

# The Interplay between Usability, Sustainability and Green Aspects: A Design Case Study from a Developing Country

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**Abstract**— Sustainability and Green ICT are concepts that are usually not engineered into the design and development of ICT systems especially in the developing countries. This paper focuses on an interactive system, the Automated Teller Machine (ATM) in Nigeria. Current research concerning ATMs does not consider sustainability and green requirements in the design loop such as how green awareness in design can help support, for example, the reduction of energy consumption and paper wastage while reducing the environmental impact resulting from human computer interaction. This paper considers the specific case of senior citizens accompanied with the general problems of adoption, and mastering of the ATM technology, while highlighting the interplay between usability, green aspects and sustainability of interactive services. The case study was carried out over a period of two months, using observations, interviews and time experiments to support the findings. Key findings include: (1) poor ATM design affects usability and sustainability due to paper wastage as the consequence of redundant menu, (2) energy wastage is the consequence of multiple iterations during withdrawals, visibility of the status of systems, menu labels, and inconsistency and, (3) poor feedback, learnability and memorability, efficiency as well as aesthetics and user satisfaction resulted in a quest for a better ATM design in Nigeria.

**Index Terms**— Sustainability, Green awareness, Automated Teller Machine, ICT, Usability, User experience, Interactive system

## I. INTRODUCTION

Nigeria, a country with a dense population of over 190 million people [1] [2], has 53% of her populace with active bank accounts who make use of the Automated Teller Machine (ATM) [3]. According to the World Factbook (2018), the demographic distribution of Nigerians aged between 55-64 years is 3.97% and those aged 65 years and above is 3.13% representing a total of 7.1%, while the population within the age bracket of 15-54 years is 50.35% of the current total population of over 190 million [2][4]. Based on these facts, it can be construed that the country represents a wide number of ATM users demographically.

ATMs were introduced originally to allow financial institutions to render transactional services to their clients without directly interacting with bank representatives or tellers [5]. Besides, banks in Nigeria have adopted the use of ATMs and strongly encourage their clients to use ATMs for ease of transactions because Nigeria has yet to become a fully cashless society [6]. There is an on-going campaign to ease financial transactions through a ‘cashless policy’ and the ATM is expected to play a major role in that by encouraging more usage and decongesting the banking halls. ATMs deployed in Nigeria provide cross-bank and cross-account services as well as personal services. They are aimed at improving service delivery

and diversifying financial services including but not limited to cash deposits, withdrawals, funds transfer, bill payments and mobile airtime top-up [7]. Veritably, ATMs are prone to many usability problems such as interface design, unusual fonts and navigation menus, which may generate paper waste resulting from incessant receipt printing. Day to day practices revealed that large heaps of paper wastes are generated from the ATMs by users' transactions. Besides, it was observed that many of these receipts fill up trashcans and the litter is strewn all over the base of the ATMs.

Most banks in Nigeria have a policy of limiting withdrawal amount per transaction on their ATMs. In addition, more than three transactions at the ATM of a different bank attract charges of N65.00 (\$0.17). As a result, many of the ATMs across the country are set to a maximum withdrawal of N10,000 (\$28) per transaction, which leads to more money for the banks (through charges) especially from Fridays to Sundays. Thereby, forcing customers to spend more time at the ATMs. For instance, a customer withdrawing N100,000 (One hundred thousand naira) will have to make the transaction 10 times instead of twice or thrice at a maximum. Thus, having to pay withdrawal charges after the third withdrawal. This type of design is flawed and viewed by the customers as unfriendly and time-wasting especially to the senior citizens considering the long queues at most of the ATMs due to the increased amount of time spent to perform a large withdrawal. This practice is gradually affecting the so-called 'cashless policy' as evident in declining usage by the customers. This shows the lack of (social) sustainability consideration – where social sustainability can encourage positive contributions towards a user community's well-being and satisfaction [8]. Figure 1 summarizes the causes and issues of poor ATM design in Nigeria.

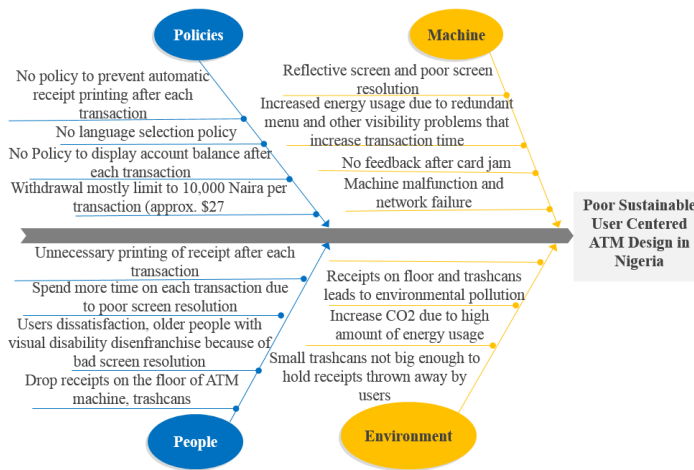


Fig 1. Fishbone Diagram of ATM Design and Usability Issues in Nigeria

Apart from the flaws in the interactive ATM design indicated from Figure 1, which may result in social problems, the amount of paper generated from incessant receipt printing gives rise to environmental problems. The lack of proper initiatives to tackle the problem of paper waste generated from ATMs and other sectors of the economy with paper waste in Nigeria has led to increased environmental issues in the country. Solving

these issues have been quite challenging due to inadequate infrastructure [9] [10] such as paper recycling facilities and efficient waste management facilities.

