

## Insights from the Review of Apps that Influence Environmental Sustainability

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# Insights from the Review of Apps that Influence Environmental Sustainability

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## ABSTRACT

Environmental sustainability is the avoidance of the depletion of natural resources in order to maintain an ecological balance. To influence people to be environmentally sustainable, several mobile apps exist to teach sustainable behaviours. These apps hold great promise as interventions for influencing people to live sustainable lives since they are often designed using behaviour change strategies. However, the effectiveness of these apps as behaviour change tools is unclear. In addition, despite people downloading these apps, their engagement level is still low. Research suggests that user experience and usability determine the adoption and usage of apps. Research also indicates that user experience and usability of apps can be gleaned from the reviews written by users on the app store. Thus, reviews are a good source of determining the user experience and usability of users. To determine the effectiveness of sustainability apps as behaviour change tools and the users' experience with the apps, we reviewed 70 sustainability apps that are available on the Google Play Store. First, using a popular behaviour change framework, the App Behaviour Change Scale (ABACUS), we investigated the persuasive strategies implemented by the apps and how these strategies were designed and implemented to achieve the targeted design objectives. Second, using natural language processing, we identified the common themes in the user reviews of the apps. The preliminary results presented here can influence the design of apps for influencing environmentally sustainable behaviour.

## CCS CONCEPTS

• Human-centered computing; • Ubiquitous and mobile computing; • Ubiquitous and mobile computing design and evaluation methods;

## KEYWORDS

Behaviour change, Environmental Sustainability, User Reviews, App Behaviour Change Scale

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## 1 INTRODUCTION

Environmental sustainability is the ability to conserve the natural resources of the planet and to maintain an ecological balance in the planet's natural environment [1]. There are several negative impacts of not living sustainably such as climate change, loss of biodiversity, loss of natural resources, and pollution [2]. These can have negative consequences on the health of people, animals, the ecosystem, and the planet we live in [2]. The United Nations<sup>1</sup> offers 17 goals for sustainable development (SDG) some of which have been categorized into: *clean water and sanitization*, for example, learning to avoid wasting water, *climate action*, an example of which is working to stop global warming, *life below water*, for example, avoiding the use of plastic bags to preserve the cleanliness of [3] the oceans, *life on land* for example, planting trees to protect the environment, *responsible consumption and production* such as recycling, and *sustainable cities and communities* such as biking, walking or using public transportation. Several tools have been developed to influence people to attain some of these UN sustainable goals and the tools are available for download on the app store. For example, Carbon Footprint and CO<sub>2</sub> Tracker<sup>2</sup>, in the category of *climate action* goals, influences people to reduce their daily emissions and carbon footprint, while FoodWise<sup>3</sup> in the category of *responsible consumption and production* influences people to reduce food waste. Despite the existence of these tools, there is still a call for people to choose green actions which are sustainable habits that can reduce our environmental footprint and reduce the damage to the planet. Furthermore, low engagement affects the effectiveness of these apps; there is a dearth of research to explain the low engagement of apps [4]. There is therefore a need to examine existing apps for influencing sustainable behaviours to determine the behaviour change potential of the apps. Such a study can identify gaps in the development of apps that could make them result in the desired behaviour change.

To contribute to research in this area, we evaluate 70 apps for environmental sustainability in two ways. First, we use the App Behaviour Change Scale (ABACUS) [5] to measure how the apps employ behaviour change strategies. The ABACUS is a reliable tool that has been used successfully in the past to determine the potential of apps to result in behaviour change [6], [7], [4]. The ABACUS rates apps against their behaviour change potential.

