**Literature Review 1st Draft**

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## **Introduction of Literature Review**

This literature review will discuss the method, scope and purpose of this literature review, before diving into the three key areas of this project: carbon footprint, behavioural psychology and gamification. In the first section, the carbon footprint metric and the factors contributing to this metric will be discussed. To understand why a knowledge-action gap exists in reducing carbon footprints, the second key area of behavioural psychology will be discussed, before reaching the final key area of applying gamification as a potential solution to address the knowledge action gap problem of reducing individual carbon footprints. To enhance knowledge surrounding a successful implementation for this project, existing solutions will be discussed, taking inspiration from their success factors and learning from their mistakes.

## **Method, Scope and Purpose**

### **Method**

Using “Carbon Footprint”, “Behavioural Psychology” and “Gamification” as search strings, reputable sources were searched in Scopus and the original results returned an overwhelming number of results. This figure was then filtered down to results based on their level of overlap across the different key search strings, before deciding on the most applicable papers. Throughout this process, hundreds of abstracts were read, before deciding whether or not to save each paper to saved lists on Scopus for further analysis.

After the initial filtration of reading through abstracts and adding a marginal portion of these papers to saved lists, each paper was then briefly read through to further refine the most applicable papers. After briefly reading through such papers, the saved lists were then further refined, before ultimately deciding on which papers to reference throughout this report.

### **Scope**

As climate change is a growing concern with each passing day, and society’s impact on our shared planet dynamically increases exponentially each day, the original approach was for only papers in the last 5 years to be consulted, however, in order to correctly reference the original authors, this original, restricted scope was given a lengthy extension. For example a 2019 paper more often than not would reference a point made from a 2013 article which may reference an article from a 2001 article. Where statistics were needed, every effort was made to use the most up to date material, however, for definitions, these were generally relatively older since these definitions will not change over time.

### **Purpose**

The purpose of this literature review was to conduct research to provide background on this problem, examine why this lack of action is occurring, how best to implement a solution and to analyse existing solutions to this problem of a lack of action taken towards climate change. By carrying out this initial extensive research, informed design decisions can be made as the project progresses. Without such research, design decisions would be merely guesswork with no justification or evidence, or indication that such decisions would prove successful or impactful. The importance of literature reviews cannot be understated, with there being “an urgent need for developing a clear understanding of advancements and state of knowledge stock in the discipline to inform and guide future researchers aiming to advance the field” (Kraus, S., Mahto, R.V. and Walsh, S.T. (2021)).

## **Carbon Footprint**

This section focuses on two major subsections: the mainstream metric of carbon footprint used for measuring impact on climate change, followed by the main factors contributing to carbon footprint emissions, namely transport, meat consumption and energy usage.

### **Metric for Environmental Impact**

As Mulrow, J. et al. (2019) mention, *carbon footprints* have become the industry norm for calculating individual impact on climate change through greenhouse gas emissions, highlighting the causes of such emissions and providing opportunity to reduce such emissions. The main purpose of a carbon footprint score is simply to “measure the carbon emissions that result from a given set of activities“ (Wiedmann, T. and Minx, J. (2007)).

The reasons for wide spread adoption of this metric over its competitors are its ease of use, greater ability to track necessary data and consumer interest in the areas contributing to this metric (Mulrow, J. et al. (2019)).

With such adoption, carbon footprints have become a useful tool to educate and motivate pro-environmental behaviour. Kenny, T. and Gray, N.F. (2009) observe a growing trend of using carbon footprint calculators to measure individual carbon footprint scores.

#### **Critiques**

Some individuals complain about the length of time and effort it takes to calculate your score with existing calculators, but these are necessary steps to take to get an accurate indication of your overall carbon emissions.

With this in mind, one approach could be to simply focus on the most contributing factors to one’s carbon footprint score, such as meat consumption and transport, as opposed to focusing on every single contributor. This introduces a trade-off in terms of actual overall carbon emissions and the time spent by the user calculating their score. This topic will be discussed further in section 3.2.

#### **Alternative Metrics**

Possible alternative metrics for measuring individual climate change impact are ecological footprint and water footprint. The differences here are that the ecological footprint focuses on “measuring the use of bio-productive space”, and water footprint measures the extent of water use in relation to consumption. Again, the carbon footprint metric has proved to be more popular due to ease of use and simplicity, resulting in its mainstream adoption.

### **Main Factors Contributing to Carbon Footprint**

Although many factors contribute to carbon footprint emissions, for the sake of brevity, this report will now discuss the most dominant contributors which are transport, meat consumption and energy usage, and which aspects society members are most interested in. Note, carbon footprint calculators tend to use different factors and underlying calculations so there is no universal answer. The following statistics are based off of Irish emissions.

