Middlesex University London

Middlesex University Research Repository

An open access repository of

Middlesex University research

http://eprints.mdx.ac.uk

Bekaroo, Girish ORCID logoORCID: https://orcid.org/0000-0003-1753-4300, Roopowa, Divesh and Bokhoree, Chandradeo (2019) Mobile-based Carbon footprint calculation: insights from a usability study. Proceedings 2019 Conference on Next Generation Computing Applications (NextComp). In: 2019 International Conference on Next Generation Computing Applications (NextComp), 19-21 Sep 2019, Mauritius. e-ISBN 9781728114606. [Conference or Workshop Item] (doi:10.1109/NEXTCOMP.2019.8883622)

Final accepted version (with author's formatting)

This version is available at: https://eprints.mdx.ac.uk/29738/

Copyright:

Middlesex University Research Repository makes the University's research available electronically.

Copyright and moral rights to this work are retained by the author and/or other copyright owners unless otherwise stated. The work is supplied on the understanding that any use for commercial gain is strictly forbidden. A copy may be downloaded for personal, non-commercial, research or study without prior permission and without charge.

Works, including theses and research projects, may not be reproduced in any format or medium, or extensive quotations taken from them, or their content changed in any way, without first obtaining permission in writing from the copyright holder(s). They may not be sold or exploited commercially in any format or medium without the prior written permission of the copyright holder(s).

Full bibliographic details must be given when referring to, or quoting from full items including the author's name, the title of the work, publication details where relevant (place, publisher, date), pagination, and for theses or dissertations the awarding institution, the degree type awarded, and the date of the award.

If you believe that any material held in the repository infringes copyright law, please contact the Repository Team at Middlesex University via the following email address:

eprints@mdx.ac.uk

The item will be removed from the repository while any claim is being investigated.

See also repository copyright: re-use policy: http://eprints.mdx.ac.uk/policies.html#copy

Mobile-Based Carbon Footprint Calculation: Insights from a Usability Study

Girish Bekaroo
School of Science and Technology
Middlesex University Mauritius
Uniciti, Flic-en-Flac, Mauritius
g.bekaroo@mdx.ac.mu

Divesh Roopowa
School of Science and Technology
Middlesex University Mauritius
Uniciti, Flic-en-Flac, Mauritius
d.roopowa@mdx.ac.mu

Chandradeo Bokhoree
School of Sustainable Development & Tourism
University of Technology Mauritius
La Tour Koenig, Pointe aux Sables
sbokhoree@umail.utm.ac.mu

***Abstract*— Human activities have been referred as key contributors to climate change since most of the warming of the climate is the result of increased anthropogenic emission of greenhouse gases from such activities. Through their daily activities, human beings contribute to the emissions of greenhouse gases that principally consist of CO_2. For individuals to effectively reduce CO_2 emissions from their personal activities and to improve their behaviour towards the environment, it is essential to quantify such emissions. Recently, there has been the emergence of carbon footprint calculators that provide an estimate of the carbon dioxide emissions that an individual is directly responsible for over a given period of time. During the past few years, there has been a decreasing trend of such tools among Internet users and a recognised way to promote adoption of systems is through improved usability. This paper investigates the usability of a proposed carbon footprint calculator called Mau Carbon Footprint and provides recommendations on improving this quality attribute of such tools. In order to achieve the purpose of this paper, a usability study was conducted based on Nielsen's usability principles. As results, an overall mean score of 3.98 was obtained for the usability of the proposed calculator.**

Keywords—Mau Carbon Footprint, Personal Carbon Emissions, Carbon Calculator, Usability, Nielsen's Principles.

I. INTRODUCTION

During the previous decade, climate change has been recognized as one of the major concerns being faced around the world [1]. It is primarily caused by global warming, where various phenomena have indicated the warming of the climate system, including the increase in global average air and ocean temperatures, melting of snow and icebergs, among others [1]. The warming of the climate system in turn is a consequence of an increase in greenhouse gases (GHGs) in the atmosphere, which is also regarded as the consequence of augmented destructive human activities [2]. Through their daily activities, human beings contribute to the emissions of such gases, principally consisting of CO_2 [3]. For example, when travelling to work, an employee emits CO_2 when the petrol within the vehicle is used. Due to their adverse impacts, it is essential to quantify such emissions so that appropriate measures could be taken for individuals to improve their behaviour [4].

