	17	9.4
7. Other*	8	4.4
8. Increase my fish/seafood	7	3.9
9. Revert to the diet I was following	3	1.7
10. Increase dairy consumption	2	1.1
11. Increase meat consumption	0	0.0
*" I am now vegan for health and environmental reasons" "I plan to eat more nuts" "I plan to eat more organic and local products" "Have a more varied diet that contains more vegetables and plant based proteins" "More wholefood plant foods" "I plan to increase my veg & fruit consumption" "I plan to eat more plant-based." "Less sugar"		

1.2 Goals

Did you start using Fork Ranger with a specific goal in mind? (select all that apply)

Question 15 sought to discover the reason for using the Fork Ranger app. The most popular goals indicated were using the app to learn more about sustainability and food (63.3%), wanting to eat more sustainably (47.2%), to learn new recipe suggestions 47% and to learn more about eating seasonably 32.2%. Full results in Table 7.

Table 7: Ranked order of specific goals users had when starting to use Fork Ranger

Did you start using the app with a specific goal in mind? (Ranked)	Amount	Percentage
1. To learn about sustainability and food	114	63.3
2. To eat more sustainably	85	47.2
3. Learn new recipe suggestions	85	47.2
4. Learn more about eating seasonably	58	32.2
5. No goal	22	12.2
6. Reduce my meat intake	22	12.2
7. Learn new cooking skills	21	11.7
8. Other*	10	5.6
9. Reduce consumption of dairy/eggs	10	5.6
<p>*Other responses included: - “I wanted to engage my kids (12, 14)”, “I was already interested in sustainability and food and how culture and behaviours might change at a population level”, “And support the amazing founders”, “I wanted to include more vegan meals in my diet”, “Curiosity”, “I wanted to cook for my family”, “I wanted to see what the app would inform me about”, “I loved the Information pieces on LinkedIn”, “I wanted to gain knowledge in a consistent and fun way”, “I wanted to include more vegan meals in my diet”,</p>		

1.5 Increase or decrease in knowledge

To assess the impact of the app on an individual’s knowledge and awareness of sustainability and sustainable diets, participants were then asked the following question: “While using and interacting with the Fork Ranger app, how would you estimate your knowledge of the following topics have changed?”

Using a Likert scale, participants were asked whether their knowledge about certain sustainable diet topics had increased or decreased while using the app. These topics frequently appear in the Fork Ranger quizzes and infographics. This question found that in most instances, as shown in figure 7, while using the app, respondents said that their knowledge increased, with the highest ranked topics being the carbon footprint of the food I eat (91.1% combined), what a sustainable diet is (86.7%), the food industry’s impact on climate change (86.1%), and the role of my diet in taking action on the climate (83.3%). Other categories where this change was less impactful, but still with a high percentage, was in what seasonal eating is (60%), how to cook tasty meals

(51.7%). The only category in which respondents were neutral was to be found in how to cook healthy meals (42.8%).

This could suggest the app has a role to play in increasing knowledge about sustainable diets, as well as influencing changes.

While using the app how would you estimate your knowledge has increased or decreased?

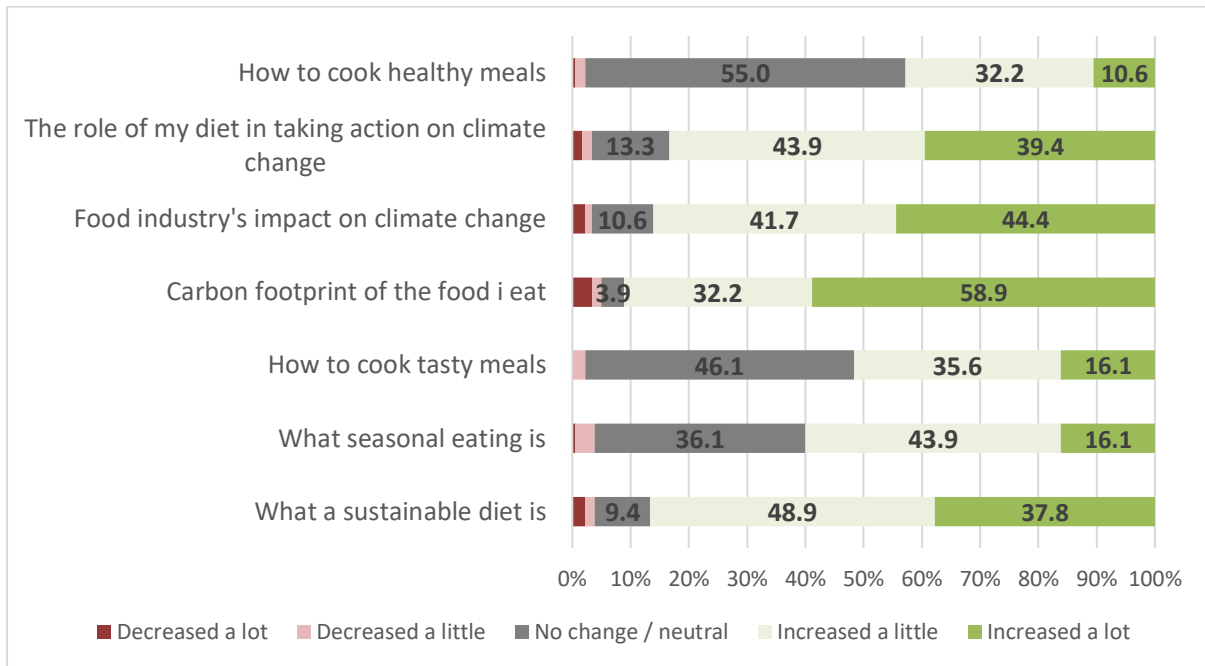


Figure 7: Bar chart showing the full results to the question “While using and interacting with the Fork Ranger app, how would you estimate your knowledge of the following topics have changed?” note figures are in %

To gauge the impact of Fork Ranger in encouraging action, question 17 also utilised a five point Likert scale to ask participants “after using the Fork Ranger app, which of the following actions are you very likely to very unlikely take? This revealed a positive impact overall across a number of sustainable behaviours.

As shown in Figure 8, combining likely and very likely percentages, participants indicated they were likely to recommend Fork Ranger to people - 88.9%, buy food with lower footprints - 89.4%, cook and eat a sustainable meal - 88.9%, buy less meat and dairy - 83.9%, and cook seasonably - 71.7%. This again suggests a correlation between using the app and taking a positive, sustainable action.

Respondents were however much less likely to share their knowledge about sustainable diets online with 36.7% admitting they were likely or very likely. Indeed this was the action they were neutral about (35.6%), or unlikely or very unlikely to do this (27.7% combined). This is a finding in which we will explore in further detail in the analysis phase.

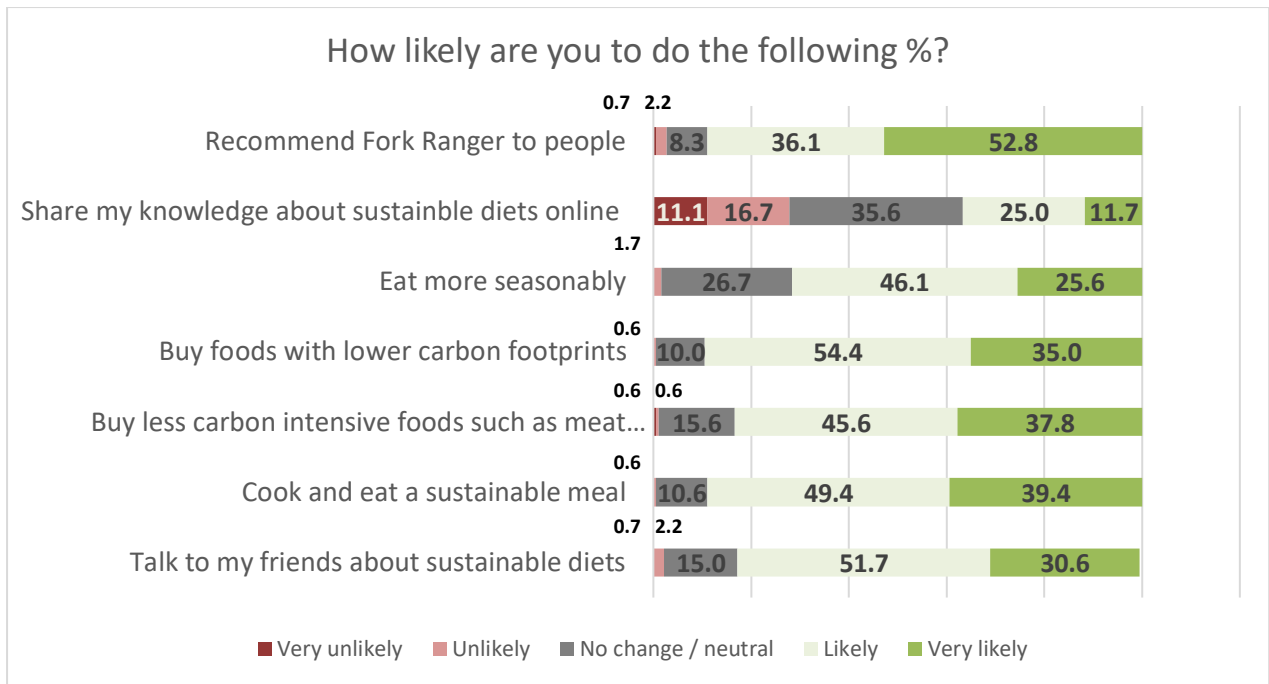


Figure 8: Bar chart listing the full responses to the question “AFTER using the Fork Ranger app - what's the likelihood of you taking the following actions?”

The Theory of Planned Behaviour (TPB)

The survey then utilised questions within the TPB to analyse a participant’s intentions to change or continue their declared behaviour. Participants were given 10 statements and using a Likert scale scored between 1 strongly disagree, to 7 strongly agree.