* + 1. **Transport**

Transport accounts for 17.7% towards carbon emissions (Environmental Protection Agency (EPA) (2022)). This is unsurprising due to the nature and frequency of use of vehicles, where they burn fossil fuels to operate.

In their academic journal on analysing the state of carbon footprint calculators, Mulrow, J. et al. (2019) discuss that users of these calculators are not only aware of the impact transport has on their carbon footprint, but are also curious about learning more about the impact transport has on their scores.

* + 1. **Agriculture**

Agriculture, and predominantly meat consumption, accounts for 37.5% of Irish carbon emissions (Environmental Protection Agency (EPA) (2022)).

Westhoek, H. et al. (2014) propose that a 50% reduction in meat, dairy products and eggs in the European Union would result in a 25%-40% reduction in greenhouse gas emissions associated with food production.

The problem here is identified by Sanchez-Sabate, R. and Sabaté, J. (2019) when they say that consumer awareness of the environmental impact of meat production is surprisingly low, as well as the willingness to change meat consumption behaviour in terms of reducing or substituting meat (e.g., by eating insects or meat substitutes).

In terms of user interest, Mulrow, J. et al. (2019) identified food and meat consumption as an area of high interest and curiosity to consumers when receiving their carbon footprint scores.

* + 1. **Energy Usage**

Agriculture, accounts for 16.7% of Irish carbon emissions (Environmental Protection Agency (EPA) (2022)).

Mulrow, J. et al. (2019) found in their research on carbon footprint calculators that a majority of participants are unable to accurately estimate the level of energy usage in their homes. Mulrow, J. et al. (2019) outline that users can retrieve this information, but this extra step would place more effort on the users’ behalf, increasing the cost of trying to learn about and implement pro-environmental behaviour.

An interesting point to note from Mulrow, J. et al.’s (2019) study is that users reported the most enjoyable and rewarding calculators to be those which pair user carbon scores with recommendations on activities to reduce such scores.

There are other factors included in calculating a carbon footprint score, however, for the sake of brevity only the primary above three have been discussed.

### **Conclusion**

This section has introduced the concept of carbon footprint as a metric to measure individual impact on climate change, analysing the different factors contributing to this metric’s score, and providing some insights into critiques of this mainstream metric.

Taking the popularity but also criticisms of carbon footprints into account, suggests there is need for a reduced, tailored “carbon footprint” score. With the tool of the carbon footprint metric at their disposal, and the arguably adequate knowledge of the factors contributing to this detrimental impact on the environment, this raises the central question motivating this project. Why is there such a large knowledge-action gap? This is where the next section provides an answer, discussing behavioural psychology towards climate change.

## **Behavioural Psychology and Carbon Footprint**

This section focuses on the key concern this paper addresses whereby having identified that consumers have the metrics and knowledge necessary to pro-actively reduce their individual carbon footprints, why do the majority of such consumers still not take meaningful action? The subsections to be discussed are the inclusion model, which highlights the importance of underlying psychological values of self-enhancing vs self-transcendence, social identity and a feeling of a lack of responsibility.

### **Inclusion Model for Environmental Concern**

De Dominicis, S., Schultz, P.W. and Bonaiuto, M. (2017) argue that traditional and historic attempts to promote pro-environmental behaviour have failed because of focusing on highlighting the altruistic benefits on nature or the greater good, where they should have focused more on self-interest or self-enhancement. De Dominicis, S., Schultz, P.W. and Bonaiuto, M.’s (2017) work expands that of the Inclusion Model for Environmental Concern (Nolan, J.M. and Schultz, P.W. (2013)), which explains how egoistic or self-interest motivated values and altruistic or self-transcendent values are hierarchically structured, whereby altruism is inclusive of self-interest. The significance of this is emphasised when De Dominicis, S., Schultz, P.W. and Bonaiuto, M. (2017) undertake 3 studies all highlighting how self-enhanced message frames, whereby users’ individual self-interests are targeted, have a much greater effect on pro-environmental behaviour than using self-transcendent message frames, such as the positive impact a participant would make on the environment.

An example of this in action, is where even though societal members know, as discussed in the previous section, that transportation increases carbon emissions, damaging the environment, individuals receive an individual reward by arriving at their location faster. Similarly, if meat consumption is popular within friend groups, individuals tend to focus on the extrinsic reward of social status and keeping with social norm, prioritising this over the environmental effect.

This theory and work explains why even with access to the knowledge and tools such as carbon footprint metrics to understand and measure environmental impact, society still continues to disregard and avoid adapting to pro-environmental behaviour.

The value of De Dominicis, S., Schultz, P.W. and Bonaiuto, M.’s (2017) research is the signification that individuals may behave pro-environmentally for non-environmental reasons, such as gaining social status (Griskevicius, V., Tybur, J.M. and Van den Bergh, B. (2010)) or being healthy (Gifford, R. (2011), (2013)) and many times individuals behave pro-environmentally even without knowing they are doing so (Gifford, R. (2013)).