As a result, these paper wastes end up incinerated thereby causing air pollution, which, given that this usually happens in the form of mixed trash incineration, poses a serious health hazard to the local population. In addition to inadequate infrastructure, there is a lack of social and environmental awareness among the citizens and general users of the ATMs. As a result, a social and environmental awareness program is required on the need to reduce waste (energy and paper waste) for both the customers and the banking institutions. This includes recognizing the need for social and environmental sustainability which brings the country closer to achieving the United Nations sustainable development goals (SDGs) [11]. The following research questions addressed in this paper were formulated considering the aforementioned issues of ATM:

- What are the usability concerns that senior citizens face when using an ATM?
- How can green requirements and sustainability aspects be incorporated into ATM services design?
- What are the relationships between the factors affecting usability, green requirements and sustainability aspects of an interactive system such as an ATM?
- What are the factors responsible for long queues at most ATMs in Nigeria?
- Can ATMs serve as a means of sustainability and Green awareness?
- What are the sustainability issues of current ATM design in Nigeria?

The next section provides background information. Section III presents current problems of ATM design in Nigeria. Section IV describes the research design. Section V presents the results. Section VI provides a summary of findings. Section VII explains the design analysis. Section VIII covers discussion and Section IX concludes the paper.

## II. BACKGROUND

The development of an interactive system such as the ATM should be user-centered. Some of the works from the HCI community on social sustainability (usability and loneliness) [12] are examples of how important user centeredness is in the design of ICT systems looking at the case of ATMs. Integrating social sustainability requirements into design can help improve user experience during interaction with any software interface which has a potential to induce sustainable behavior. Lack of a proper guide for designers on how sustainability can be translated into interface design for the system has hindered the ability to have sustainability considered during systems design. Kem-Laurin [13] identified this challenge and proposed the use of a Sustainability User Experience Framework to assist software designers.

HCI plays a major role in creating green user awareness through eco-feedback which is based on the work of Froehlich et al. [14] as a way of showing users their positive and negative habits, which in this context refers to printing receipts during the use of ATMs. Another role of HCI is to also provide a solu-

tion to the problem of obsolescence by considering interactions between the device and its owner, the user experience and how these two factors can affect the length of ownership for that device, its usage and finally disposal [15]. This will provide insightful solutions on the design of end user devices. However, there is less research in the field of sustainable HCI on the application of sustainability by using a design framework into different design practices [16]. Spagnolli et al.'s [17] work on application of eco-feedback has shown a positive result for changing user behaviour towards sustainability. However, the major challenge for eco-feedback is the pattern and manner in which information is presented to the users. If the presentation from eco-feedback is not well structured, it can hinder the ability to promote green awareness based on user interaction [18]. Information from eco-feedback must be designed and tailored to educate and encourage users to change their habits and become greener. An example of such an eco-feedback can be seen from Quintal et al. [19] who provide user engagement through art inspired tangible eco-feedback that engages users emotionally.

Sustainability is not yet the core of HCI as a design discipline according to Fallman [20]. However, there are strong supporters of sustainability in the HCI field, as seen in the work of Eli Blevis [21] where it was indicated that sustainability should be the core of HCI with the methods and reasoning behind the design and development of interactive systems. This challenge has hindered the ability for designers of the interactive system to evaluate the consequential positive and negative effects of different choices which can either improve users' green awareness or increase their negative habit as indicated by Nicolas Makelberge [22]. A practical example is that the current ATM design in Nigeria, based on observation and interactions with bank staff, shows that a single ATM generates up to five big rolls of receipts on a weekly average. However, most of these receipts end up in the trashcan. This is in addition to the papers automatically printed as a ledger for the ATM custodians (Bank) for every transaction performed on the machine.

According to Bonanni et al. [23], sustainable HCI has a huge potential to facilitate and support the design and development of new interface design that can increase sustainability awareness among users. This awareness can motivate positive environmental impact through green awareness because user interactions with these new interfaces can lead to new habits due to informed decisions on how a user's action can affect the environment.

The challenge of creating green awareness by incorporating sustainability into the design of interactive systems such as ATMs is one of the root problems for designing better ICT systems with sustainability and green requirements. Design based solutions can help improve ICT energy efficiency, promote a low carbon economy and reduce the carbon footprint of ICT systems [24]. However, the challenge of integrating sustainability into ICT is because of the pervasive nature of current ICT systems and its advancement in power, performance and affordability. This can be improved through proper analysis of the first, second and third order effects of ICT systems design [25]. Based on the research Madden et al. [26], if ICT

systems are designed, developed and applied badly without sustainability consideration, it will have adverse effect such as abnormal increase in energy usage, accelerate climate change, worsen inequality for those who do not have access and increase pollution and resource use. The Global impact of ICT on CO2 emissions is 2% and accountable for approximately 8% of the European Union's (EU) electricity consumption [27].