One popular quantitative expression of CO_2 emissions from an activity is 'carbon footprint' and is helpful in carbon emissions management as well as assessment of mitigation measures [5]. However, manually determining the carbon footprint of an individual involves formula-based calculation and has been found to be complex due to the involved parameters in the calculation process [6]. As a solution to this problem, online and mobile carbon footprint calculators have emerged [7]. These tools are developed by government agencies, non-governmental organizations, as well as private companies, and do not only help human beings to measure their carbon emissions, but also help to track and provide advices on mitigation practices [8].

However, even though carbon footprint calculators are regarded as essential tools towards reducing carbon emissions of individuals, decreasing popularity and trend [1] among Internet users has been recorded during the past few years. As such, there is a need to improve popularity of such tools and for this, promoting adoption amongst end-users is becoming essential. A recognised way to promote adoption of systems is through improved usability [9]. According to Nielsen [10], usability is a quality attribute that assesses how easy and pleasant it is to utilize features of a system. In relation to carbon footprint calculators, previous studies focused on investigating methodologies for estimating carbon footprint of individuals rather than delving into usability and adoption of such tools. Taking cognizance of this limitation, this paper investigates the usability of a proposed carbon footprint calculator and provides recommendations on improving this quality attribute of such tools. The findings revealed in this paper are intended to help policy makers, researchers and designers of carbon calculators better understand the usability of such tools towards improving their design and for promoting their adoption.

This paper is structured in the following successive manner: In the next section, related works are reviewed. Then, the design and implementation of a proposed mobile-based carbon calculator is described in section III. The evaluation method used to assess the usability of the proposed calculator is discussed in section IV before presenting the results from the experiment conducted in section V. Recommendations on improving the usability of such tools are given in section VI before concluding the research in section VII.

II. RELATED WORKS

By providing a quantitative representation of carbon emissions released in the atmosphere due to a particular activity, carbon footprint calculation has been regarded as an essential tool to help individuals assess carbon reduction measures and reduce their personal impacts on climate change [11]. Due to the importance of such tool, various studies have been conducted involving such tools recently [8]. However, the focus of published research has been on investigating methodologies for estimating carbon footprint. Previous studies critically reviewed different prevailing carbon footprinting methods and issues associated with them in order to help selection or even improvement of existing methodologies [11, 4]. Another study developed a carbon footprint calculator to assess the carbon footprint of typical households within the US Virgin Islands based on the

[1] Google Trends on Carbon Calculators:
https://trends.google.com/trends/explore?date=all&q=carbon%20calculator

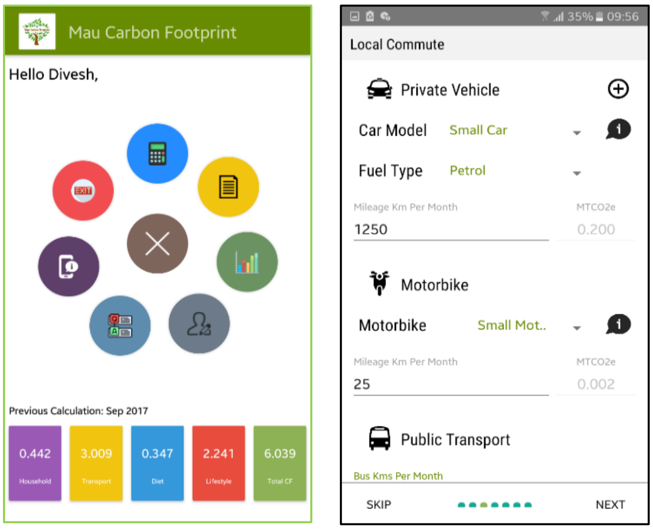
consumption-based life-cycle accounting techniques [12]. Similarly, the Yo!Green Carbon Calculator was proposed for individuals and households to estimate and obtain simple mitigation measures on their carbon emissions within India [13]. Furthermore, through the use of REAP Petite carbon calculator, impacts of communicating consumption at household level was investigated in addition to mitigation options [14]. In the domain of behavioural analysis, a recent study measured continuance intention to use online carbon footprint calculator through integrating the Expectation-Confirmation Model (ECM) and Theory of Planned Behaviour (TPB) models. As such, none of these works reviewed investigated the usability of carbon calculators thus confirming the significance of the gap addressed in this study.