### **Social Identity**

Bouman, T., Steg, L. and Zawadzki, S.J. (2020) argue that the values individuals perceive their groups to endorse can critically motivate individuals to engage in pro-environmental action. In their study, Bouman, T., Steg, L. and Zawadzki, S.J. (2020) present concrete evidence where Americans with no concern for the environment begin to change their concern for the planet after groups the participants strongly identify with show environmental concern. Bouman, T., Steg, L. and Zawadzki, S.J. (2020) expand on the work of the “Social Identity” outlined by (Fielding, K.S. and Hornsey, M.J. (2016); Jans, L., Bouman, T. and Fielding, K. (2018)), whereby groups can provide standards that guide individual actions. Bouman, T., Steg, L. and Zawadzki, S.J.’s (2020) social identity argument aligns with the Inclusion Model, where self-enhancing social image is a key indicator for motivating behavioural change in individuals.

### **Lack of Responsibility - Proportion of Individual Impact**

Schwenkenbecher, A. (2014) poses in her research, “Is there an obligation to reduce one’s individual carbon footprint?” Her work tackles the societal issue of environmental responsibility and proportionality.

With increasing awareness of the proportion of individual impact being tiny compared to large corporations, society feels a lack of responsibility to tackle climate change and argues that no one individual has the capability to make a meaningful change in global emissions.

To excellently discredit this notion of individuals contributing no harm and being unable to have a significant effect, Schwenkenbecher explains in depth the power of aggregate harm, where yes individual contributions are too negligible to have a meaningful effect, but through the power of compounding, aggregated individual change leads to meaningful emission reductions. Additionally, Schwenkenbecher highlights how individual change can be influential, pushing others towards making similar change, which we have seen can be powerful in the case of social identity discussed by Bouman, T., Steg, L. and Zawadzki, S.J. (2020).

Acceptance must be made towards the fact that compounded individual acts can be harmful, and the need for individual action to be taken to break this compounding effect.

### **Conclusion**

This section has illustrated why society continues to avoid pro-environmental action even when faced with the tools and knowledge that facilitate and encourage such change. Intrinsic and extrinsic motivations play a key role in unlocking the key to achieving societal behavioural change, and without appealing to these factors, any attempts are made in vein.

## **Gamifying Carbon Footprint**

This section introduces the concept of gamification, and how it can be applied to tackle the behavioural psychology challenges outlined in the previous section, with the ultimate goal of reducing individual carbon footprints. First the theory, then the importance of selecting design features, and finally the effects of gamification as evident from existing solutions applied to climate change will be discussed.

### **Theory of Gamification**

Deterding, S. et al. (2011) define gamification as “the use of game design elements in non-game contexts”, with Sailer, M. et al. (2017) expanding on this definition, saying “to foster human motivation and performance in regard to a given activity.” The significant factor here is the purpose of gamification being to motivate behaviour change.

Applying this logic to this project proposes the potential success of applying gamification principles and design to spark pro-environmental behavioural change.

At its core, gamification has three broad, categorical features: immersion, achievement and social features.

Immersive features are those such as avatars (Annetta, L.A. (2010); Peng, W. et al. (2012)), narration and personalisation (Kim, K. et al. (2015)), attempting to provide the player with a sense of freedom and control through the feeling of voluntary participation (Bormann, D. and Greitemeyer, T. (2015); Kim, K. et al. (2015); Koivisto, J. and Hamari, J. (2019), Rigby, S. and Ryan, R.M. (2011); Sailer, M. et al. (2017)), targeting the autonomy aspect of self-determination theory.

Achievement-related features are those such as badges, points, levels, leaderboards and performance graphs which ultimately target the competence aspect of self-determination theory, where users want to improve their skills or get feedback on their performance or progress (Xi, N. and Hamari, J. (2019)), valuing self-mastery and growth (Rigby, S. and Ryan, R.M. (2011)).

Social-related features are those such as teams, cooperation, competition, groups and chat, which ultimately target the relatedness aspect of self-determination theory, providing players with a sense of community and belonging stemmed from frequent communication, sharing of ideas and reciprocity (Francisco-Aparicio, A. et al. (2013)).

Each type of gamification feature fulfils a corresponding psychological user need, improving overall user experience, fulfilment and engagement with the application. By implementing a combination of immersion, achievement and/or social features, gamification can effectively achieve its goal of motivating behaviour change, when appropriate design choices are made. The theory suggests that gamification can be applied to overcome the psychological barriers outlined in the previous section, ultimately resulting in meaningful behavioural change towards reducing individual carbon footprints.