The pathway to a sustainable society is unclear since sustainability means different things to different people [28]. People's different lifestyles, values and practices also affect how sustainability is treated [29]. However, with proper design inspired by sustainability and green requirements, ICT can reduce the impact of other sectors by up to 16% [30]. Furthermore, one of the major problems for software designers is that even with a systems approach, there are few existing tools that wrap core principles of sustainability together [31]. Also, there are only few studies and suggestions about 'what' aspects of sustainability to measure and 'how' to do it with regards to ICT [32] that can be applied to the case of ATM.

Adoption of green requirements for the design and development of ATMs has the potential to educate users during system interaction. Oyedeji et al. [33] propose to incorporate sustainability and green requirements into the requirements gathering process using the sustainable business goal metric approach (S-BGQM). Such requirements can lead to the addition of green and sustainable criteria in the evaluation of user interface. The work of Jeffries et al. [34], Stary et al. [35] and Wenham et al. [36] for user interface evaluation shows sustainability or green requirements are not included as a criterion used in any of the techniques for user interface (UI) evaluation. Park et al. [37] also proposed the use of the structured methodology for the evaluation of UI designs through usability criteria and measure with a process consisting of two phases: prescreening phase (expert judgment-based approach) and the evaluation phase (user-based approach). The proposed model has no criteria or measures though relating to sustainability and greenness.

Kem-Laurin's book "User Experience in the Age of Sustainability" [13] highlights some of the design issues in the modern-day design of user experience with consideration of sustainability. Kem-Laurin proposed the use of a sustainability user experience framework as a way to guide designers during design and development of systems with a set of questions. The framework contains a product life cycle, user-centered data, and list of methodologies that can be applied during design.

### III. CHALLENGES OF CURRENT ATM DESIGN IN NIGERIA

Information available from the Nigerian Inter-Bank Settlements System reveals that, as of June 2017, the total number of ATMs deployed in the Country stood at 17,712 (a figure expected to have further risen to about 18,000 currently). Total Transaction volume from January to June 2017 was 336.77 Million and total transaction value (in Naira) from January to June 2017 was 3.05 Trillion [38], [39].

Previous researches have shown that ATMs in the banking industry have contributed immensely to customer satisfaction through reliability and accessibility of services, privacy, convenience, user-friendly services, which have improved satisfac-

tion significantly as noted by Al-Hawari and Ward, Mwaikali [40], [41]. However, recent findings revealed that the current design of ATMs in Nigeria is flawed with many usability problems, as a result, making it very frustrating and disappointing to use [42]. A formerly attractive solution is fast becoming unacceptable and does not reflect the progress expected in the design of such an interactive system. Thus, requiring an urgent need for improvement. Notable among these are poor network quality, card locking [41], reflective display screen, redundant menus, inadequate profiling of card linked to account, small withdrawal limit, inadequate feedback, repeated receipts printed for each transaction, machine breakdown, ATMs running out of cash, insufficient number of ATMs in the metropolis, and delay in the dispensation of cash [42].

In addition to the aforementioned problems, specific issues faced by adults aged 55 – 64; and senior citizens aged 65+ are another major grey area. Akinnuwesi et al. [43] stress that the addition of multi-lingual and multi-denomination features to the current ATM design is capable of enhancing the functionalities and robustness of the machine. Thus, providing services to users with less stress. Apart from elders, some users of ATM in Nigeria are also rural dwellers (who understand their local language only – majorly Hausa, Igbo and Yoruba), having a machine that speaks their language will raise acceptability and users’ satisfaction among such a minority group. The lack of localization in the usability of ATMs in the cities and especially in rural towns usually leads to an increase in printed receipts for each transaction by users which ends up as litter.

#### IV. RESEARCH DESIGN

The research was conducted using observation methods and interviews. It was conducted in Abuja, the Federal Capital Territory (FCT), with a population of 2.44 million [4]. The major reason for choosing FCT as the sample population is because of its strategic importance, and it has at least a branch of all the banks in Nigeria and therefore provides the opportunity to cover as many banks as possible. ATM usage habits were observed across the FCT over a period of two months, focusing on all categories of ATM users. The exercise covered all banks across the metropolis. Participants were selected by actually visiting random ATM points within the city, and after a brief introduction, some declined to be interviewed while others were excited that they have the opportunity to discuss challenges faced with the current design and also take part in the questionnaire. There were 500 participants.

Observation method [44] was first used in data collection from different ATM points within Abuja. This is to eliminate any bias in order to find truly the cause of usability and sustainability problems of ATMs. Participant and non-participant observation was applied during the data collection to increase the participant sample size.

Since the information from the observation is not able to provide insights such as participants’ background details, opinions, what features to improve and personal preferences in using the ATMs, a second method of short personal interviews [45] was conducted to understand the personal usability and sustainability problems of each user. This also provides some

supplementary information about each participant’s personal characteristics and environment. It is important to state that sustainability dimensions are considered from the following perspectives in the study design:

- *Economic*: This is about maintaining a cost-effective design solution for ATM design while reducing cost.
- *Social*: Covers the sustainability in terms of relational ties and trust among a community of users of ATMs.
- *Individual*: Refers to the ability of each user to complete their task successfully with ease regardless of their age (old or young).
- *Environment*: Focus on how to reduce paper waste, encourage recycling and create awareness among users for climate issues that can generate enough consciousness in users on how their actions and inactions affect natural resources through paper receipt wastage, pollution, and energy consumptions.
- *Technical*: Develop sound and easy to use solutions for ATM design which can be deployed easily and maintained as requirements evolve.