Descriptive statistics of the TPB (as shown in Table 8) showed that attitude ranked highest with a total mean of 6.43 and a standard deviation (SD) of 1.12, indicating that participants had a very high belief that it was important to eat sustainably for both their health and the environment. The lowest mean was around subjective norms, which had a total mean of 5.1 (SD = 1.06). This showed that while participants felt on average that eating sustainably was important, their influencing environment encouraging them to eat more sustainably was relatively low. However, the intention to eat more sustainably regularly (mean: 6.03, SD =1.16) and to seek out sustainable food options in the future (mean 5.88, SD=1.16) meant that the total intention indicated that participants behavioural outcome would be to eat sustainably (mean: 5.96, SD = 1.13)

To test for a significant correlation, the data was then analysed through the SPSS statistics software to calculate a Pearson Correlation coefficient, where it was found all three variables (Attitude, Subjective norms, and PBC) to have a statistically significant correlation with Intention ($p < .01$). As shown in Table 9, there is a very strong relationship between these variables and intention. The strength of this relationship is further indicated by the correlation coefficient, which is very high (0.796) for both Attitude and Subjective norms.

Table 8: Descriptive statistics of the theory of planned behaviour results

		Mean (1 = Strongly disagree, 7 = Strongly agree)	Standard deviation

Attitude	Eating a sustainable diet will be good for me and my health	6.25	1.16
	Eating a sustainable diet will be good for the environment	6.6	1.12
	Total attitude	6.43	1.26
Subjective norms	Most people who are important to me would approve of me eating a sustainable diet	5.79	1.26
	People who I admire, or who influence me, would think that I should buy sustainable food	4.9	1.33
	Eating a sustainable diet is a popular or fashionable thing to do	4.62	1.35
	Total subjective norms	5.1	1.06
Perceived Behavioural Control	It is easy to find sustainable options	5.22	1.42
	Sustainable food options are affordable	5.43	1.37
	I am confident I can eat a sustainable diet	5.76	1.20
	Total Perceived Behavioural Control	5.46	0.88
Intention	I plan to eat a sustainable diet regularly	6.03	1.16
	I will actively seek out sustainable food options in the future	5.88	1.16
	Total Intention	5.96	1.13

Table 9: Pearson correlation coefficient of all participants

Grouping	Category	Correlation & Significance	Intention
ALL participants (N=180)	Attitude	Correlation	0.796
		Significance	<.001

Subjective norms	Correlation	0.796
	Significance	<.001
Perceived Behavioural control	Correlation	0.611
	Significance	<.001

1.7 Features of the app

This section of the survey sought to find out which features of the Fork Ranger app users found most useful, to help inform which elements of a BCSS users react most positively to and are potentially influenced the most by. The most valued features, as shown in Figure 9, were listed as testing my sustainable food knowledge (65%), learning new facts I can share (58.9%) and getting recipe inspiration (52.8%). Further nuanced explanations to these features will be examined in the qualitative section of the study.

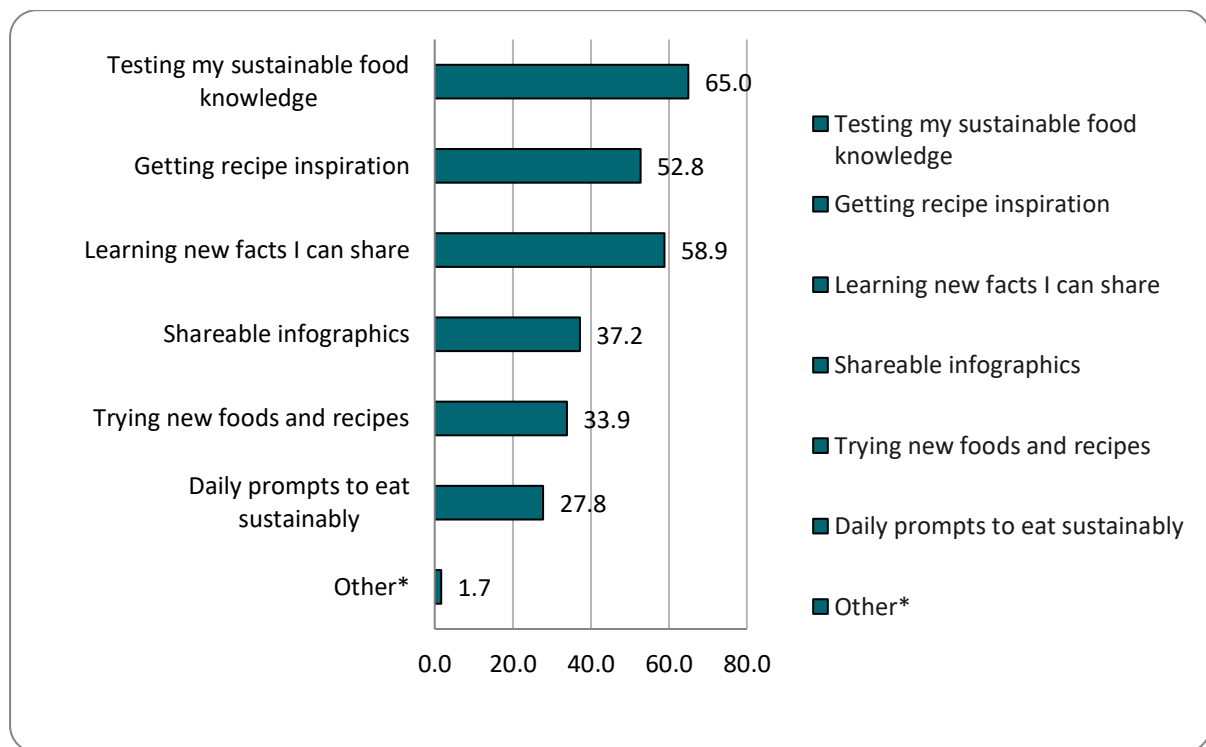


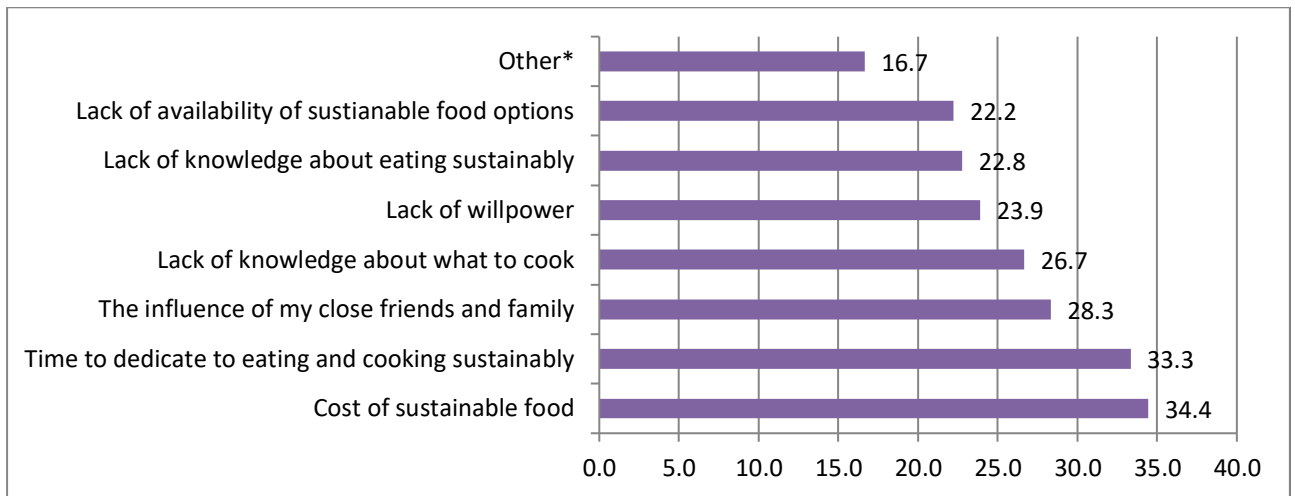
Figure 9: Bar chart showing which features of the app users valued most (figures are shown in %)

Other responses included: *i) “Knowing what changes in my diet have the highest positive impact on the climate”, ii) “Searchable recipes and mark favourite”, iii)*“The very accurate and interesting info shown to me. I can understand deeply the impact of what I eat in our world.

1.8 Barriers and challenges

The final question on the survey then asked participants about barriers or challenges they face to eating more sustainably. As displayed in Figure 10, these challenges were fairly evenly split across each option, with the most common barriers being the cost of sustainable food – 34.4%, Time to

dedicate to eating and cooking sustainably – 33.3% and the influence of my close friends and family 28.3%.



Sample “other” responses included: Getting the right nutrients on a plant based diet, feeling of powerlessness, diet restrictions due to a health issue such as diabetes, contradicting information, lack of availability of alternatives, extra time and effort to shop sustainably and convenience of “regular” food. Note, further detailed responses were discussed during the qualitative interviews.

Figure 10: Pie chart showing challenges and barriers participants said they faced when trying to eat sustainably (figures shown are %)

2.1 Correlations in diet changers

Analysing the data further, the research identified two key sub-groups for further analysis to identify any correlations between engagement with the app and inaction and action. These two sub-groups were named as 1: “Sustainable changers” (N=81), which contained respondents who recorded a change to a more sustainable diet, for example from omnivore to flexitarian, or vegetarian or vegan, or they recorded a reduction in meat eating, and 2: “No-changers and unsustainable diets” (N=29) which concerned participants who followed diets which contained animal products, and who reported no change after using the app, and whom consumed meat more than twice a week.

Regarding frequency of use of the app, in figure 11, there appears to be no clear pattern and impact between how often users engaged with the app, and whether it impacted their decision.

Within length of engagement however, the data in figure 12 shows a slight correlation between length of time using the app and the impact on making changes. The sustainable changers sub-group is represented highly in mid to long term users: 13 people who changed their diets reported using the app for 1-2 months, 21 for 2-3 months and 10 for 3-4 months. This could suggest that it is during this period of engagement in which a change in diet is made.