<sup>1</sup><https://www.un.org/sustainabledevelopment/sustainable-development-goals/>

<sup>2</sup>[https://play.google.com/store/apps/details?id=\\$app.thecapture.tracker&hl=\\$en&gl=\\$US](https://play.google.com/store/apps/details?id=$app.thecapture.tracker&hl=$en&gl=$US)

<sup>3</sup>[https://play.google.com/store/apps/details?id=\\$com.foodwise.android&hl=\\$en&gl=\\$US](https://play.google.com/store/apps/details?id=$com.foodwise.android&hl=$en&gl=$US)

**Table 1: App Behaviour Change Scale (ABACUS)**

Category	Measure
<b>Knowledge and Information</b>	Customize and personalize features Consistent with national guidelines or created with expertise Baseline information Instruction on how to perform the behavior
<b>Goals and Planning</b>	Information about the consequences of continuing and/or discontinuing behaviour Willingness for behaviour change Goal setting Review goals, update, and change when necessary
<b>Feedback and Monitoring</b>	Understand the difference between current action and future goals Self-monitor behaviour Share behaviours with others and/or allow for social comparison User feedback (in person or automatically) Export data Material or social reward or incentive
<b>Actions</b>	General encouragement Reminders and/or prompts or cues for activity Encourage positive habit formation Practice or rehearsal, in addition to daily activities Opportunity to plan for barriers Restructuring the physical or social environment Distraction or avoidance

Second, we analyze the reviews of users in the app store who have downloaded the 70 sustainability apps by applying natural language processing (NLP) methods to identify pertinent topics. The app store reviews are a rich source of valuable insights from users and are commonly used to extract important information such as user experience, satisfaction, and general feedback using NLP methods [3].

The main aim of this paper is to determine if we can use the ABACUS scale to review sustainability apps to identify their behaviour change potential. We also aim to ascertain the important topics in the app store reviews of sustainability apps to infer users' perceptions of such apps. To the best of our knowledge, no one has carried out similar research on sustainability apps. This research is still work in progress as we have only analyzed the data from the Google Play Store which we present in this paper. We are still collecting data from Apple's App Store which we will analyze in the future.

## 2 BACKGROUND INFORMATION

The App Behavior Change Scale (ABACUS) is a reliable knowledge-based tool developed by McKay et al. [5]. It can be used to identify the behaviour change potential of apps. The 21-item scale includes items in four categories: knowledge and information (five items), goals and planning (three items), feedback and monitoring (seven items), and actions (six items) with examples for each of the 21 questions. These items measure the existence of specific persuasive strategies in an app. Persuasive strategies are nudges that when applied at the right time can lead to a change in attitude or behaviour [8]. According to the authors of the ABACUS scale, apps that have a high chance of behaviour change will implement several of the

persuasive strategies on the scale [5]. The more strategies an app implements from the scale, the higher the likelihood of the app resulting in behaviour change [5]. The scale creates a quick and standard way of reviewing apps across a range of behaviour change categories. The 21 items of the ABACUS scale are shown in table 1. Although the scale was originally developed for behaviour change in the health domain, due to its comprehensive nature and the lack of other scales to measure the potential for behaviour change, it has been adapted and used in other domains such as social media [9] and childcare [10]. Due to the scale's popularity and the unavailability of other behaviour change scales, we adopted this scale in our study of sustainability apps.

## 3 STUDY DESIGN

We approached this research work in two main phases. First, we reviewed apps using the ABACUS scale to determine their potential to change behaviour. Second, we analyzed the reviews of users of the apps in the app store using NLP techniques to determine the main topics of discussion of users.

### 3.1 Inclusion and Exclusion Criteria

We chose the Google Play store (the Android app store) as our primary data source because of the popularity and low cost of Android devices. Android systems are more common than iOS because Android is the operating system used by a wide range of manufacturers of mobile devices, Android devices are affordable and are available at a wide range of prices, Android is compatible with many more mobile devices compared to iOS, and Android developers do not need to have a paid account to release an Android app compared to iOS developers who have to have a paid account