Table 1 defines the roles and responsibility of each author in the study. The authors initials are used in Table 1 in the following order: Shola Oyedeji (SO), Mikhail O. Adisa (MA), Bilal Naqvi (BN), Mariam Abdulkareem (MA), Birgit Penzenstadler (BP) and Ahmed Seffah (AS).

**TABLE I.** ROLES AND RESPONSIBILITY

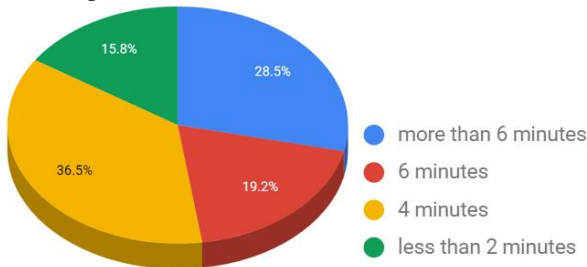
Description	SO	MA	BN	MA	BP	AS
Identify primary research	*	*				
Define hypothesis	*	*				
Design interview questions	*	*	*	*		
Background study	*	*	*	*		
Review interview questions						*
Study evaluation					*	*
First internal validation						*
Second Internal validation					*	
Write paper	*	*	*	*	*	
Review paper					*	*

#### V. RESULTS

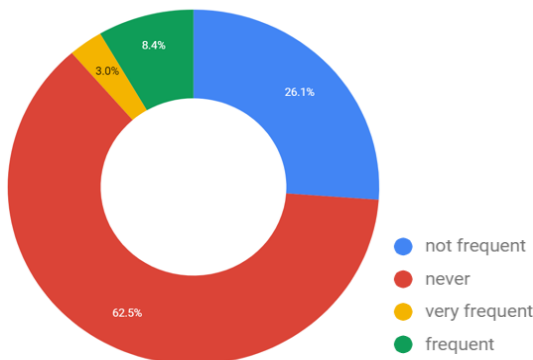
The results of the study are categorized into demography, Frequency of ATM usage, Ease of Use, Sustainability and Green consideration.

- Demography**: Age range was from 15-24, 25-34, 35-44, 45-54, 55 and above. Out of the 500 participants, senior citizens aged 55 and above covers slightly above half, while the rest is somewhat evenly distributed among aged 15 – 54 respectively. At the same time, the highest responses came from the female participants at 59.3%. In addition, a little above half of the participants had up to degree level of education and one-fourth had a post-graduate degree. Overall, one-third of the participants earned over N200,000 (approx. \$550) and approximately one-fifth earned less than \$140, respectively.

- B. **Frequency of usage:** Two-third of the participants had two or more ATM cards linked to their accounts, with approximately half of them claiming to have used their cards in the last one week. While one quarter claimed to have used theirs about three or more weeks ago.
- C. **Ease of use:** 15.56% of the participants claimed that it took them less than 2 minutes to complete a N40,000 (\$100) transaction, while 36.5% claimed to have achieved the same within 4 minutes, 19.2% took 6 minutes. However, 28.7% were able to achieve theirs in more than 6 minutes (Figure 2). This can be attributed to the limitation on the maximum amount of cash that can be withdrawn per each transaction from ATM.

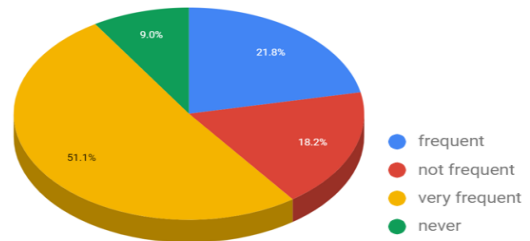


**Fig. 2.** The amount of time required to complete withdrawal transaction of 40,000 naira (\$100)

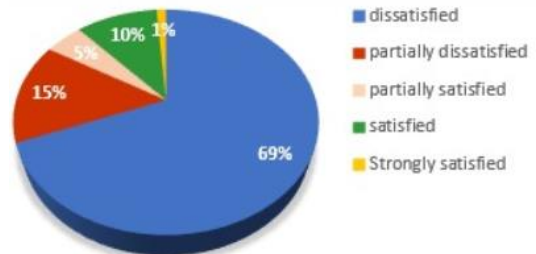


**Fig. 3.** Percentage of 40,000 naira (\$100) withdrawal at once

In the same vein, 62% of the participants claimed to have never been able to withdraw N40,000 (\$100) at once before and only 8% claimed to have being able to do same before (Figure 3). The ability to withdrawal N40,000 (\$100) appealed to more than 70% of participants, while 17% of them opted for N20,000 and just 10% agreed with the status quo of N10,000 single withdrawals. This shows the problem of the ATM policy from most banks that reduce maximum cash withdrawal to 10,000 naira per transaction. It explains one of the major reasons for why most people spend more time in queue at most ATMs as seen in responses from Figure 4.