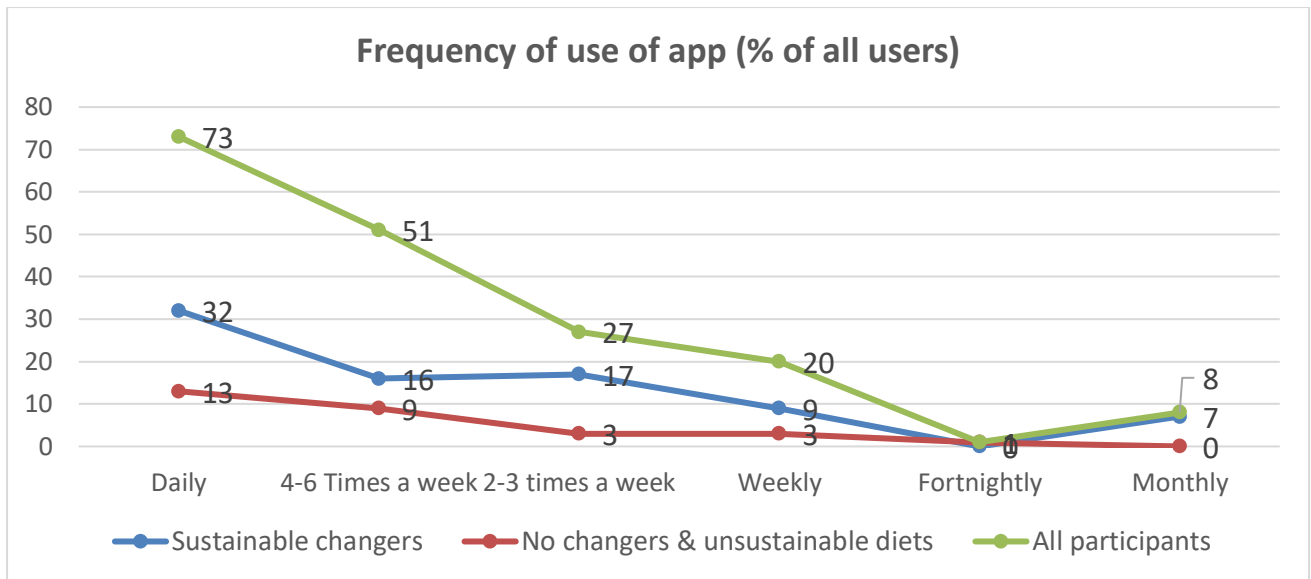


Figure 11: Line chart showing frequency of app usage across the two sub-groups in %.

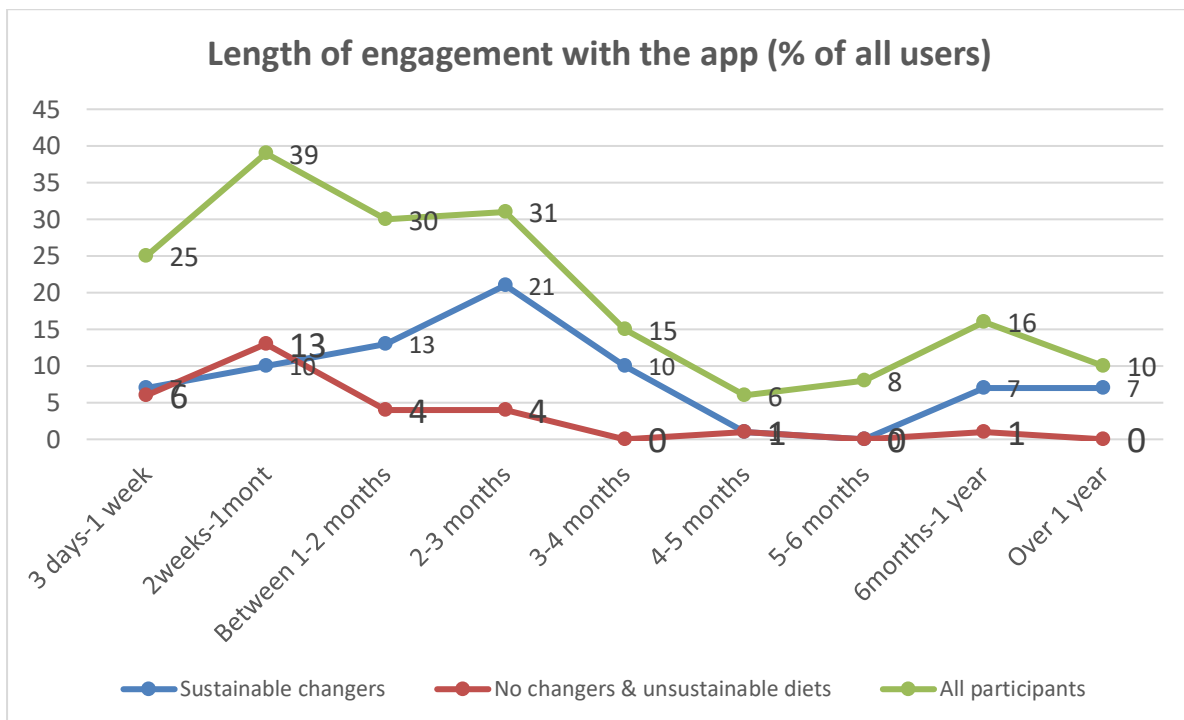


Figure 12: Line chart showing length of engagement with the app in %

Table 10 showcases the different mean averages and standard deviations in response to the question "While using and interacting with the Fork Ranger app, how would you estimate your knowledge of the following changed?"

The Sustainable Changers sub-group reported slightly higher average knowledge gains on specific topics compared to those who didn't change (no changers). This difference was most notable for "how to cook tasty meals" and "what seasonal eating is."

The mode (most frequent response) also differed for some knowledge questions, with no changers being less confident on topics like "sustainable diets" and "climate change." However, their knowledge still increased overall.

Similar trends emerged regarding the question which asked "AFTER using the Fork Ranger app - what's the likelihood of you taking the following actions?" The Sustainable Changers reported a higher likelihood of performing actions like "cooking sustainable meals" and "buying lower footprint foods" compared to no changers.

Table 10: Table highlighting the different mean averages and standard deviations between the core data and those who reported a dietary change to the question "While using and interacting with the Fork Ranger app, how would you estimate your knowledge of the following changed? scale was 1 (increased a lot) – 5 (decreased a lot).

	What a sustainable diet is	What seasonal eating is	How to cook tasty meals	The carbon footprint of the food I eat	The food industry's impact on climate change	The role of my diet in taking action on climate change	How to cook healthy meals
ALL PARTICIPANTS							
Average	1.81	2.28	2.34	1.58	1.75	1.82	2.49
Standard Deviation	0.84	0.79	0.77	0.91	0.86	0.85	0.73
Mode	2	2	3	1	1	2	3
SUSTAINABLE CHANGERS							
Average	1.7	2.2	2.2	1.6	1.7	1.7	2.4
Standard Deviation	0.9	0.8	0.8	1.1	0.9	0.9	0.8
Mode	1	2	3	1	1	1	3
NO CHANGERS & UNSUSTAINABLE DIETS							
Average	1.8	2.6	2.6	1.4	1.7	1.8	2.7
Standard Deviation	0.5	0.5	0.6	0.5	0.6	0.5	0.5
Mode	2	3	3	1	2	2	3

Table 11: Table highlighting the different mean averages, standard deviations and mode values between the two sub-groups and all participants to the question: "AFTER using the Fork Ranger app - what's the likelihood of you taking the following actions? 5= Very Unlikely, 1= Very Likely"

	Talk to my friends	Cook and eat a	Buy less carbon	Buy foods with	Eat more seasonably	Share my knowledge about	Recommend Fork

	about sustainable diets	sustainable meal	intensive foods such as meat and dairy	lower carbon footprints		sustainable diets online	Ranger to people
ALL PARTICIPANTS							
Average	1.91	1.72	1.81	1.76	2.04	2.91	1.62
Standard Deviation	0.8	0.7	0.8	0.6	0.8	1.2	0.8
Mode	2	2	2	2	2	3	1
SUSTAINABLE CHANGERS							
Average	1.8	1.6	1.6	1.6	2.0	2.8	1.5
Standard Deviation	0.7	0.7	0.8	0.7	0.8	1.1	0.7
Mode	2	1	1	1	2	3	1
NO CHANGERS & UNSUSTAINABLE DIETS							
Average	2.2	2.1	2.0	2.0	2.2	3.3	2.2
Standard Deviation	0.8	0.6	0.4	0.5	0.8	1.1	1.0
Mode	2	2	2	2	2	3	2

The applicability of the Theory of Planned Behaviour (TPB) model was also assessed for all participants (N=180) and further examined within the two subgroups. Correlations were analysed between attitude, subjective norm, perceived behavioural control (PBC), and intention to adopt a sustainable diet. The detailed results with correlation coefficients and their corresponding significance levels (p-values) are presented in Table 12. All participants and the sustainable changers exhibited statistically significant correlations ($p < 0.001$) between all TPB constructs (attitude, subjective norm, PBC) and intention to adopt a sustainable diet.

The No Changers and Unsustainable Diet group showed a different pattern. While PBC had a statistically significant correlation ($p < 0.001$) with intention, the correlation between attitude and intention was weak and non-significant ($p < 0.584$).

These findings will be further explored in the Discussion section to understand how the TPB model applies to each group and to explain the observed differences.