“Not surprisingly, in 2017, the global gamification market was valued at $2.17 billion and is estimated to reach $19.39 billion by 2023” according to Mordor Intelligence, (2018). Such a valuation is a clear indication that gamification, when appropriately designed, is an effective, efficient, and widely popular method of achieving behaviour change, and is promising for achieving this project’s goal of reducing individual carbon footprints.

### **Selecting Effective Design Features**

Gamification is well known for its success in various applications by fulfilling basic psychological user needs (Sailer, M. et al. (2017)), however, one cannot assume that gamification will automatically work. Gartner, (2012) states that 80% of current gamified applications fail to meet their objectives due to poor design (Xi, N. and Hamari, J. (2019)). This coincides with Sailer, M. et al.’s (2017) argument that “gamification is not effective per se, but specific game design elements have specific psychological effects.”

With this in mind, it is crucial to carefully plan which features to include in the design of a gamified application. Xi, N. and Hamari, J.’s (2019) research discovers that among the three broad categories of gamification features of immersion, achievement and social features, achievement had the most significant impact on fulfilling the psychological user needs of autonomy, competence and relatedness, followed by social and then immersive features. Each feature had its own benefits, however with immersion only targeting autonomy, and achievement features having a greater impact on autonomy, competence and relatedness than social features, achievement features were the clear winners, followed by social features as a close second.

This research provides great motivation for this project to prioritise implementing achievement features such as leaderboards, points and progress maps, before progressing on to social features such as chatting and teamwork.

### **Conclusion**

This section has introduced the theory and importance of selecting gamification design features, providing great insight into how specifically to overcome the psychological barriers to pro-environmental action outlined in section 4.

## **Existing Solutions**

This section is arguably the most important section, analysing existing solutions to gamify climate change to reduce carbon footprints. The existing solutions of “Ant Forest” and “Green Life” will be analysed, 2 solutions with contrasting levels of success.

### **Ant Forest**

Ant Forest is a Chinese based app, which pioneered the use of gamification for public environmental protection. As shown in Figure 1, users on the platform can earn "green energy" to cultivate a virtual tree by online and offline low-carbon behaviours. When the virtual tree grows, a real tree will be planted by the public welfare partner of Ant Financial Services Group. The Ant Forest has now developed multiple forms of gamified interactions, such as team up or race with friends (Cao, Y. et al. (2022)).

Timeline

Description automatically generated

Figure 1: Workflow of Ant Forest app to promote and gamify pro-environmental behaviour (Cao, 2022).

The success of Ant Forest is indicative of its user base reaching 500 million users as of 2019, all participating in reduced carbon actions. The cooperative and competitive features in Ant Forest have resulted in more than 20 million tons of “green energy” (It takes at least 17 kg of "green energy" to plant one tree). To put this into perspective, the carbon emissions reduction of this “green energy” is equivalent to saving 29.4 billion kwh of electricity, which is equivalent to one full day of China’s electricity consumption (Cao, Y. et al. (2022)).

This impressive reduction is proof that individual environmental action, when aggregated, can have significant benefits, as outlined previously by Schwenkenbecher, A. (2014) in her paper on the proportion of individual impact.

Not only have emissions drastically reduced, but Ant Forest is evidence that individual environmental change, can influence others to do the same, as seen by companies agreeing to work with Ant Forest to incentivise green consumption behaviour, again previously proposed by Schwenkenbecher, A. (2014).

As such, Ant Forest is hard evidence that applying gamification to climate change can reduce carbon footprint scores. With such success, Ant Forest is a key motivation for the design and rationale of this project.

### **Green Life**

“Green life” is an app that encourages waste separation and recycling by offering free trash bags or other cash rewards. Having an underwhelming user base of 700,000 users in total so far, with a concerning app store rating of only 2.3 out of 5, “Green Life” is a good example of how solely providing financial incentives is inadequate to achieve behavioural change amongst a wide customer base. Green Life is the perfect illustration of the danger of assuming any form of gamification will result in effective behavioural change, and that, as previously mentioned by (Gartner, 2012), 80% of current gamified applications were estimated to fail to meet their objectives due to poor design. (Xi, N. and Hamari, J. (2019)). With this example in mind, this project will focus on the most effective combination of gamification features needed to achieve the required environmental behavioural change.

## **Conclusion**

This literature review has analysed the area of a carbon footprint, outlining the need for an adapted carbon footprint metric, targeted at the most contributary actions towards carbon emissions. After identifying the knowledge-action gap problem, the central motivation for this project, the inclusion model, social identity and lack of responsibility put into perspective why such infrequent action is taken. By connecting the ability of gamification to tackle these psychological barriers to pro-environmental behaviour change, and analysing this in practice through existing solutions of Ant Forest and Green Life, motivations and direction will be taken forward throughout this report, to aid in the design of this project.

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