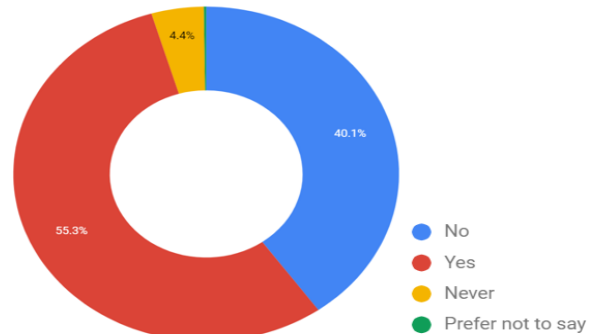


**Fig. 4.** Frequency of queue at ATM

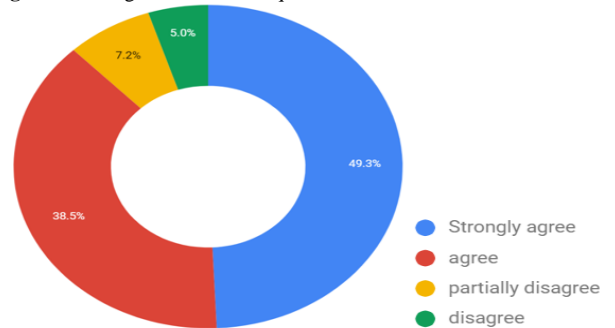


**Fig. 5.** Percentage of user satisfaction with current ATM design and usability

Over 60% of users are dissatisfied with current ATM design and usability and less than 20% are satisfied (Figure 5). Some of the issues for this level of dissatisfaction can be linked to withdrawal limit of 10,000 per transaction from most banks, long queues, security feature of re-entering ATM pin after each transaction. And over 50% of the users required one level of assistance to complete their transaction (Figure 6) mainly because of screen resolution and language. Additionally, more than 80% preferred to have a multi-lingual interface to ease their transactions (Figure 7).



**Fig. 6.** Percentage of users that required assistance for ATM Transaction



**Fig. 7.** Users response to Multi-lingual feature in ATM

D. **Sustainability and Green Consideration:** More than half of the participants (61.5%) were used to frequently printing receipts after their ATM transactions (Figure 8) and are unaware of the negative impact of such on the environment (Figure 9).

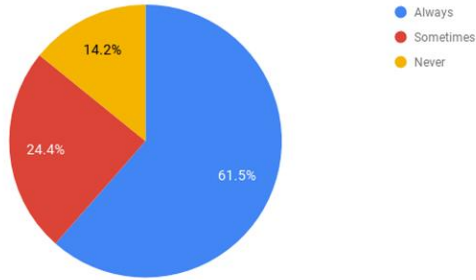


Fig. 8. Percentage for printing receipt after each transaction

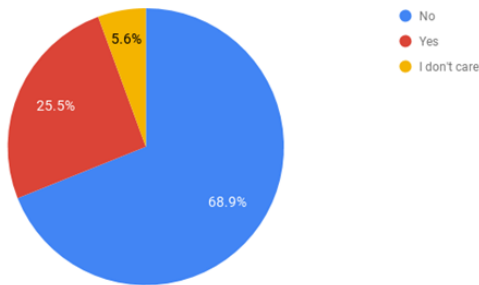


Fig. 9. Level of users' awareness about impact of printed receipts on environment

In addition, more than half of the participants suggested that the banks should burn the receipts left in the trash can by the customers, while 10% are for recycling and 30% are for sending the said receipts to a trash collector for proper disposal (Figure 10). Almost half of the participants also claimed to understand the meaning of sustainability, while 48.9% claimed they don't know the meaning, and less than 10% preferred not to respond to the question (Figure 11). Overall, 97% are aware of climate change according to the responses.

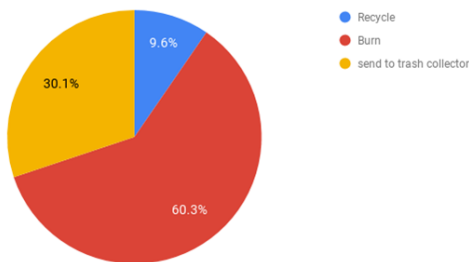


Fig. 10. Level of users' awareness about air pollution and recycling

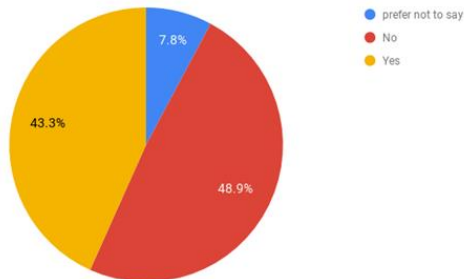


Fig. 11. Percentage of sustainability awareness among users

## VI. SUMMARY OF ATM USABILITY, GREEN AND SUSTAINABILITY DESIGN ISSUES IN NIGERIA

Our findings reveal that many of the problems encountered by users of ATMs in Nigeria can be eliminated if the users' expectation meets the design goal with consideration of environmental, social and individual sustainability. As different technologies are invented to better the life of users, usability and users' engagement studies should be periodically carried out to understand their challenges and how best to reduce ambiguity without having a negative impact on the environment.