III. Mau Carbon Footprint: A Mobile Based Carbon Footprint Calculator

As a Small Island Developing State (SIDS), Mauritius is among the countries that are most vulnerable to the adverse effects of climate change [15]. Several environmental indicators have recently revealed the detrimental changes brought by climate invariability to the island, such as increase in sea level, average temperature and extreme weather events such as flash floods [16]. Hence, it is essential to investigate climate change and global warming towards providing sustainable solutions for such islands including Mauritius [17]. While many countries have already created a personal carbon footprint calculator that could be used by its inhabitants, Mauritius is yet to develop and establish its own calculator even though this island is among the most vulnerable ones to climate change as highlighted earlier. Existing calculators are not fully suitable for the context of Mauritius because many fields are present within existing calculators that are not applicable to this island where key examples include travel by train and tram, heating oil, coal, among others [18].

In order to address this limitation, a carbon calculator called '*Mau Carbon Footprint*' was implemented for the context of Mauritius and the usability of this tool is investigated in this paper. Mau Carbon Footprint is a mobile-based carbon footprint calculator that has been developed to enable Mauritian citizens to improve their understanding on personal emissions and climate change through estimating and managing their carbon footprint. The tool also advises on best practices to help users reduce their personal carbon emissions. Within the tool, personal carbon emissions are categorised into household energy use, transport, diet and lifestyle due to popularity of such taxonomy [3, 4, 19]. Also, for calculating carbon emissions of individuals, relevant emission factors had to be determined for the context of Mauritius. An emission factor is a representative value that attempts to relate the quantity of air pollutants which is released into the atmosphere from a process to a specific activity associated with generating those emissions [20]. After conducting extensive research through research databases and within local regulatory organisations, it could be found that there is a lack of country-specific carbon emission factors for many inputs and processes specific to Mauritius. Owing to the lack of data, emission factors from external databases such as from the Department of Food and Rural Affair (DEFRA) and Environmental Protection Agency (EPA) were used to complement the missing values with global average values [21]. Then, calculation methodologies [22] to be used for estimating personal carbon footprint based on the adopted taxonomy were determined for implementation within Mau Carbon Footprint. Also, the principles for determining personal carbon footprints from a previous study [8] were applied when designing the proposed tool.

For the implementation of Mau Carbon Footprint, Android based devices were targeted since this operating system is the most popular one in the world [23]. The mobile-based calculator also makes use of a database that stores user and calculation related data. In terms of key features of Mau Carbon Footprint, end-users need to create their profile when the application is utilized for the first time and once logged-in, the home screen is displayed to the end user where any details on previous calculation are displayed (as in the first image in Fig. 1. Through the interactive menu, end users can navigate and calculate their personal carbon footprint for a particular period of time (annually, monthly or even for a given time period) for the earlier mentioned taxonomy. A screenshot of part of the calculation screen is given in the second image in Fig. 1 which illustrates some of the parameters needed towards determining carbon emissions from personal transportation related activities. Following input of the parameters for the four categories of the taxonomy, a break-down of the carbon emissions of the end-user is given via interactive charts, as shown in the third screenshot in Fig. 1. Within the same interface, the user can select the "Reduce Carbon Footprint" button to obtain advices on how to minimise carbon emissions based on the values computed by the application. In addition, Mau Carbon Footprint enables end users to track and obtain historical details on their monthly or annual personal carbon emissions (as in the fourth image in Fig. 1). Along with these features, users can also forecast their future emissions and can access a quiz that enables assessment of their knowledge in the area of personal carbon emissions estimation and minimization. Following implementation, Mau Carbon Footprint was thoroughly tested and published[2] on Google Play.