Table 12: TPB correlation and significance of all groups

Grouping	Category	Correlation & Significance	Intention
ALL participants (N=180)	Attitude	Correlation	0.796
		Significance	<.001
	Subjective norms	Correlation	0.796
		Significance	<.001

	Perceived Behavioural control	Correlation	0.611
		Significance	<.001
Sustainable changers (N=81)	Attitude	Correlation	0.775
		Significance	<0.001
	Subjective norms	Correlation	0.559
		Significance	<0.001
	Perceived Behavioural control	Correlation	0.802
		Significance	<0.001
No changers and unsustainable diets (N=29)	Attitude	Correlation	0.106
		Significance	0.584
	Subjective norms	Correlation	0.565
		Significance	0.001
	Perceived Behavioural control	Correlation	0.879
		Significance	<0.001

4.4. Qualitative results

To further analyse the impact an app can have in encouraging more sustainable diets, the study's next stage involved 10 one-to-one interviews with participants from the quantitative survey. These respondents were selected based on their responses during the qualitative stage. The main characteristics of these respondents is listed below in table 13.

The questions during this stage focused on whether the app had influenced their diets, if it had, it would then look at how it made an impact, as well as the reasons why, including a focus on what features of the app had the most impact. Finally, the interviews would then focus on identifying future changes, as well as challenges individuals face to eating sustainably.

Table 13: Characteristics of the interview participants

Participant name in transcripts and ID # from raw data	Age	Gender	Duration of app use	Characteristics
Participant A (ID 94)	25-34	Female	3-Days to 1 Week	Early stage user, reported shift to vegetarian to vegan

Participant B (ID 40)	25-34	Female	1-2 months	Mid-term user, reduced meat consumption from every other day to a meal once a week
Participant C (ID 112)	25-34	Male	2 Weeks – 1 Month	Reported change from omnivore to flexitarian; reduction in meat from daily to a meal once a week
Participant D (ID 111)	25-34	Female	6 months – 1 year	Reported change from one meal a day to a meal once a week
Participant E (ID 141)	25-34	Female		Pescetarian, doesn't eat meat, scored lower on
Participant F (ID 59)	35-44	Male		Short-term user, vegetarian, set future target to eat less dairy
Participant G (ID 138)	45-54	Male	1-2 month user	Changed from eating meat twice a week to eating meat once a week
Participant H (ID 58)	35-44	Female	2- 3 months	Went from eating meat twice a week to never, now vegan

Participant I (ID 113)	25-34	Male	3 days to 1 week	Vegetarian, reported target to reduce dairy intake
Participant J (ID 53)	25-34	Female	2 weeks to a month	No change in diet

Where possible, the participants for this stage were chosen based on characteristics which would elaborate on the findings from the quantitative results, with the working hypothesis that the app, from the quantitative survey, suggesting the app has an influence with users. It should be noted at this point that while respondents reported an initial duration of engagement of the app, by the time the interviews took place these participants had been using the app for an additional month. The analysis phase of the qualitative interviews employed Braun and Clarke's (2006) thematic analysis, resulting in the identification of three key themes: positive impact on behaviour, usability and functionality, and challenges to sustainable eating. Table 14 below reveals the codes, derived from quotes from the interviews, alongside a frequency tally, which should serve as a descriptive measure to highlight how often certain parts of a theme were mentioned in the interviews. Appendix C contains sample quotes from these interviews.

Table 14: The themes coded from the ten interviews

Key theme	Codes	Frequency
Theme #1: Positive Impact on behaviour	Reduction in dairy	12
	Reduction in meat	5
	Increased knowledge	25
	Impact on choice	6
	Confidence	5
	Social sharing	4
Theme 2: Usability and Functionality	Competition	1
	Ease of use	2
	Free	2
	Education	24
	Visually appealing	9
	Streak building	5
	Notifications	1
	Concise information	19
	Transparency	1
	Rewards	3
	Lack of detail (negative)	1
Recipes & cooking skills	20	
Theme 3: Challenges to Sustainable Eating	Health and nutrition	6
	Difficulty in changing social norms	2
	Lack of control	1
	Availability	4
	Peer pressure	5

Cost	4
Taste	5
Habit	6
Effort	2

Theme 1: Positive Impact on Sustainable Behaviour

Increased awareness of food’s climate impact

A frequent code across most interviews revealed a significant increase in participants' knowledge about the climate impact of their food choices. This newfound awareness empowered them to make informed decisions about what they ate.

Participants consistently highlighted the app's role in raising their awareness of the environmental consequences of their dietary choices. For example, participant C spoke about significantly reducing their meat consumption, stating, "Pretty much six days out of seven is vegetarian now, whereas before it was probably 6-5 or six days out of seven would be meat." Similarly, participant B described how the app "made it easier to add another day or two days or so into my routine" of vegetarian meals, and participant H said learning about the facts made them think "Maybe we should do something about it!"

Dietary Choices

This impact extended beyond meat eaters. Participants I and G, who were already vegetarian, discussed how learning about the climate impact of soft cheese influenced their behaviour.

Participant I stated, "It turned out eating the amount of cheese I do, I'd be better off eating a chicken. Which is a bit shocking to be honest... I've bought vegan cheese because of that."

Participant G echoed this sentiment, admitting that the information "jolted my behaviour a bit" and led them to share it with others. Other users said that they use Fork Ranger while shopping "If I ask my boyfriend to over WhatsApp, OK, what should we eat tonight then? He always sends a screenshot of a recipe that he has from Fork Ranger"- participant A, while F said that they use Fork Ranger to discover different plant based recipes to cook, to overcome the issues of taste and habit they said arrive from eating more plants.

Confidence and Sharing

The app also instilled confidence in users, they spoke about feeling empowered by the knowledge they had learned to not only make a sustainable choice, and therefore feel good about it, but it also made them more willing to share their newfound knowledge within their social networks. This aspect of behaviour change, as your quantitative data suggests, was previously an area of less frequent action by participants. Overall, with the exception of participant J, all users admitted to continued use of the app and expressed positive experiences with it, acknowledging the app's role in modifying their diets and they also planned to make further sustainable choices, including further reducing their meat and dairy consumption.

Theme 2: Usability and Functionality

Another key theme focused on how the app's functionalities fostered user engagement.

Participants consistently praised the app for providing clear and concise information on the environmental impact of their food choices. For instance, participants A, B, C, G, and F spoke about the benefits of receiving just one daily fact, finding it "not a chore or too intrusive" (A), "short but impactful" (F), and appreciating the app's "transparency" compared to "greenwashing" or confusing information (B).

The app also included features that leveraged gamification principles to promote engagement. Participants, such as A, B, and H, highlighted the benefits of the graphs and infographics, finding them "fun" (H) and easier to understand than "dry" text (B). Another engaging feature, mentioned

by participants B, C, and A, was the streak building functionality. Participants enjoyed seeing their daily streak with participant A feeling it served as a "steady reminder" to be sustainable. The app's ability to utilize existing information in an engaging format seemed to be particularly beneficial in educating users about unsustainable food choices. For example, participant E, a pescetarian, discovered the high climate impact of certain fish, such as tuna and salmon, and learned about more sustainable alternatives. Similarly, participants G, I, and F expressed surprise when learning about the higher environmental impact of soft cheeses compared to hard cheeses. The majority of participants also found the recipe recommendations helpful, with a high frequency of mentions across the interviews as shown in Table 10. Participants E and A described the satisfaction of receiving recipe rewards, while F appreciated the opportunity to discover new recipes and break out of their cooking routines.

Theme 3: Challenges to Sustainable Eating

During the interviews, while participants were keen to speak about the benefits the app had provided them with choosing to follow, learning and eating a sustainable diet, the interviews also covered challenges to participants becoming sustainable. The problems of dining in restaurants and spending money on a sustainable or plant-based food option proved to be a popular discussion point as to why users would choose to continue to eat meat, albeit in a reduced manner. Participant C's statement: "I think I'd struggle to go out and spend a lot of money on a meal and pick a vegan option", this could be down to taste, with participant B speaking about how "all of the vegetarian pizzas are very bland or even worst case they only have gorgonzola, then I would struggle to not eat meat". This suggests that there are challenges and influences that can't be solved through this app.

However, Participant C was keen to stress that going fully vegan or vegetarian would be too difficult, and being more flexible and having a treat of a meat option while out for dinner would be better for him to be more sustainable in the long-term. Participant B and F also spoke about the benefits of having that flexibility to maintain a more sustainable diet in the long-term.

Other varied challenges spoke about included how eating a sustainable diet "requires more planning and preparation." – Participant E, as well as taste and a lack of knowledge. Participant H provided insights into this challenge, stating: ""If you don't know how to cook that way (with vegetables), it's gonna be the most boring food, unfortunately." Participant B elaborated on the difficulty of finding flavourful sustainable recipes, mentioning the need to "stock up your pantry with all kinds of flavour items." However, both E and B then went on to speak about how Fork Ranger has a role in solving this challenge, and an appreciation of the recipes accessed through the app for giving them inspiration and for being easy to follow.

The interviews also revealed a small number of concerns about maintaining a balanced diet while adopting sustainable diets. Participant J, who did not change their diet, highlighted taste and protein intake as key deterrents, as well as maintaining a healthy weight after having a baby. Participant J further explained the taste barrier by describing a dislike for a suggested recipe: ""But, again, the recipe they gave me, I was like, you're just mixing chopped tomatoes with some pasta."

Overall, however, as covered in the first two themes, participants, aside from J, spoke of the benefits using Fork Ranger has had in answering these challenges: "it's good to have inspiration like from the app, where they are easy recipes that are actually quite tasty and look great." Participant H, notably, participant D admitted to relying solely on Fork Ranger recipes, praising their taste, variety, and ease of preparation.

5. Discussion

5.1. Recap of research objectives

At the beginning of this research study the author set out three research objectives, to help answer the overall aim of finding out the role mobile apps can play in influencing the adoption of sustainable diets. These were:

1. *Evaluate the influence a BCSS has in encouraging people to eat more sustainably*
2. *Examine the strengths and weaknesses of BCSS' in influencing sustainable diets*
3. *Highlight the implications of this study for action on sustainable diets*

Utilising a mixed-methods approach, this study was able to reveal detailed findings into the benefits a BCSS can have in enacting a behavioural change, how it can help to solve some of the challenges people face in giving up meat and dairy, as well as highlight how interventions through the form of a BCSS can have advantages over other interventions in enacting change at scale.