The study outcome revealed that most ATM interfaces in the country are not user-friendly. The fonts are either too tiny or the interface screen used by some banks is reflective and not friendly to the eyes (in this case, the customers have to adjust and squint their eyes to see properly). No consideration of social and individual sustainability. Customers have to select account type out of three options (Savings, Current and Credit) even when the card is linked to only one account number. Lack of feedback about the unavailability of cash to dispense, as customers had to insert and perform all the withdrawal steps before getting to know that the ATM cannot dispense cash (Time wastage). Most of these banks usually limit withdrawals to a maximum of N10,000 per withdrawal as discussed in the introduction and, thus, consuming more electrical and mechanical energy to dispense larger sums (energy waste).

Another major observation is the amount of paper generated as receipts, as most users often drop the said receipt right at the base of the ATMs. A typical ATM in the capital territory generated up to five rolls of receipt paper per week, most of which ended up as waste. Expanding this sample to another part of the country will reveal heavy loads of paper wastage. This shows lack of concern for environmental sustainability. Table 2 summarizes all the design issues faced by different user groups along with the affected dimensions of sustainability.

TABLE II. DESIGN ISSUES IN CURRENT ATM IN NIGERIA

No	Design Issues	Target Users	Sustainability Dimension
1.	Font/Screen Resolution	Elders/ Senior Citizens	Individual, Social
2.	Reflective display screen	All users	Technical
3.	Redundant menu (repeatedly select account type)	Users with a single account	Technical, Environment
4.	Automatic receipt printing after a 'fund transfer transaction'	ATM Owner, All users	Technical, Environment
5.	No choice of language selection	All users	Individual, Social
6.	Withdrawal limit of N10,000	All users, ATM owners	Technical, Environment
7.	No choice of currency notes selection	All users	Technical
8.	Incessant network failure without corresponding feedback from interface	All users, ATM owners	Technical, Individual, Environment
9.	Feedback on card jam/capture	All users	Technical, Individual, Social
10	No display of account balance after the transaction	All users, ATM owners	Technical, Environment

The design issues summarized in Table 2 and results from section five show the need to rethink the design of ATMs in Nigeria in order to promote sustainability and reduce business costs. To fix the identified issues, analysis how usability heuristics can help improve the current interface design influenced by the framework for sustainability of software system design [46] was carried out. The framework shows the need, during system design, to incorporate sustainability goals such as design for sustainable efficiency, reusability, increased sustainability awareness among users, design for reuse, and localization. It suggests using sustainability concepts such as cradle to cradle, biomimicry, life cycle sustainability assessment, social return on investment, and sustainability awareness diagrams.

The ten usability heuristics for user interface design by Jakob Nielsen [47][48] were adapted for sustainability. Table 3 highlights the details of the green and sustainable guidelines based on Jakob Nielsen heuristics [48] used as a guide for the proposed new ATM design.

TABLE III. GREEN AND SUSTAINABILITY HEURISTICS GUIDELINES (BASED ON NIELSEN HEURISTICS)

Name	Description
Visibility of system status	The interface should not be reflective, so as to enhance readability. Green awareness should be made visible from the UI through appropriate warnings within reasonable time.
Match between system and the real world	The system should use phrases and terms that users are familiar with to pass the message of green awareness in a natural and logical order. This is supported with a multi-lingual option (to address the need of those that speak mainly native language)
User control and freedom	When users make the mistake of selecting to print receipt and wants to cancel, there should be a clear way for users to undo the action without difficulty (without going through an extended dialogue)
Consistency and standards	All screens should have consistency in order not to confuse user, for example green awareness campaign message should be consistent in all transaction screen.
Error prevention	The user interface should be designed in a way to

	avoid errors during transactions especially during currency/multi-lingual selection and when deciding to print or not to print receipts
Recognition rather than recall	Make objects and options visible for users, options of green and sustainability must be clear enough to avoid making users recalling information from one part to another.
Flexibility and efficiency of use	The user interface should be designed to suit all categories of users. All unnecessary steps towards user goal during usage should be avoided. (e.g. asking user to select account type when the card is linked to just one account which just increases the number of steps in the transaction and increase energy used)
Aesthetic and minimalist design	Information on the screen should be precise to make users locate information easily. This will ensure users are aware of their actions during each transaction and a structured information would help create green awareness. (Avoid using a reflective screen that affects visibility of menus)
Help users recognize, diagnose, and recover from errors	Error message should be in simple and plain language to express the problem and suggest solution. (e.g. information on Card Capture Resolution should be visible when such error occurs)
Help and documentation	There should an easy help function to guide and assist users whenever needed. This can also be a good avenue to propagate green awareness.

## VII. DESIGN ANALYSIS AND RECOMMENDATION

This paper is proposing a redesign of the current ATMs in Nigeria that will address all the aforementioned issues in Table 2 and use the guidelines from Table 3 as a solution path. The redesign will target all demographics including the Nigerian elderly citizens (who complained mostly about the readability of fonts, reflective display screen, time to perform single withdrawal, and redundant menu), improve human-to-machine interaction, encourage re-use and promote a greener and safer environment. With the current ATM usage statistics in Nigeria, the technology could also serve as a focal point for the Green Awareness Campaign. Table 4 summarizes the solutions and the first, second, and third order impacts [49] [50] of these design changes.