[2] Mau Carbon Footprint, Available at: https://play.google.com/store/apps/details?id=com.project.mau_carbon_footprint

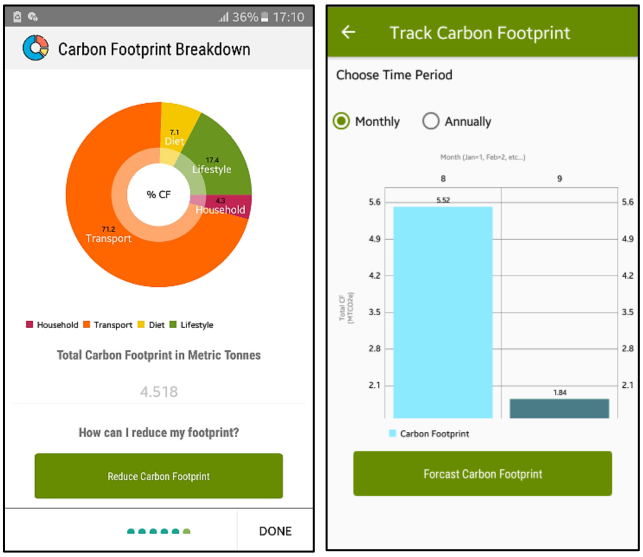


Fig. 1. Key Screenshots of Mau Carbon Footprint

IV. Evaluation Method

In order to evaluate the usability of the implemented mobile-based carbon footprint calculator, Nielsen's principles were considered due to its popularity for assessing usability of systems [24]. According to Nielsen, usability has been referred as a quality attribute that evaluates how easy user interfaces or systems are to use and it consists of five essential attributes [10]:

- *Learnability*: This quality attribute relates to the level to which end-users feel that it is effort-free to utilize a system.
- *Efficiency:* This is about how quickly end-users can perform tasks once having learnt about the design of the system.
- *Memorability*: Relates to how easy it is to remember a system such that when a user is using the system again after some time, he/she does not have to learn everything about how to use it again.
- *Errors*: A reduced number of errors should be present in a system and that end users should make few errors while using it. Also, in case of any errors encountered, it should be easy to recover from.
- *Satisfaction*: This attribute relates to how pleasant it is to utilize the design. In other words, satisfaction is about freedom from discomfort and positive attitudes towards using a system.

Each usability attribute could be assessed by different measured items as listed in Table I. These measured items have been adapted from previous studies that applied Nielsen's principles for evaluating usability of systems [25, 26]. Using the evaluation criteria given in Table I, a questionnaire was designed as data collection instrument in order to collect usability related data on Mau Carbon Footprint. Each of the measured items was assessed through the Likert-5 scale, where 1 meant strongly disagree and 5 represented strongly agree. The questionnaire consisted of two sections, notably for gathering data on usability and demographic details on participants.

TABLE I. USABILITY ATTRIBUTES AND MEASURED ITEMS

Attribute	Measured Item
Learnability	L1: It was easy to learn to use the mobile application for the first time. L2: I was able to learn to utilize the application quickly. L3: I could use the application without referring to the user manual. L4: Most users will be able to learn to use the application without any issues.
Efficiency	E1: The task could be completed quickly. E2: The task could be completed in an efficient manner. E3: I was able to use the application smoothly.
Memorability	M1: It was easy to memorise the key aspects of the application. M2: It was easy to re-access and re-establish use of the application after some time.
Errors	R1: No errors were encountered when using the application. R2: The application could still be used even after encountering small errors. R3: Recovering from any errors was easy. R4: No critical error was encountered which stopped me from completing the task.
Satisfaction	S1: I am satisfied with the ease of learning to use the system. S2: I am satisfied with the ease of use of the application. S3: I am satisfied with the amount of time it took to complete the task given. S4: I am satisfied with the design and overall look of the system. S5: Overall, I am satisfied with the system.

After preparing the data collection instrument, an experimental study was conducted involving 32 participants from Middlesex University Mauritius, while also meeting the minimum participant requirements for such study [24]. The participants were undergraduate students aged between 19 and 25 who were studying Information Technology related courses. Students were selected as target audience since fostering pro-environmental behaviour of such group is essential due to their future impact on the environment as leaders of tomorrow [27]. Participants were recruited within classes after lectures and with every participant, an introduction to the purpose of the study was given individually before seeking informed consent to participate in the research. Also, only participants owning an Android-based phone was recruited due to compatibility reasons with Mau Carbon Footprint. After providing consent, the application was installed on the mobile phone of the participant and a list of tasks was given. The participant was then given a week for completing the tasks that related to using the key features of the application and to calculate their personal carbon footprint for the previous month. After a week, a debriefing session was conducted with each participant to gather feedback on the use of the application, while also checking whether the given tasks were completed. During the session, the participant also had to fill-in the usability questionnaire while responding to all the measured items for each quality attribute discussed earlier. The filled-in questionnaire was then collected for input and analysed using SPSS. As key challenges of the experiment, compatibility issues were faced with two devices which were using an old version of Android. These users had to be excluded from the evaluation.