The following discussion brings the quantitative and qualitative findings from this study together and evaluates the results with external literature and the research objectives.

5.2. Improving knowledge and awareness about sustainable diets

The first research objective (RO1) sought to evaluate the role a BCSS can play in encouraging people to eat more sustainably. Encouragingly, both the quantitative and the qualitative data indicate that apps can play an important influencing role in changing a person's dietary choices, with the first benefit identified as improving the knowledge of users through an interactive and engaging format.

86.7% of respondents said their knowledge about what a sustainable diet is had increased, so too had the role of their diets in combating climate change (83.3%), the carbon footprint of the food an individual eats (91.1%), and the role a person's diet can play in tackling climate change (86.1%).

This is reflected in people's willingness to eat more sustainably after using the app, just under half (45%) of all respondents reported a change in their diet after engaging with the app. Only three participants in the survey said that they intended to revert to the diet they were following before using the Fork Ranger app. This is a promising finding and hints that apps can play a deciding role in making a person eat more sustainably.

Utilising the Theory of Planned behaviour, the results also indicate that the changes self-reported through the study revealed an intention to continue to eat sustainably, with correlation coefficients revealing strong relationships between attitude and subjective norms (0.796 for both). The drop in meat consumption is potentially surprising, given only 12.2% of respondents said they started using Fork Ranger with a goal to reduce their meat intake.

Most users (63.3%) downloaded Fork Ranger to learn more about sustainability and food, and "Testing my sustainable knowledge" was also one of the key features users valued the most during the use of the app Fork Ranger, with 65% of users listing it as their favourite feature.

Learning new information and education was also a popular theme and outcome discussed during the qualitative interviews, with participants describing the role the app played in encouraging them to make more sustainable choices, whether that be consuming less meat, or eating less dairy.

Participant C said that, as a result of using Fork Ranger, they had reduced their meat intake from 4-5 times a week, to just once a week. Other interviews, such as with Participant G and I, who were

both vegetarians, spoke about being surprised by the information they learned such as about the climate impact of soft cheeses.

Increasing a person's knowledge about sustainability and the impact of foods such as meat have been proven to be an effective way to foster a greater willingness to change an individual's meat consumption (De Boer et al, 2014, Verain et al., 2015). Combining information provision with a motivational goal, such as a daily streak, has also been shown to be an effective means in which interventions can encourage behaviour changes (Abrahamse, 2020). The streak and daily reminders helped to develop new sustainable habits and habitual behaviours were one of the reasons why people still eat meat (Allès et al., 2017). Further, the app was noted by participants for helping them to develop new skills to eat, shop and cook sustainably, which was noted by Kwasny et al. (2022) as a key focus for an effective behaviour change intervention.

5.3. BCSS Strengths

From the findings, it appears that one of the greatest strengths of the BCSS is the user experience of using the app to learn and engage with information about sustainable diets, and this helps to answer both the first and second research objectives.

Breaking habits, user interface and rewards

While the quantitative survey revealed in Figure 9 that users enjoyed features of Fork Ranger including testing their sustainable knowledge, getting recipe information, learning news facts and the shareable infographics, these features are available via other sources of information such as TV, newspapers and books. But Theme 2 highlighted just how effective presenting this information in an app on a phone can be in helping users learn. In the interviews users praised the experience of using the app from the graphs and infographics, and its interactive daily quizzes, and how this format helped users learn in a way in which they felt they didn't connect with elsewhere. During the interviews (Table 10, and Appendix C), participants praised the app for this user design, its pragmatism, its ability to deliver useful information in a concise manner, as well as its use of quality sources, which helped boost trust between the user and the information they received, while they also spoke about how Fork Ranger delivered the right amount of information in a way which didn't overwhelm users. This led to them feeling confident and willing to eat more sustainably.

This is a defining feature of a BCSS as outlined by Oinas-Kukkonen (2010), who points out that a well-designed user experience has been proven to help users access and learn information in a positive way. Beck et al. (2019) noted that the most effective persuasion technology experiences were those which paired this information with gamification elements such as daily quizzes and the ability to track a user journey, and to receive rewards. And these elements of Fork Ranger were viewed positively by users; participants B, C and A spoke about how they had maintained a streak of over 30 days, participant A spoke about her annoyance, or disappointment in herself, at missing a day. They were also positive about the rewards of the daily recipes which helped them to feel accomplished.

Recipes and skills building

In addition to knowledge and greater awareness of the climate impact of the food a person eats, two of the biggest barriers to eating more sustainably were listed in the quantitative survey as time to dedicate to cook and eat sustainably (33.3%) and lack of knowledge about what to cook (26.7%). This corroborates with external sources, where convenience of cooking and eating meat and habitual cooking behaviours have been described as a common challenge to why people can't give up eating meat (Stoll-Kleeman et al., 2017, Culliford et al., 2020). From this study, half (52.8%) of

users used the app for recipe inspiration, while in the interviews, users such as Participant B spoke about how the recipes provided inspiration for new meals, while others said they used it to help shop and make sustainable choices in supermarkets, and that they enjoyed the reward of the recipe at the end of each day. Participant D said that they now only ever use Fork Ranger.

Developing new recipe knowledge and being given easy to follow cooking skills reflects the recommendations from Kwasny et al. (2022), who made the recommendation for future interventions to focus on behaviour change interventions which would focus on skills building, such as cooking, and interventions which would encourage habit formation around eating sustainably. From the survey results, this was achieved. Participant B spoke of adding new recipes into her weekly meal plan rotation, to replace dishes based on meat, which could be shown as developing a new habit.

Overall, the findings were positive and showed a strong correlation between the use of Fork Ranger and eating more sustainably.

5.4 Correlations and challenges

To further explore the research objective and to examine the strengths and weaknesses of BCSS, there is a need to investigate why the app made an impact with some users, and not others. The findings were therefore split into two sub-groups: 1) The Sustainable Changers (n=80), and the 2) Unsustainable no changers (n=29)

Time and frequency of use of app

While frequency of app use (Figure 11) did not show a clear correlation with dietary change, there was an interesting trend regarding the duration of engagement (Figure 12). A higher proportion of Sustainable Changers were found among mid- to long-term users (1-4 months). This suggests that sustained engagement over a period of 1-4 months might be a critical factor for the app to influence dietary change in a user.

Increased Knowledge and tendency to take action

The analysis of user knowledge and intended actions following engagement with the Fork Ranger app revealed less significant differences between the two sub-groups (Table 11 and Table 12). Sustainable Changers exhibited slighter increases in knowledge on specific topics compared to Unsustainable No Changers, and there was a small notable increase in knowledge for practical skills directly related to dietary changes, such as "how to cook tasty meals" and "what seasonal eating is" in the sustainable changers, which support the earlier discussion points about the impacts of increasing knowledge plus skills building can have on eating sustainably (Kwasny et al, 2022, De Boer et al. 2018). This could explain why they made changes as opposed to the no-changers.

The research was not able to identify exactly why the Unsustainable Non-Changers sub-group didn't make any changes, despite displaying an overall increase in knowledge across various topics, although they reported lower confidence on their own knowledge of "what a sustainable diet is" and "the food industry's impact on climate change." It may well be that these individuals had an emotion or cultural attachment to meat which couldn't be identified in the quantitative survey, Graca et al., (2015) noted that despite an increase in knowledge, if participants displayed this emotional connection they still refused to reduce their meat intake.

The Theory of Planned Behaviour

Using the Theory of Planned Behaviour, the pattern observed for the unsustainable non-changers group was intriguing. The weak and non-significant correlation between attitude and intention suggests that even if unsustainable non-changers have positive attitudes towards sustainable diets, these attitudes do not translate into a strong intention to change. This finding deviates from the typical TPB model (Ajzen, 1992) and warrants further exploration.

However, the significant correlation between subjective norm (social pressure) and intention indicates that social pressure might be a more influential factor for this group. This suggests that interventions that leverage social norms and peer pressure could be more effective in promoting sustainable dietary changes among those who are resistant but might be susceptible to social influence.

Interestingly, perceived behavioural control also had a strong and significant correlation with intention for unsustainable non-changers. This finding is unexpected as this group currently does not follow a sustainable diet. It could be that they perceive sustainable diets as more difficult to adopt than they are, or that addressing perceived barriers to ease could be a crucial first step for this group.

The weak link between attitude and intention for unsustainable non-changers suggests the potential influence of external factors not captured by the TPB model. These could include factors like lack of access to affordable healthy foods, limited time for meal preparation, or cultural norms around food. The issue of external challenges was identified in the quantitative survey, such as cost (34.4%) and availability of sustainable foods (22.2%).

A significant barrier to eating more sustainably for this participant was the difficulty in cooking and eating sustainable foods after giving birth to a child, due to the stresses of early parenthood, and the perception that to lose weight they needed to focus on eating protein which they could only get from eating meat.

The topic of protein and nutrition was also a concern for other participants: For participants H and J, health was their biggest priority, and while H felt that they were able to still be healthy while eating sustainably, J felt that this challenge was too difficult. Participant C also spoke about a concern about eating enough protein whilst reducing their meat consumption.

However, as Willet et al., 2019 shows in the the EAT Lancet report, respondents who eat a sustainable diet are also healthy. A suggestion for Fork Ranger, and other BCSS interventions then is that while focusing on sustainable diets and sustainable information is crucial to raise awareness and to enact behaviour change, so too is communicating the health benefits.

5.5 External challenges

While this study shows the benefits and positive influence on behaviour Fork Ranger has, one of the challenges, which Fork Ranger was unable to solve, lay in availability and pricing of sustainable food. In the qualitative interviews, respondents spoke about challenges with availability in restaurants, or sustainable recipes requiring a pantry stocked with ingredients. While apps such as Fork Ranger try to solve this problem with solutions such as easy to follow, simple recipes, it has no bearing or control on food prices in supermarkets, or the availability of plant-based options on supermarket shelves or on menus in restaurants.