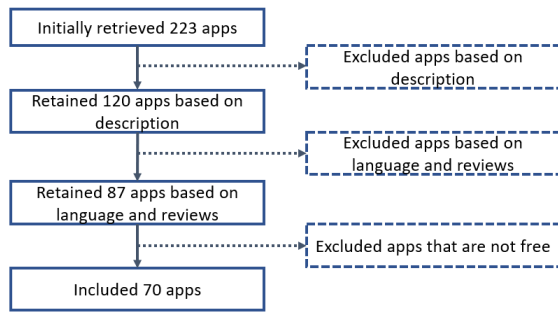


Figure 1: The selection process

[4]. We searched for apps using the search terms “sustainability”, “sustainable activities”, “recycling”, and “climate change”. A total of 223 apps were included in our result set. We read the description of the apps in the app store and excluded those that were not related to environmental sustainability. At this point, we had a total of 120 apps. We also excluded apps that were not in the English language and those that did not have any reviews. Reviews are important as we were also interested in the topics and themes of discussion and these were determined from the reviews. After this exclusion criteria, 87 apps were left. Furthermore, we excluded apps that were not free to use. We excluded apps that are not free because the free apps are more accessible to users compared to the paid ones since there is no cost associated with them. A total of 70 apps met our inclusion and exclusion criteria and were used in this study. Figure 1 summarizes the inclusion and exclusion criteria.

Since the Google Play store does not have a public Application Programming Interface (API) for automatically retrieving the reviews of users, we used a web service called Heedzy<sup>4</sup> to do so. Heedzy curates reviews of iOS and Android apps and is commonly used by researchers [3].

### 3.2 Behaviour Change Potential

The process of evaluating apps against the items on the ABACUS scale was done by the authors. We adopted the approach of Alslaity et al. [4] in evaluating the apps to determine their behaviour change potential. This is because Alslaity et al. used the ABACUS scale to measure the potential of behaviour change and they also evaluated several apps on the app store. We assessed the behaviour change potential of the 70 apps using the ABACUS tool on a binary scale of exists (1) or does not exist (0). For each of the 21 items in the ABACUS scale as shown in Table 1, we assigned 1 if the item exists in the app and 0 if it did not exist at all. To ensure that apps were evaluated well, each app was downloaded and used by both authors for at least 10 minutes to test all the features of the app before reviewing. This was in line with the developers of the ABACUS scale [5] and with the approach of Alslaity et al. [4]. We then reviewed the apps using the well-established ABACUS scale [5] to investigate the behaviour change potential of the apps. When there were differences in the reviews, both reviewers discussed how they scored the item and came to a unanimous decision over the final score. There were no items where the reviewers could

<sup>4</sup><https://heedzy.com/>

not reach a unanimous agreement. Similar to the work of [4] and [11], we computed a *Behaviour Change Score* ( $BCS$ ). This score was computed for strategies and apps. For *strategies*, the score was computed for all the items on the ABACUS scale; that is for each item  $X$  on the scale, the  $BCS_{str}$  is the sum of the scores (ones and zeroes) given to  $X$  in all the apps by the reviewers. For each app  $Y$ , the  $BCS_{app}$  was computed as the sum of scores for all 21 items of the ABACUS scale in app  $Y$ .

### 3.3 Topic Modelling

To identify the main topics of discussion of users from their reviews, we carried out topic modelling using NLP techniques. We used the Latent Dirichlet Allocation (LDA) modelling technique, a generative probabilistic model for collections of discrete data [12]. We chose this model because of its high accuracy in text classification [12] and its popularity in analyzing user reviews [13]. We also considered the current small size of the datasets and estimated future datasets from the iOS reviews, and concluded that running such modelling will generate a relatively small amount of heat with less environmental impact compared to other resource-intensive techniques. We extracted the reviews from the Play Store using the Heedzy tool. A total of 111,692 reviews were extracted. We then preprocessed the data to clean and prepare it for modelling. The preprocessing tasks carried out in Python include removing non-English reviews, removing stop words and punctuations, removing numeric characters and non-alphabetic characters, removing short sentences that had 3 words or less and finally stemming the words to reduce them to their word stem. We then applied the gensim pre-trained LDA model (`gensim.models.ldamodel`) to the processed data. We varied the number of topics between four and ten. We visualized our results using the `pyLDAvis` function of the gensim package.

## 4 RESULTS

In this section, we present the results of our analysis, particularly the results of the behaviour change score for both strategies and apps as well as the results of our topic modelling model.