V. Results and Discussions

From the 32 participants who were involved in this study, 20 were male and 12 were female, representing 62.5% and 37.5% respectively. In addition, none of the participants previously utilized a carbon footprint calculator. Results on the different usability attributes are discussed as follows:

A. *Learnability*

According to the participants of the study, the most positive aspect pertaining to learnability was that most participants were able to utilize the application without referring to the embedded user manual. Because of this, the participants also perceived that most users will be able to learn to use the application without any issues. On the other hand, the lowest mean score was received for L2 where 10 participants were neutral about being able to learn to utilize the application quickly. This was because of different reasons where first of all, 3 users highlighted that the images used on the menu had to be interpreted and that some caption could help to improve understanding of the icons. In addition, 2 participants found it challenging to obtain information about how to minimise carbon emissions. This feature is available only after a user computes his/her carbon emissions and a separate menu item could be made available such that the user can access such information whenever required. Overall, a mean score of 4.19 was obtained for the learnability of Mau Carbon Footprint where the end-users agreed that it is effort-free to utilize a system. The mean score for the different measured items are given in Table II.

TABLE II. LEARNABILITY ASSESSMENT

Measured Item	**Mean Score**
L1: It was easy to learn to use the mobile application for the first time.	4.25
L2: I was able to learn to utilize the app. quickly.	3.91
L3: I could use the application without referring to the user manual.	4.41
L4: Most users will be able to learn to use the application without any issues.	4.19

B. *Efficiency*

The overall efficiency of Mau Carbon Footprint obtained a lower mean score of 3.51 as compared to learnability and this was particularly due to E1, as given in Table III. The task that took the longest amount to complete was the personal carbon footprint calculation. Within this task, end-users had to make reference to respective bills (e.g. electricity) and provide estimations about different aspects (e.g. distance covered by car or by bus, dietary consumptions, money spent on clothing, etc.), which is time consuming according to most participants. However, a better score was obtained for E2 and this was because even though some tasks are time consuming to complete, end users could save their progress and get back whenever the needed details are obtained, rather than having to restart the calculation process. Among the 3 aspects studied, the highest score was obtained for E3 where most participants claimed to be able to utilize the application smoothly.

TABLE III. EFFICIENCY EVALUATION

Measured Item	**Mean Score**
E1: The tasks could be completed quickly.	2.50
E2: The tasks could be completed in an efficient manner.	3.75
E3: I was able to use the application smoothly.	4.28

C. *Memorability*

For this attribute, an average score of 4.01 was received following experimentation and this shows that it was overall easy for end-users to remember the system. Among the measured items, most participants agreed that it was easy to re-access and re-establish use of the application after some time (M2). This could also be influenced by the fact that only a week was given to the participants, which could be considered as a short duration to forget an application according to two participants. Similar to M2, a positive score was obtained for M1 where most users agreed that it was easy to memorise the key aspects of the application. Among the key aspects of the application, end-users found it challenging to memorise the various inputs needed during the calculation process. This is worsened during the calculation of a longer period (e.g. annual carbon footprint) where the end user has to provide values for bills for the 12 months along with expenses for the same period. The results for the measured items considered for memorability assessment of Mau Carbon Footprint is given in Table IV.

TABLE IV. MEMORABILITY ASSESSMENT

Measured Item	**Mean Score**
M1: It was easy to memorise the key aspects of the application.	3.81
M2: It was easy to re-access and re-establish use of the application after some time.	4.22

D. *Errors*

A positive overall result was obtained for this usability attribute and this was principally due to the thorough testing phase that the application went through before evaluation involving the end-users. Most participants agreed or strongly agreed that no errors were encountered when using the application. Due to no reported critical errors (R4) or small errors, participants were neutral about the item related to recovery from errors (R3). In terms of errors, two Android devices were found to be incompatible with the proposed application and these users were excluded from the experiment as discussed earlier. Overall, a mean score of 4.05 was obtained for this quality attribute and results are given in Table V.