This reflects other studies and reviews which discuss the limits of BCSS and digital interventions, which are limited by other environmental and social factors not within their control (Kwasny et al. 2022). While the TPB section revealed that attitude and subjective norms showed a strong

correlation with intention, perceived behavioural control, i.e. the environment which surrounds people, scored lower, indicating more users felt the environment they're in is a challenge to eating sustainably.

6. Conclusion

6.1 Summary of findings and implications

The research set out to investigate the role behaviour change support systems in the form of mobile apps can play in influencing the adoption of sustainable diets. The study employed a mixed-methods approach, combining quantitative data from a survey (n=180) with qualitative data from user interviews (n=10), with the findings providing valuable insights into the strengths and limitations of BCSS.

Both the quantitative and qualitative data revealed significant increases in individuals' knowledge about sustainable diets, and in practical skills such as cooking tasty meals and understanding the climate impact of different food items, after engaging with the BCSS. While the format of BCSS can help to tackle some of the most common challenges in reducing an individual's meat consumption, from breaking habits, to educating people about the links between excess meat consumption and climate change, as well as helping users develop the skills and knowledge about how to cook, eat and shop sustainably.

This further supports the hypothesis that BCSS can be an effective way to influence behaviours around sustainable diets, just like how they've experienced positive results in other sectors such as healthcare. In particular, the findings showed how the user interface and design of BCSS can combine information provision and skills development in a unique way that connects with users that other methods can't in promoting user engagement and learning through features such as interactive quizzes, daily infographics, streak building, recipe rewards and knowledge building were particularly well-received by users. The impact of the app tended to be most effective in mid- to long-term users (1-4 months) of the app. This suggests that sustained engagement may be a critical factor of BCSS to influence dietary change.

Additionally, the Theory of Planned Behaviour (TPB) correlation results suggest that the app may be effective in promoting positive attitudes towards sustainable practices, encouraging social norms that support these practices, and fostering a sense of ease and control over adopting sustainable diets, which indicates a longer-term behaviour change.

However, there are challenges to BCSS in answering all the problems facing individuals when it comes to adopting sustainable diets. BCSS are only as useful as the external environment they are used in; prices of sustainable food and availability of sustainable options in shops and restaurants will hinder the ability of people from eating sustainably. Additionally, one clear challenge present in the qualitative interviews was the misperception that they cannot get essential nutrients such as protein from eating less meat. Greater attention in a BCSS must be paid to health messaging in addition to sustainability focused messaging in interventions.

At the beginning of this thesis the urgency and the need to change the way we eat was clear, there is a need for a large-scale intervention to move diets towards ones which are less damaging to the environment. While there are calls for unpopular measures such as meat taxes, digital behaviour change interventions such as apps like Fork Ranger offer policymakers and organisations the

opportunity to influence sustainable diets, and reduce the consumption of meat in a more positive way. With the proliferation of mobile phones in modern society, it also gives organisations opportunity to enact large scale behaviour change interventions that can help to educate and influence people about sustainable diets, building their skills into how to cook tasty but sustainable meals, through a positive nudge-based campaign.

6.2 Reflections, limitations and future research

While the study provides valuable insights, some limitations require consideration. The relatively small sample size in general (n=180), and the over-representation of females and those of white ethnicities, means that the findings cannot be treated as representative for the wider population.

On reflection, during the qualitative interviews it became clear that users were as equally concerned about dairy as well as meat, and, as shown in external research and in Fork Ranger, individual diets can actually be more sustainable if they removed soft cheeses and red meat, but continued to consume a small amount of Poultry. For future research into this area, the recommendation would be to consider a question on dairy consumption as well as meat, and in the meat question perhaps this should be split this into red meat and poultry meat, although this would require more questions and be more difficult to design in a survey.

Additionally, the study focused on self-reported dietary changes, and, while measures were taken to avoid confirmation bias, users who experienced a positive engagement with the app would naturally be more inclined to engage with a dissertation survey. This issue was particularly prevalent during the qualitative interview stage, where the majority of users who left their emails for a follow-up interview were positive and had experienced a positive change through the app. Thankfully, Participant J responded at the last minute, to help offer a counter point as to why the app didn't influence them.

Valuable future research would be to look into how effective Fork Ranger could be in influencing behaviour change within a sample of population who are heavy meat eaters and aren't concerned about sustainability.

The way in which this research was conducted, from distance and online, also means, despite the promise of the findings, they must be treated with a level of caution. Given more time, the author believes in-depth findings of greater reliability could have been achieved via an in-person, observational study over a period of a few months, where participants had what they were eating and cooking recorded. This was not possible due to time constraints, but perhaps represents a natural area for future research of this topic.

The author suggests future research could focus on these observational studies to further prove this research's findings.

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7. Appendices

7.1 Appendix A

Higher resolution photos of the Fork Ranger app.

✕
←

The footprint of 'winter tomatoes'

From a study in Austria

Production Method	kg CO2e/ kg
Local heated greenhouse	~1.4
Canned from Italy	~1.1
Transported from Spain	~0.8
Organic summer tomato	~0.2

■ Agriculture
 ■ Transport
 ■ Packaging

Thaler, M. C., Hobel, H., Eitz, K. H., & Liedtke, T. (2018). Contrasted greenhouse gas emissions from local versus long-range tomato production. *Agronomy for Sustainable Development*, 34, 589-602.

Learn more at ForkRanger.com

Of course, seasonal food is the best option. But during winter months, canned food is also a good option. Canned tomatoes are harvested during summer. In the can they remain fresh and are often tastier than tomatoes from a greenhouse.

It's easy to feel decision stress with all these options. Just keep in mind: eating fewer animal products is more important than buying the most sustainable tomato.

Next

The average Western Diet

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., ... & Jönvall, M. (2019). Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, 393(10170), 447-492. [Average Dutch diet: Voedselconsumptiepeiling 2010-2016, Rijksinstituut voor Volksgezondheid en Milieu.]

Learn more at ForkRanger.com

Who needs to know this? 😊

Share this infographic

Today

My Journey

Recipes

Supporter

7.2 Appendix B:

Fork Ranger & Sustainable diets

Hi - I'm Jack, a student at the Centre of Alternative Technology, I'm working with Fork Ranger to look into the role of apps and their impact on individual knowledge about sustainable diets and eating habits.

Before taking part in this study, please take time to read the following information below carefully and feel free to email me (jack.ferris@student.cat.org.uk) if you would like more information or if there is anything that you do not understand.

The survey should take no longer than 5-10 minutes, you will be asked about your eating behaviours and use of Fork Ranger, with your data anonymised and then analysed as part of my final Masters dissertation. At the end of the study, you may also leave your contact details and email address if you are interested in a follow-up interview.

I would like to stress that you do not have to take part in this study, and should only agree to take part if you want to. This study has received ethical approval from CAT's Ethics Committee (06.09.23)

By taking part in this study, you consent to your data being stored, and you will not be able to withdraw it. All data will be identified only by a code, with any personal details kept on a secure computer with access only by the immediate research team. Your information will be anonymised (i.e. personally identifiable information deleted) and collated with others upon completion of my research module. Identifiable information will still be included in raw data which will be shared with academic staff at the Centre for Alternative Technology and the University of East London as part of my assessment. The anonymised dataset will also be shared with Fork Ranger.

Who can I contact if I have further questions?

Student: Jack Ferris jack.ferris@student.cat.org.uk

Supervisor: Sam Saville sam.saville@cat.org.uk

Fork Ranger: hello@forkranger.com

* Required

* This form will record your name, please fill your name.

Your consent

Before we can begin the survey, please indicate that you consent to be a part of the study

1. I confirm that I have read and understood the information provided for the following study *

Yes

No

2. I understand and agree that other authorised researchers will have access to this data, and may use my data in publications, reports, web pages, and other research outputs, only if they agree to preserve the confidentiality of the information as specified in this form. *

Yes

No

3. I agree to take part in the study and understand that taking part will include answering the following questionnaire. *

Yes

No

4. Before we begin, please confirm that you use, or have used, the Fork Ranger app for longer than three days? *

Yes

No

About you

This section seeks to learn more about you, and to discover whether there are any interesting findings we may discover through analysing demographics. **Please note you do not need to answer these if you do not want to do so - please just click the prefer not to say option.**

5. What is your gender? *

Male

Female

Non-binary

Prefer not to say

Other

6. How old are you? *

Under 18

18-24

25-34

35-44

45-54

55-64

65-74

75-84

85+

Prefer not to say

7. How would you describe your ethnicity or ethnic background? *

- Prefer not to say
- Arab: Arab or Arab European
- Asian: Bangladeshi or Bangladeshi European
- Asian: Chinese or Chinese European
- Asian: Indian or Indian European
- Asian: Pakistani or Pakistani European
- Black: African or African European
- Black: Caribbean or Caribbean British/European
- Mixed: White or white European and Asian or Asian European
- Mixed: White or White European and Black African or Black African European
- White or White European and Black Caribbean or Black Caribbean European
- White: European such as British, Dutch, German, French etc.
- White: Gypsy, Irish Traveller, Traveller or Roma
- Other

About your use of Fork Ranger and knowledge of sustainable diets

This section will ask about your useage of the Fork Ranger app, as well as your diet before and after interacting with the app.