### 4.1 Categories of Applications

We categorized the 70 apps according to the United Nations SDGs1. The apps we analyzed fell into one or more of six goal categories: *clean water and sanitation*, *climate action*, *life below water*, *life on land*, *responsible consumption and production*, and *sustainable cities and communities*. Of the 70 apps, 40% of them fell into Goal 12 - *responsible consumption and production* while about 23% were in Goal 11 - *sustainable cities and communities*. Goal 14 - *Life below water* was the least popular category as one app was in that category. This shows that most apps were developed to promote responsible consumption and production such as recycling. Figure 2 summarises the categories of apps into their respective SDGs.

### 4.2 Behaviour Change Score of Strategies - $BCS_{str}$

As stated earlier, we computed  $BCS_{str}$  by summing all the scores (ones and zeroes) for each item of the ABACUS scale for all 70 apps. The strategy *self-monitor* behaviour had the highest  $BCS_{str}$  score

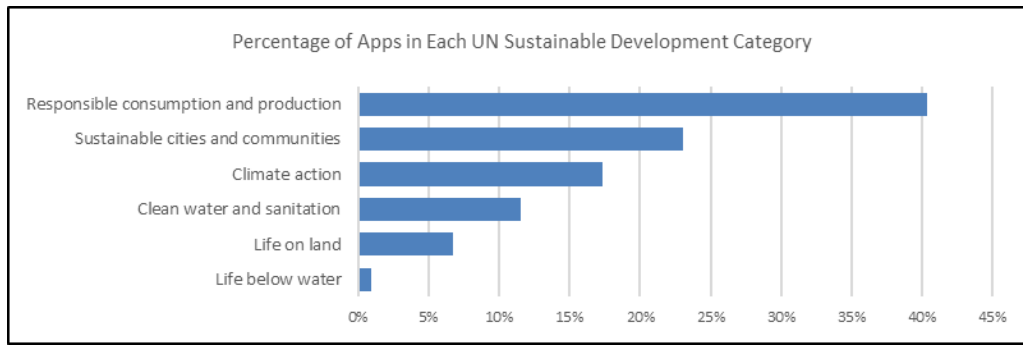


Figure 2: Percentage of apps in the United Nations SDGs categories

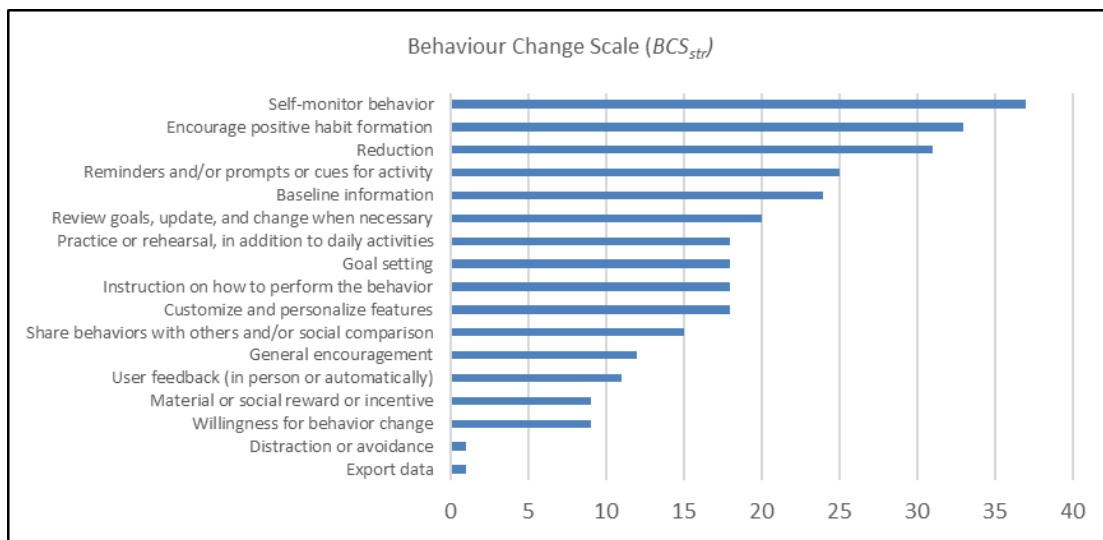


Figure 3: Result of Behaviour Change Scale (BCS<sub>str</sub>)