TABLE V - ERROR ASSESSMENT

Measured Item	**Mean Score**
R1: No errors were encountered when using the application.	4.59
R2: The application could still be used even after encountering small errors.	3.41
R3: Recovering from any errors was easy.	3.19
R4: No critical error was encountered which stopped me from completing the task.	5.00

E. *Satisfaction*

For this usability attribute as well, a mean score exceeding 3 was obtained for all the measured items as shown in Table VI. Amongst, the highest score received was for the overall satisfaction of using the system (S5). According to the participants, this was mainly because many participants commended the utility of such a tool to engage citizens in Mauritius towards reducing their carbon emissions given the fact that the island is highly vulnerable to the impacts of climate change. 3 users were also neutral to S5 and this was because the users felt that the application was built for the context of Mauritius and that the local language was not integrated. These participants suggested that integrating other languages including Creole and French could better help to target more users within the island. Similar to S5, a score above 4 was obtained for S1, S2 and S4 respectively. However, for S3, a lower mean score of 3.5 was obtained and this was mainly due to the amount of time needed to calculate the carbon footprint of an individual, as discussed for E1. Most participants were neutral for this criterion and felt that some automated mechanisms could have been integrated with the solution in order to simplify the calculation process. For instance, interfaces could have been provided such that whenever an individual makes some expenses or obtains bills, information could be directly input and then the carbon footprint automatically determined on a monthly or annual basis. Overall, applicants found Mau Carbon Footprint pleasant for use where a mean score of 4.12 was obtained.

TABLE VI. SATISFACTION EVALUATION

Measured Item	Mean Score
S1: I am satisfied with the ease of learning to use the system.	4.29
S2: I am satisfied with the ease of use of the application.	4.13
S3: I am satisfied with the amount of time it took to complete the task given.	3.53
S4: I am satisfied with the design and overall look of the system.	4.31
S5: Overall, I am satisfied with the system.	4.41

F. Discussions

Among the 5 usability quality attributes investigated, the mean score for 4 of them exceeded 4, thus showing an overall positive result for the usability of the proposed application. Amongst, learnability and satisfaction obtained the highest mean scores since most of the participants were able to learn how to use the application easily and were satisfied with the application. On the other hand, the least score was received for efficiency and this was particularly due to the various parameters that are needed as input for the carbon footprint calculation. Overall, a mean score of 3.98 was obtained for the usability of the proposed tool and the chart comparing the different quality attributes is given in Fig. 2.

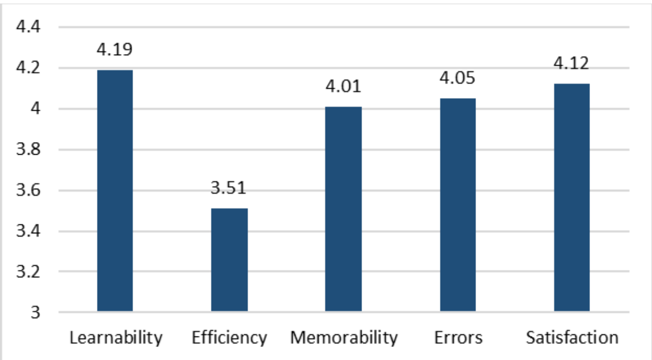


Fig. 2. Comparison of Usability Attributes

Even though an overall positive score was obtained for the usability of Mau Carbon Footprint calculator, the study was undermined by a few limitations. Firstly, the participants selected for the experimental study were all undergraduate students in IT related courses, who may not encounter much difficulty in using mobile applications. As such, users from other areas of study and having different demographics details could have been considered to eventually compare usability results. In addition, different usability assessment frameworks could have been considered for evaluation of this tool to eventually compare results.