8. How long have you been using the Fork Ranger app? *

- 1-2 Days
- 3 Days to 1 Week
- 2 Weeks to a month
- Between 1-2 months
- 2-3 Months
- 3-4 Months
- 4-5 Months
- 5-6 Months
- 6 Months-Year
- Over 1 year

9. How often do you use the Fork Ranger app? *

- Daily
- 4-6 times a week
- 2-3 times a week
- Weekly
- Monthly
- Fortnightly
- Monthly

10. **BEFORE** you started using Fork Ranger, which of the following best describes your diet? *

- Vegan (i.e. you only ate plants)
- Vegetarian (i.e. you ate plants, eggs and dairy)
- Pescetarian (i.e. you ate fish, plants, eggs and dairy)
- Flexitarian (i.e. you ate a primarily vegetarian diet but occasionally eat meat or fish)
- Omnivore (i.e. you ate plants, eggs, dairy, meat, fish etc.)
- Carnivore (i.e. you only ate red meat, poultry, fish, and eggs)
- Other

11. **AFTER** using the Fork Ranger app, which of the following options best describes your diet now? *

- Vegan (i.e. I only eat plants)
- Vegetarian (i.e. you eat plants, eggs and dairy)
- Pescetarian (i.e. you eat fish, plants, eggs and dairy)
- Flexitarian (i.e. you eat a primarily vegetarian diet but occasionally eat meat or fish)
- Omnivore (i.e. you eat plants, eggs, dairy, meat, fish etc.)
- Carnivore (i.e. you only eat red meat, poultry, fish, and eggs)
- Other

12. **BEFORE** using Fork Ranger, how much meat do you estimate you ate on average each week? *

- For more than two meals a day
- One meal a day
- A meal every other day
- A meal two times a week
- A meal once a week
- Never

13. **AFTER using Fork Ranger, how much meat do you estimate you now eat on average each week? ***

- For more than two meals a day
- One meal a day
- A meal every other day
- A meal two times a week
- A meal once a week
- Never

14. **How do you see your diet changing in the next year? (Please select up to 3 choices) ***

Please select at most 3 options.

- I plan to make no changes
- I plan reduce my meat consumption
- I plan to eat more seasonal food
- I plan to reduce my dairy consumption
- I plan to reduce my egg consumption
- I plan to reduce my fish / seafood consumption
- I plan to increase my meat consumption
- I plan to increase my dairy consumption
- I plan to increase my fish / seafood consumption
- I will revert to the diet I was following prior to using Fork Ranger
- Other

15. Did you start using Fork Ranger with a specific goal in mind? (select all that apply)

*

- I wanted to eat more sustainably
- I wanted to reduce my meat intake
- I wanted to learn more about eating seasonably
- I wanted to learn new cooking skills
- I wanted new recipe suggestions
- I didn't set a particular goal
- I wanted to reduce my consumption of dairy and/or eggs
- I wanted to learn about sustainability and food
- Other

16. While using and interacting with the Fork Ranger app, how would you estimate your knowledge of the following topics have changed? 5=Decreased a lot, 1=Increased a lot

*

	5	4	3	2	1
What a sustainable diet is	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
What seasonal eating is	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
How to cook tasty meals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The carbon footprint of the food I eat	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The food industry's impact on climate change	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The role of my diet in taking action on climate change	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
How to cook healthy meals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

17. **AFTER** using the Fork Ranger app - what's the likelihood of you taking the following actions? 5= Very Unlikely, 1= Very Likely *

	5	4	3	2	1
Talk to my friends about sustainable diets	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cook and eat a sustainable meal	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Buy less carbon intensive foods such as meat and dairy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Buy foods with lower carbon footprints	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat more seasonably	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Share my knowledge about sustainable diets online	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Recommend Fork Ranger to people	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

18. The questions in this part of the survey about sustainable diets make use of a rating scale. Please select the number that best describes how you feel.

Our definition of a sustainable diet: Fork Ranger bases its app on the findings from the Eat Lancet report (2019), which describes sustainable diets as: "a diet which largely consists of vegetables, fruits, whole grains, legumes, nuts, and unsaturated oils, and a low to moderate amount of seafood and poultry. This includes no or a low quantity of red meat, processed meat, added sugar, refined grains, and starchy vegetables." *

	1. Strongly disagree	2	3	4. Neutral	5	6	7. Strongly agree
Eating a sustainable diet will be good for me and my health	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eating a sustainable diet will be good for the environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Most people who are important to me would approve of me eating a sustainable diet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
People who I admire, or who influence me, would think that I should buy sustainable food	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eating a sustainable diet is a popular or fashionable thing to do	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is easy for me to find sustainable food options	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sustainable food options are affordable to me	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am confident I will be able to eat a sustainable diet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I plan to eat a sustainable diet regularly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I will actively seek out sustainable food options when I buy my food in future	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

19. Which part of the Fork Ranger app do you find most useful? *

- Testing my sustainable food knowledge
- Daily prompts to eat sustainably
- Getting recipe inspiration
- The shareable infographics
- Learning new facts I can share with friends and peers
- Trying new foods and recipes
- Other

20. Which barriers or challenges do you face when it comes to eating sustainably? (choose your top 3) *

Please select at most 3 options.

- The cost of sustainable food
- A lack of knowledge about eating sustainably
- Lack of willpower
- The influence of my close friends and family
- The lack of availability of sustainable food options
- Time to dedicate to eating and cooking sustainable food
- Lack of knowledge about what to cook
- Other

21. Is there anything else you'd like to say about sustainable diets and food consumption, or Fork Ranger that haven't been covered in this study? Please take the opportunity to write a short comment in the box below

- Other

Thank you so much for taking part in this survey.

This survey data is completely anonymous. I will also be conducting short online interviews to better understand user experiences and motivations of the Fork Ranger app. If you would like to be involved and contribute further to this research, please leave your email address. This will be stored securely for the length of the project, not shared nor used for any other purpose than this research.

22. Please list your email address if you'd be interested in a follow-up interview where we will look into your use of Fork Ranger and sustainable diets further.

7.3 Appendix C

Themes	Sample quotes
Theme #1: Positive Impact on behaviour	
Reduction in dairy	<p>“It turned out eating the amount of cheese I do, I'd be better off eating a chicken. Which is a bit shocking to be honest. I did not realise that and I've bought vegan cheese because of that.” Participant I</p> <p>“I'm pretty much full veggie, but one of my changes that I've had is I didn't realise until I had this app about the carbon footprint of cheese, like really didn't appreciate its impact, and I've shared that with quite a few people.” Participant G</p> <p>“And we really decreased as well the amount of dairy we eat, but that was difficult because I really love cheese. I really love it and it's the hardest thing to let go but still it's also a nice journey to look for a new other alternative and vegan option.” Participant F</p>
Reduction in meat	<p>“The information in the app is really useful to telling me what I can do to reduce my footprint. So stop eating meat, eat more lentils and beans and things like that we increased it.” Participant F</p> <p>“I've made huge, huge reductions, to be honest. Pretty much six days out of seven is vegetarian now, whereas before it was probably 6-5 or six days out of seven would be meat. And so, yeah, a big, big reduction (since using the app).” Participant C</p> <p>“I was already aware of trying to lower my meat consumption overall, but the app made it easier to add another day or two days or so into my routine” Participant B</p>
Increased knowledge	<p>“While using the app I kind of thought maybe I'll need to start to maybe either reduce the number of times I eat salmon and tuna, or maybe start getting different types of fish as well to cut to just balance it out” Participant E</p> <p>“It's jolted my behaviour a bit, again we're talking small things here, small changes, but the food that we're having tonight... it's vegan” – Participant G</p> <p>“The bit about cheese blew my mind. You know about how carbon inefficient eating cheese is, and we help with something.</p> <p>That kind of shocked me and I didn't realize, and that's probably the thing that was the greatest jolt on me in terms of, like, my habits and my diet so far.” Participant G</p> <p>“ It was useful understanding about nuts and things like that as well because we never know which, like whether we should be putting black beans in like kidney beans, chickpeas like, what's the best one and that like some of that was covered about their amount of protein and things because we always worry about protein.” – Participant I</p> <p>“ I'm more aware about the climate because of the app and all the different little facts. So it's like wow, is that true? Hmm maybe we should do something about it!” Participant H</p>

	<p>“The fact that Fork Ranger provides like actual facts, statistics, information has definitely made me think about it and to be more and more conscious of it, and it's helped to inform the choices I make.” Participant G</p> <p>“What I find is most things which are good for the environment are also tend to be more ethical, but that's where Fork Ranger kind of comes in. It's educating me on things like not all vegetables, fruits, legumes and stuff are equal in terms of their environmental impact and by making some small tweaks, having this type of bean instead of that or XY and Z, you can have the best of both worlds” Participant G</p> <p>“We have a certain routine about cooking, and you come home after work, you start to cook and, well, sounds familiar probably. And every now and then you think, like I'm fed up with the same thing again, again. And then you start looking for some recipes. And in this case. Fork Ranger can help” Participant F</p> <p>“I become more and more aware of the the impact of ethics sustainably or eating not sustainably.” Participant A</p> <p>“I would say this app increased my knowledge because again, certain things like there was a lesson about avocados <and their impact>. I've never thought about it like that. So it definitely gave me more information.” Participant E</p> <p>“I'm more aware about the climate because of the app and all the different little facts. So it's like wow, is that true? Hmm maybe we should do something about it!” Participant H</p> <p>“I think my knowledge has increased in like understanding that while this obviously all it's kind of obvious really, but like having perhaps just like a small amount of hard cheese is far better than having some mozzarella, just because you're using far lesser that kind of thing. It's not something I'd really considered before.” Participant C</p>
Impact on choice	<p>“It's difficult to say really <If the participant will maintain the meat reduction>, but I think I think there's more of a chance this time. I feel a lot more in the kind of habit” – Participant C</p> <p>“If I ask my boyfriend to over WhatsApp, OK, what should we eat tonight then? He always sends a screenshot of a recipe that he has from Fork Ranger. So we're really in there now you know, we're really big fans.” Participant A</p> <p>“I found it to be a way more compelling and interesting experience than I thought I would and yeah, it's certainly helped me make changes that I kind of wanted to but wasn't able to previously .So yeah, I definitely I recommend it for anyone that is on the fence about wanting to reduce carbon intensive diets and or learn how they could.” – Participant C</p>
Confidence	<p>“It's kind of consciously happening in my brain like I know if I use a recipe from Fork Ranger that I'm doing a good thing you know and that's not something that the other sources bring me. So I like to gather a lot of different recipes that I like, but especially for this one, it really validates my choices in my mind, which makes it feel good.” Participant A</p> <p>“Yeah <it has increased my knowledge>. And also a made me a little bit more confident and aware of.. oh, this is going to make so much bigger impact on that and you know where to put your effort in” Participant B</p>
Social sharing	<p>“So it kind of does hook you a little bit to start with, because the info it gives to you is, I don't want to say shocking, but just new, and it gives me something to talk about with people.” Participant I</p>
Theme 2: Usability and Functionality	