of 37. This means that self-monitoring was the most common persuasive strategy that was implemented in most of the 70 apps. This result is in line with research in the area of persuasive strategies for sustainable behaviour change. For example, Adaji and Adisa [14] recently carried out a systematic review of articles on persuasive technologies to influence sustainable behaviour. Their results suggest that self-monitoring was the second most popular strategy implemented in the articles they reviewed. Other researchers have also identified the popularity of self-monitoring in app development in other domains such as health [15]. The average  $BCS_{str}$  of all 70 apps was 6.25. Figure 3 shows the  $BCS_{str}$  of all 21 strategies on the ABACUS scale.

### 4.3 Behaviour Change Score of Apps – $BCS_{app}$

We computed  $BCS_{app}$  for each app as the sum of the scores (ones and zeroes) of all 21 items on the ABACUS scale. Figure 4 shows the apps with the highest  $BCS_{app}$  of the apps that we reviewed. The app with the highest score *Ailuna*, falls within two UN sustainable goals: *clean water and sanitation* and *climate action*. The app implements 16 of the 21 strategies on the ABACUS scale. For example, it allows

users to customize and personalize features. Users are provided with instructions on how to perform the target behaviour in the form of a demo of some of the app’s features. However, the app does not allow users to export their data which is one of the items on the ABACUS scale.

Figure 5 shows a histogram of the distribution of the  $BCS_{app}$  for the 70 apps. Most apps implemented between one and seven persuasive strategies. This is in line with existing research in behaviour change apps for sustainability where researchers found that apps typically implement between one and six persuasive strategies [14]. The result in Figure 5 also shows a right skewness which indicates that only a few apps implement more than ten persuasive strategies. This finding was similar to that of Alslaity et al. [4] who investigated the use of persuasive strategies in mobile apps for health and wellness. The authors concluded that only a few apps implemented many strategies and most apps implemented few strategies.

### 4.4 Result of Topic Modelling

The result of the topic modelling revealed four distinct topics. These are summarized in Table 2. The first topic, topic #1 indicates that

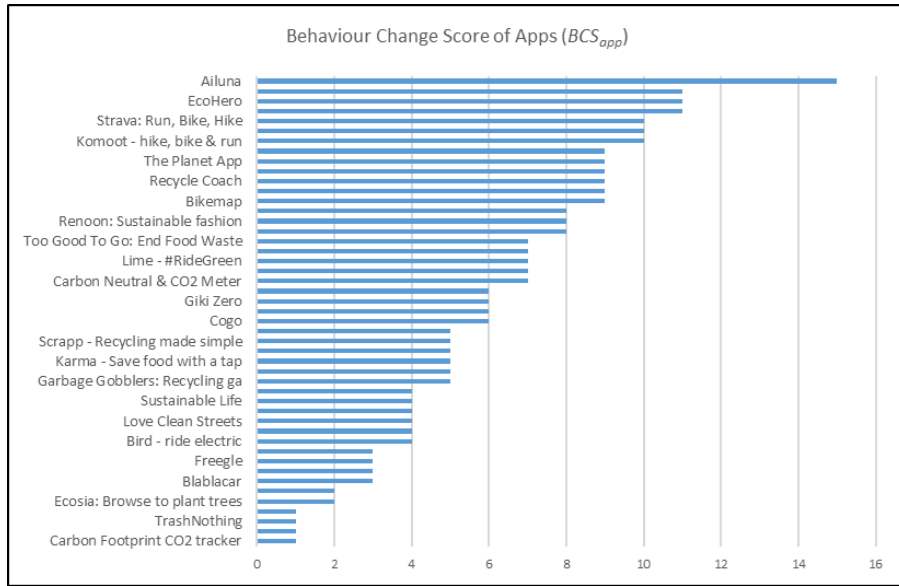


Figure 4: Result of Behaviour Change Scale (BCS<sub>app</sub>)