TABLE IV. SOLUTIONS AND OPPORTUNITIES FOR USER CENTERED ATM DESIGN

Issues	Target Users	Sustainability Dimension	Solution/Expectation	First order Impact	Second order Impact	Third order Impact	Opportunities
Font/Screen Resolution	Elders/ Senior Citizens	Individual, Social	Profile user by age and increase font size	Improve usability by older users and those with vision problem	Increase usage by senior citizens	Reduce the amount of time spent on making each ATM transaction which in turn will reduce the amount of energy used	Acceptability, improve usability for elders
Automatic receipt printing after a 'fund transfer transaction'	ATM Owner, All users	Technical, Environment	Allow the user decide if printing is necessary after fund transfer, show green campaign message to discourage wasteful printing	Reduce amount of printed receipts	Reduce the amount of paper waste, Reduce energy usage overtime with less receipt printing	Create awareness among user about sustainability, reduce the amount of trees used in producing papers, educate users in the long run to use resources judiciously in their personal life	Improve user behavior positively towards the environment and the bank expenses on paper for printing receipts
Lack of option to track each printed receipt for transactions	ATM owners, All users	Individual, Social	Green awareness campaign by tracking monthly printing habit with message influenced from	Dissuade users from printing on all transactions from ATM	Prompt user to stop monthly, quarterly and yearly paper summary of account	Increase sustainability and green awareness, create a society of educated users about sustainability and impact on environment	Improve usability, reduce energy usage which in turn reduce bank energy bill

			biomimicry		transaction		
Reflective display screen	All users	Technical	Non-reflective display screen	Improve usability	Reduce time on performing transactions	Improve user satisfaction	Positive feedback from user and increase in patronization
Redundant menu (repeatedly select account type)	Users with a single account	Technical, Environment	Automatic account type identifier	Reduce time to complete transaction	Reduce energy usage	Improve usability, user satisfaction, reduce queue thereby prompting quick transaction	Save time, conserve energy, Improve usability
Withdrawal limit of N10,000	All users, ATM owners	Technical, Environment	Increase limit to *40 of currency note (N40,000 for N 1,000 and N 20,000 for N 500)	Reduce time to complete cash withdrawal transaction	Improve user satisfaction because of shorter time to withdraw cash	Increase the amount of transaction	Improve usability, Save time
No choice of currency notes selection	All users	Technical	Display currency note available and allow the user to choose either N1,000 or N500	Increase time for transaction due to added menu for currency selection	Increase acceptability	Increase satisfaction	Improve acceptability and usability
Incessant and un-inform network /ATM failure	All users, ATM owners	Technical, Individual, Environment	Automatically display network error on the screen before user insert their card	Reduce time wastage	Reduce energy usage by ensuring user doesn't have to start a transaction to see the ATM has problem or unable to dispense cash	Increase satisfaction	Promote cashless policy with more users willing to do other transactions (pay school fees, utility bill, fund transfer) via ATM
Feedback on Card Jam/capture	All users	Technical, Individual, Social	Display appropriate steps for resolution	Make users less worried because of informed decision based on displayed information	Reduce bank queue for Jammed / Retained card in bank premises	Improve satisfaction	Improve Interactivity and usability
No display of account balance after the final transaction	All users, ATM owners	Technical, Environment	Automatic display of account balance after the final transaction	Reduce time used for transaction	Reduce paper waste because user don't have to select option of print receipt after transaction	Reduce energy usage and paper receipt printing	Improve satisfaction as user does not need to re-enter PIN to view account balance

## VIII. DISCUSSION

The study has shown some of the problems and challenges of ATM users in Nigeria. Based on the results from the observation and interviews, the frequency of ATM card usage and the number of ATM cards owned by participants shows that ATM usage is high in Nigeria, and as a developing country where cashless policy is still in its infancy, ATMs serve as a major source of making transactions. One of the biggest challenges in the current ATM design is the lack of consideration for the older age groups (individual and social sustainability). This has also impacted negatively on the environment because a majority of the participants spend more time trying to complete smaller transactions due to small fonts, reflective display screen, network failure and card jams which in turn lead to frequent incessant queues. Almost three-quarter of the study participants claimed to have experienced long queues during their transaction with two-thirds among them experiencing a long queue very frequently. Only one-tenth claimed to have never experienced a long queue.

Furthermore, with regards to sustainability, it is surprising that 43.3% of the participants were aware of sustainability and 97.8% claimed to have heard of climate change, yet 60.3% (Figure 10) of the participants suggested that the trashed receipts should be burnt while only 9.6% suggested recycling. Burning in itself will lead to environmental pollution which is hazardous to human health. In addition, over 60% of participants who always printed receipts at the end of each transaction are not aware that the trashed receipts have a negative impact on the environment. This is because usually most receipts end up in a landfill, where they will be burnt, or conversely, they are thrown into the drainage thereby causing blockage.

It is therefore important to look at ways of improving sustainability and green awareness among ATM users in a developing country like Nigeria in order to promote social, individual and environmental sustainability. The first step will be presenting the result of these findings to some of the banks where the observations and interviews were conducted to explain the advantage and benefits of incorporating sustainability and green requirements into ATM design. Table 4 can serve as a way of presenting the first, second and third order impacts with



opportunities that can be derived from re-thinking the design of current ATMs. The second step will be creating sustainability and green awareness for example:

1. Add a tag message “Track your commitment to a greener environment, do no print receipt except if necessary” on all screen during ATM transactions

2. On the screen to print receipt, display of a tag message “Consider your environment, printed receipt has negative impact on the environment”

3. On the printed receipt itself, a tag stating the total amount printed receipts from the user in relation to trees killed in the forest can be added for example 35 receipts printed this week = two trees killed, is shown on the receipt. While the third option might not be supported by a bank as it might potentially put their customers off, it is a simple way to directly show and give eco-feedback on how the impacts of individual users’ choices accumulate.