Competition	<p>"I like the fact that you've got the question like because I'm quite competitive, I like need to get things right." Participant G</p>
Ease of use	<p>"And now with fork Ranger. I actually have to turn it down to two people and like, that's amazing." Participant B</p> <p>What's nice about the app is that it's very pragmatic. – Participant B</p>
Free	<p>"And especially considering this doesn't cost anything, just literally free doesn't take very long and you get benefits from it because you learn interesting stuff and you get cool recipes. You know, for me. Like, what's not to like, really?" Participant G</p>
Education	<p>"The cheese thing really surprised me. Like, I would have thought it would have had a high carbon footprint just because of like, it comes from cows.</p> <p>But to be have a higher carbon footprint than like, even like lamb or chicken. It really surprised me." Participant I</p> <p>"It's educating me on things like not all vegetables, fruits, legumes and stuff are equal in terms of their environmental impact and by making some small tweaks, having this type of bean instead of that or XY and Z, you can have the best of both worlds." Participant G</p> <p>"It did increase my knowledge... for example, a lesson I did recently was about salmon and tuna and that they are not very sustainable because they, in order to grow salmon or tuna, you need to feed them other fish, and I just never thought about it like that." Participant E</p> <p>"The fact that Fork Ranger provides like actual facts, statistics, information has definitely made me think about it and to be more and more conscious of it, and it's helped to inform the choices I make." Participant G</p>
Visually appealing	<p>" Also, the nice thing is that all the visuals that it brings and information about the footprint of for example ingredients or just, you know, yeah, like the cows versus chicken versus pigs." Participant A</p> <p>"we both read and see the picture, the infographics. It helps you to remember what it was that you read. So yeah, I think. And the way it's done like it's a bit of fun designs, and that makes it fun. It's not like you're reading some very formal dry piece of paper. It's been done in a fun way" Participant H</p> <p>"the graphs really just makes it easier to intuitively understand, like, ohh, now I get it and then it gives you a little bit more sense of the ratios or how they compare against one another rather than if it was just text." Participant B</p>
Streak building	<p>"I got a notification at the other day saying I've done my 50th day and completed my 50th story." – Participant C</p> <p>"So I can see my daily streak. I've been using it for 67 days and consecutively and I am using it every day and I really like it." Participant G</p> <p>"So having that daily reminder, I think is probably the thing that's kept <this change> rather than any particular piece of information." Participant C</p> <p>"I'm a sucker for things that say like streaks and yeah." Participant B</p> <p>"If I've skipped a couple of days and did not see those journey moments and I feel like shoot, I already missed four days. You know, that makes me feel really shitty. So in that sense it keeps me also active in the app, you know, because I feel like, wait, I haven't been, I</p>

	haven't been active., I haven't looked at this each day and I try to commit myself to it" Participant A
Notifications	<p>"It can be really easy to forget to do something like that, and then if you get a push notification, even if you don't do it, even if I'm really busy and I don't do it at lunchtime when I get home, I'll see that notification now, like right, I can then do Fork Ranger." Participant G</p> <p>"for me it's a steady reminder every day to be more sustainable" Participant A</p>
Concise information	<p>"I think the app gives good information and also good sources and really provides in-depth information as well. But not in a sense that it's too detailed. – Participant A</p> <p>"It doesn't take too long. So it's not like a chore or too intrusive." Participant G</p> <p>"It's really, really short, but it's impactful and the content is different every day, so it's hardly ever on the same subject, so sometimes transportation and it's I don't know meat or fish or grain." Participant F</p> <p>"It was just, these are facts. This is what you know, if you were to reduce a little bit, this is the benefit it could have. I don't feel like it's playing on emotions, but it's more just delivering, you know, regular facts and prompts and kind of nudges." Participant C</p>
Transparency	"The whole thing of why I like the app is that its not greenwashing or has confusing sustainability information..... I like the transparency." Participant B
Rewards	<p>"All the recipes are already on the Internet, but I think that psychologically it does feel like a reward. Getting the recipe so and it's all cause you never know what you're getting. I think it works as a nice as a nice incentive, like a nice reward" – Participant E</p> <p>"I really try to, you know, take in those rewards a bit more because like ohh nice I did this. You know, so yeah, it works for me." Participant A</p>
Lack of detail (negative)	"It just didn't go into enough detail like not enough to make it stick in my head, like it would just be one question that you had to guess and then it would be about 6 lines about it and then a recipe." Participant J
Recipes & cooking skills	<p>"I only cook Fork Ranger I nearly never cook anything else." – Participant D</p> <p>"It's kind of consciously happening in my brain like I know if I use a recipe from Fork Ranger that I'm doing a good thing you know and that's not something that the other sources bring me. So I like to gather a lot of different recipes that I like, but especially for this one, it really validates my choices in my mind, which makes it feel good." – Participant A</p> <p>Well they are tasty definitely, they are different from what I knew before which was just meat, potatoes, vegetables kind of stuff. And they're easy to follow. So in some way I have the feeling that I also learned some cooking skills through the recipes. – Participant D</p>

	<p>“It is bringing me inspiration... not only about like the about the ingredients and what kind of diet it is, but also just how the app is structured and how the recipes are very easy to follow and the recipes are quite easy themselves as well” Participant A</p> <p>“We have a certain routine about cooking, and you come home after work, you start to cook and, well, sounds familiar probably. And every now and then you think, like I'm fed up with the same thing again, again. And then you start looking for some recipes. And in this case. Fork Ranger can help.” Participant F</p> <p>“But I mean, that's why I've also done several of the recipes because you can, you know, you can see the recipe and make the shopping list. And then you have the shopping list, so you know, OK, this I have this. I have. I need the rest and it's really practical. Very easy to follow.” Participant H</p> <p>“it's good to have inspiration like from from the app, where they are easy recipes that are actually quite tasty and look great.”</p>
On my phone	<p>“if I wanted to make a change that I wanted to stick to. I think I'd need my phone to help me do that.” Participant I</p>
Theme 3: Challenges to Sustainable Eating	
Health and nutrition	<p>“For example, in a recipe I could have pretty low iron and I know that that's something I could get more easier out of eating or cooking with meat. Theres tons of advice like “yeah eat spinach”. But like, there's only so much spinach that you wanna eat you know?” Participant B</p> <p>"Health is my biggest, biggest driver. It's my main driver. I know it's also really good for me after I've learned more about the impact of what we eat on the climate" Participant H</p> <p>“It's about also about the health benefits and other positives of eating plant based.” Participant F</p> <p>“I would say I do it (eat meat daily) purely because, well, I do it half because it is the best source of protein that I know to do, and like I said, eating healthy and losing weight is my biggest importance after having a baby. But also it is tasty.” Participant J</p>
Difficulty in changing social norms	<p>“So people who really need to change their diet, I don't think they'll ever come across this app, unfortunately.” Participant E</p>
Lack of control	<p>“I'm here and living alone and when I cook, I never cook meats and when I go to the restaurant I also try to uh, not choose a meat meal. And I try to choose vegan, it's not that difficult, but when the meat is present, it's difficult for me to not choose it, to not take it so.” Participant D</p>
Availability	<p>“What shops am I gonna go to? Where can I find fair trade produce? what are usually also or a lot of them are also bio products? So I think that's a challenge to find the food in the right places from the right sources.” Participant D</p> <p>“I had to think of like coconut milk for instance. I know Fork Ranger mentions that. Uh, actually, it's it might be an important product to to choose fair trade. I haven't found it yet. Not at the shops that I go to, which are like bio, usually bio shops. So sometimes it's not easy to find.” Participant D</p>

	<p>"You know, it's so it's so easy to choose from meats in the supermarket. It's so easy to, you know, choose it in a restaurant and I feel I have a strong feeling that a lot of people do not connect the like an actual animal to the piece of meat in the supermarket." Participant A</p> <p>"So I think that's a challenge to find the food in the right places from the right sources." Participant D</p>
Peer pressure	<p>"Although I see some changes but I come from a farmer's family, so meat is a big thing. Meat is a daily, daily thing in in life of my family and a lot of my friends." Participant D</p> <p>"Sometimes when I'm with friends, if everybody's enjoying it and I'm like, oh, well, OK, well, what would it even matter if I do it?" Participant A</p>
Cost	<p>"I think I'd struggle to go out and spend a lot of money on a meal and pick a vegan option." Participant C</p>
Taste	<p>"Umm, I think a challenge is that a lot of the recipes that are vegetarian that are more sustainable, so you go into the beans and all those kinds of flavoured things. They're often either relatively bland. Or you need an entire, or you need like to stock up your pantry with all kinds of flavour items. Well, in my perception, so I definitely need that inspiration to make it make it work" Participant B</p> <p>"But, again, the recipe they gave me, I was like, you're just mixing chopped tomatoes with some pasta. [participant rolled eyes at this]" Participant J</p> <p>"So if you don't know how to cook that way (with vegetables), it's gonna be the most boring food, unfortunately." Participant H</p> <p>"Again another thing that makes me makes it difficult to eat more sustainably. It's just personal preference.</p> <p>I do love the taste of avocado and I do love taste of. I do love like prawns, muscles, salmon. So it it's the fact that again, I know just things that taste good aren't always sustainable." Participant E</p>
Habit	<p>"It's so hard to break habits. And like. I see sometimes people go to the grocery store and buy the same things because that's what they always buy. That's like my mother-in-law. She always buys the same thing. Always." Participant H</p> <p>"<eating meat> I believe it's kind of a habit of people." – Participant A</p>
Effort	<p>"It requires more planning and preparation." – Participant E</p>