VI. RECOMMENDATIONS

During the usability evaluation of Mau Carbon Footprint, different limitations were identified on such mobile based carbon footprint calculator. Recommendations based on identified limitations could provide insights to the research community and designers of such tools so as to improve design and adoption of personal carbon footprint calculators by end-users. These recommendations are:

- *Need for improved calculation process*

The calculation process was reported to be a lengthy process by a few participants due to the various bills that need to be referred to. In order to address this issue, a different approach to the calculation process could be investigated. For instance, rather than having the end user to gather all bills at once and perform the calculation, a different approach would be to propose an inventory based system where the user inputs the parameters as soon as bills are obtained. Then the carbon footprint could be automatically determined based on current inventory and given to the user as reports, notifications or display on the home screen. This approach could promote more frequent utilization of such tool.

- *Automation*

In addition to the lengthy calculation process highlighted earlier, some participants found it challenging to memorise the various inputs needed for the calculation process. These issues could be addressed by automating some of the calculation parameters. For example, algorithms involving the use of Global Positioning System (GPS) could help to detect changes in locations and automatically determine the distance covered to compute associated emissions. This could potentially make the calculation process more efficient.

- *Reduced estimation period*

Results showed that when calculating the carbon footprint for a longer period (e.g. annual carbon footprint), end users have to gather bills and details for the whole period thus reducing accuracy in case of such details are lost. This could be addressed through promoting monthly-based calculation. This would not only improve interaction and engagement with the tool but could also improve accuracy of calculated carbon footprint.

VII. CONCLUSIONS

Limited studies have been undertaken that explore the usability of carbon footprint calculators and this study attempts to complement literature by investigating the usability of a proposed carbon footprint calculator called Mau Carbon Footprint, which was developed for the context of Mauritius. As research framework, a usability study was conducted involving 32 participants who utilized the tool and were asked to rate it based on Nielsen's usability principles. In this process, five usability quality attributes were analysed, namely learnability, efficiency, memorability, errors and satisfaction, where each contained different measured items. Among these attributes, learnability and satisfaction were the highest rated ones whilst efficiency had the lowest rating. Overall, a mean score of 3.98 was obtained for the usability of Mau Carbon Footprint calculator. During this study, different limitations were also identified and recommendations have been made on how usability of such tool could be further improved.

As future works, large scale deployment of the Mau Carbon Footprint calculator is envisaged while also planning for feedback from the larger audience. This will also enable comparison of usability based on the demographic details of the participants. Moreover, the usability of Mau Carbon Footprint calculator could be compared against other calculators to reveal further insights to the research community. Furthermore, the recommendations proposed in this study will be further investigated towards implementing a different calculator with the proposed calculation process to eventually compare usability of calculation processes.

ACKNOWLEDGMENT

The authors wish to thank the Mauritius Research Council (MRC) for funding this research project as well as all participants who participated during the evaluation phase of the study.

REFERENCES

[1] IPCC, "IPCC Fifth Assessment Report," IPCC, 2014.

[2] P. C. Jain, "Greenhouse effect and climate change : scientific basis and overview," Renewable Energy, vol. 3, pp. 403-20, 1993.

[3] J. Padgett, A. Steinemann, J. Clarke and M. Vandenbergh, "A comparison of carbon calculators," Environmental impact assessment review, vol. 28, no. 2, pp. 106-115, 2008.

[4] T. Kenny and N. Gray, "Comparative performance of six carbon footprint models for use in Ireland," Environmental Impact Assessment Review, vol. 29, no. 1, pp. 1-6, 2009.

[5] Carbon Trust, "Carbon footprinting. An introduction for organizations," 2007. [Online]. Available: http://www.carbontrust.co.uk/publications/publicationdetail.htm?productid=CTV033. [Accessed 4 Apr 2015].

[6] D. Pandey, M. Agrawal and J. S. Pandey, "Carbon footprint: current methods of estimation," Environmental monitoring and assessment, vol. 178, no. 1-4, pp. 135-160, 2011.

[7] G. Bekaroo, W. Moedeen, C. Bokhoree and P. Ramsamy, "Personal Carbon Footprint Reduction: ICT as a Key Enabler," in Emerging Research Paradigms in Business and Social Science (ERPBSS), Dubai, 2015.

[8] A. Birnik, "An evidence-based assessment of online carbon calculators," International Journal of Greenhouse Gas Control, vol. 17, p. 280–293, 2013.

[9] E. Lacka and A. Chong, "Usability perspective on social media sites' adoption in the B2B context," Industrial Marketing Management, vol. 54, pp. 80-91, 2016.