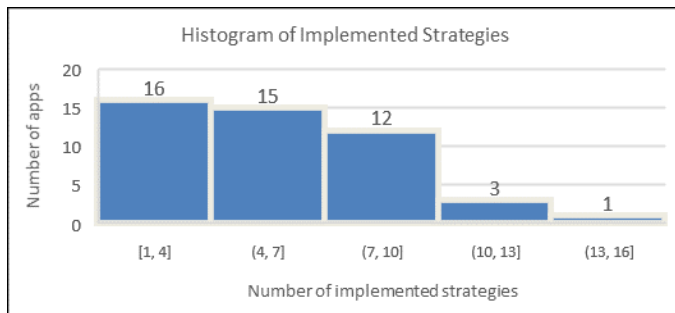


Figure 5: Histogram of implemented strategies. Apps that did not implement any strategy were excluded

several reviewers love recycling apps and see them as helpful and brilliant. The topic that was formed with most of the tokens is topic #3 which speaks on the monetary aspects of the apps. This topic is reasonable because while we excluded the apps that were not free from the list of reviewed apps, some apps have in-app purchase options for additional features such as fewer ads. Topic #4 was an interesting topic as it supports topic #1 in the sense that it describes sustainability apps as being a great concept and idea with users having a great experience.

The topic modelling results suggest that users have a pleasant experience using sustainability apps. In the future, we plan to carry out a more detailed analysis, such as app metrics (to determine adoption and popularity), and emotion detection and sentiment analysis (to determine conclusively if the users’ thoughts towards the apps are positive or negative).

#### 4.5 Discussion

This study is an ongoing late-breaking result and it provides valuable insights on the current persuasive strategies implemented in the environmental sustainability apps and how it has influenced users’ behavioural changes. The first stage of the analysis of app descriptions and user reviews reveals that more efforts have been put into sustainable behavioural change apps through the lens of SDG Goals 12, 11, and 13 with other goals receiving less attention from apps developers. Furthermore, the emerging themes and patterns show that developers favoured the implementation of multiple strategies to guarantee broader adoption among targeted users. In addition, the findings show potential areas for improvement and implications for app developers to reconsider their design strategies in designing more interactive and personalised features to empower app users to not just download the app but take concrete actions towards sustainable living. Positive reviews lend credence to the

Table 2: Result of topic modelling

Topic	Words that represent topics	Percentage of tokens that form topic
topic #1	”love”, ”helpful”, ”brilliant”, ”fantastic”, ”recycling”	7.8%
topic #2	”support”, ”review”, ”cancel”, ”information”, ”coach”	18.2%
topic #3	”waste”, ”service”, ”money”, ”save”, ”account”, ”sold”	43.2%
topic #4	”easy”, ”idea”, ”great”, ”experience”, ”concept”	22%

ability of the apps to raise sustainability awareness and provide relevant information, while negative reviews often cite usability issues, lack of engaging content, or insufficient personalised options.

As an ongoing research, the current scope was limited to the analysis of app descriptions and user reviews: However, the findings can be utilised by sustainability app developers to create more effective and engaging mobile tools that facilitate broader adoption of sustainable behaviours. Future research could complement these findings and bring more insights by exploring the app metrics and the actual impact of the apps on sustainable behavioural change and user engagement.

## 5 CONCLUSION

To determine the behaviour change capability of smartphone apps, we used the ABACUS scale to review 70 apps on the Google Play Store. Our results indicate that most apps implemented between one to seven strategies, thus have a good potential for influencing behaviour change. To determine the perception of users towards the apps, we carried out topic modelling using the reviews of the 70 apps. Our results indicate that the distinct topics indicate a pleasant experience with using sustainability apps. In the future, we plan to compute the BCS for each category of the ABACUS scale to determine if there is a specific category that is implemented more than others. In addition, we plan to repeat this study for apps in the Apple App Store to ascertain if the BCS scores for strategies and apps are similar on both the Google Play Store and Apple App Store.

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