[10] J. Nielsen, "Usability 101: Introduction to Usability," 2012. [Online]. Available: https://www.nngroup.com/articles/usability-101-introduction-to-usability/.

[11] D. Pandey, M. Agrawal and J. Pandey, "Carbon footprint: current methods of estimation," Environmental Monitoring and Assessment, vol. 178, no. 1-4, p. 135–160, 2011.

[12] R. Shirley, C. Jones and D. Kammen, "A household carbon footprint calculator for islands: Case study of the United States Virgin Islands," Ecological Economics, vol. 80, pp. 8-14, 2012.

[13] D. Nahar and P. Verma, "Shaping public behavior and green consciousness in India through the 'Yo! Green'Carbon Footprint Calculator," Carbon Management, vol. 9, no. 2, pp. 127-144, 2018.

[14] S. West, A. Owen, K. Axelsson and C. West, "Evaluating the use of a carbon footprint calculator: communicating impacts of consumption at household level and exploring mitigation options," Journal of Industrial Ecology, vol. 20, no. 3, pp. 396-409, 2016.

[15] Mauritius Meteorological Services, "Climate Change," 2016. [Online]. Available: http://metservice.intnet.mu/climate-services/climate-change.php. [Accessed 11 October 2016].

[16] Ministry of Environment and Sustainable Development, "Climate Change," 2014. [Online]. Available: http://environment.gov.mu/English/Climate_Change/Pages/Climate-Change.aspx. [Accessed 1 June 2014].

[17] I. Kelman and J. West, "Climate change and small island developing states: a critical review," Ecological and Environmental Anthropology, vol. 5, no. 1, pp. 1-16, 2009.

[18] G. Bekaroo, C. Bokhoree, P. Ramsamy and W. Moedeen, "Development of a Carbon management framework for the tertiary education sector in Mauritius: carbon footprint measurement and employee sensitization," Mauritius Research Council, 2018.

[19] G. Bekaroo, C. Bokhoree, P. Ramsamy and W. Moedeen, "Investigating personal carbon emissions of employees of higher education institutions: Insights from Mauritius," Journal of Cleaner Production, vol. 209, pp. 581-594, 2019.

[20] EPA, "Basic Information of Air Emissions Factors and Quantificatio," 2016. [Online]. Available: https://www.epa.gov/air-emissions-factors-and-quantification/basic-information-air-emissions-factors-and-quantification#About%20Emissions%20Factors. [Accessed 11 November 2016].

[21] EPA, "Basic Information of Air Emissions Factors and Quantification," EPA, 2016. [Online]. Available: https://www.epa.gov/air-emissions-factors-and-quantification/basic-information-air-emissions-factors-and-quantification#About%20Emissions%20Factors. [Accessed 25 Nov 2018].

[22] Shrink That Footprint, "Calculate your carbon footprint," 2017. [Online]. Available: http://shrinkthatfootprint.com/calculate-your-carbon-footprint. [Accessed 15 February 2017].

[23] Network World, "Android now the world's most popular operating system," Network World, 2017. [Online]. Available: http://www.networkworld.com/article/3187011/mobile-wireless/android-is-now-the-worlds-most-popular-operating-system.html.. [Accessed 28 May 2017].

[24] V. Ramrecha, G. Bekaroo, A. Santokhee and S. Juddoo, "Exploring the application and usability of NFC for promoting self-learning on energy consumption of household electronic appliances," in 2017 IEEE 4th International Conference on Soft Computing & Machine Intelligence (ISCMI), 2017.

[25] A. Hussain, E. Mkpojiogu, N. Fadzil, N. Hassan and Z. Zaaba, "A Mobile Usability Evaluation of a Pregnancy App," Journal of Telecommunication, Electronic and Computer Engineering (JTEC), vol. 10, no. 1-11, pp. 13-18, 2018.

[26] A. Nurhudatiana, A. Hiu and W. Ce, "Should I Use Laptop or Smartphone? a Usability Study on an Online Learning Application," in 2018 IEEE International Conference on Information Management and Technology (ICIMTech), 2018.

[27] T. Twari, "A Comparative Study of Environmental Awareness and Scientific Attitude of under graduate Students," International Journal Of Scientific Research, vol. 3, no. 8, pp. 70-72, 2014.