### IX. CONCLUSION

This paper addressed the issue of usability, sustainability and green awareness challenges that the users of current ATM design in Nigeria experience. The study targeted senior citizens (age 55 and above) who often felt disenfranchised in the usability consideration of the technology, and also other users (age range from 15-54).

The proposed green and sustainability heuristics guidelines provide a means for evaluating ATM design towards changing users’ habits, emotions, and behavior concerning the environment. The proposed redesign highlights how green ATM design can provide suitable feedback to users on their printing habits, and subsequently promoting green awareness. Through green awareness, users can be more aware of their actions towards the environment. The aim of this paper is to encourage software designers to consider the different usability, green and sustainability issues in their development work to improve usability, learnability and sustainability of ATM in Nigeria.

The ATM case study presented in this paper refers to a dependency between sustainability and usability. The major focus of designers and developers is to ensure ease of use and provide rich user experience, whereas dimensions like social and individual sustainability are usually ignored. This paper is an attempt towards incorporating all sustainability dimensions in design of ATM.

This paper aims to open a discussion among the conference participants on designing usable sustainability and green user experience – or: on how best to design and evaluate usable green-aware interactive systems. In addition, we hope to raise interest among participants to further research on the best guidelines to assist designers in developing countries and provide techniques that consider green and sustainability requirements. Further research investigations are needed to:

- Get to know the user experiences and interactions with software systems regarding sustainability. Where are they being used and what are their impacts in terms of sustainability?
- Develop a theoretical framework to understand the best green UX design practices. How can sustainable

user experience design help to design software products that are sustainability-centric?

- Perform a larger observational study and describe the experiences and feelings of users about the sustainability of interactive system. How do people interact with systems while being more aware of their impacts on the environment?

### REFERENCES

- [1] UNICEF, “Nigeria Country programme document 2014-2017,” no. September 2013, pp. 1–13, 2013.
- [2] Wordometers, “Nigeria Population 2018 Available at <http://www.worldometers.info/world-population/nigeria-population/>, Accessed on 18-04-2019.” 2018.
- [3] O. Chima, “ThisDay Ericsson Report Available at <https://www.thisdaylive.com/index.php/2016/03/03/report-53-of-nigerians-in-banking-system/>, Accessed on 20-04-2018,” 2016. .
- [4] “The World Factbook — Central Intelligence Agency: Nigeria Demographics Profile 2018,” 2018. [Online]. Available: <https://www.cia.gov/library/publications/the-world-factbook/geos/ni.html>.
- [5] A. S. Adepoju and M. E. Alhassan, “Challenges of Automated Teller Machine (ATM) usage and fraud occurrences in Nigeria - A case study of selected banks in Minna metropolis,” *J. Internet Bank. Commer.*, vol. 15, no. 2, pp. 1–10, 2010.
- [6] B. Odusina and A. Olumide, “Automated Teller Machine usage and Customers’ Satisfaction in Nigeria,” *Glob. J. Manag. Bus. Res.*, vol. 14, no. 4, 2014.
- [7] E. E. Okafor and F. N. Ezeani, “Empirical Study of the Use of Automated Teller Machine ( ATM ) Among Bank Customers in Ibadan Metropolis , South Western,” vol. 4, no. 7, pp. 18–34, 2012.
- [8] M. Al Hinai and R. Chitchyan, “Engineering Requirements for Social Sustainability,” *Proc. ICT Sustain. 2016*, 2016.
- [9] E. Yusuf, A. Kogi, S. Polytechnic, T. Challenges, and N. D. View, “Waste Management and Sustainable Development in Nigeria : A Study of Anambra State Waste Management Agency Waste Management and Sustainable Development in Nigeria : A Study of Anambra State Waste Management Agency,” no. January 2016, 2017.
- [10] P. Nwofe, “Waste Management and Environmental Sustainability : a Case Study of Selected Cities in Ebonyi State,” no. July, 2015.
- [11] United Nations, “Sustainable Development Goals Available at: <https://www.un.org/sustainabledevelopment/sustainable-development-goals/> Accessed on 28-12-2018,” no. September 2000, pp. 8–23, 2015.
- [12] M. Al Hinai and R. Chitchyan, “Social Sustainability Indicators for Software: Initial Review,” *Proc. Third Int. Work. Requir. Eng. Sustain. Syst.*, vol. 1216, no. 22nd International Conference on Requirements Engineering (RE 2014), pp. 21–27, 2014.
- [13] K.-L. Kramer, *User Experience in the Age of Sustainability. Available at: <http://dx.doi.org/10.1016/b978-0-12-387795-6.00001-9>*. 2012.
- [14] J. Froehlich, L. Findlater, J. Landay, and C. Science, “The Design of Eco-Feedback Technology,” pp. 1999–2008, 2010.

- [15] L. M. Hilty and B. Aebischer, "ICT Innovations for Sustainability," *Adv. Intell. Syst. Comput.*, vol. 310, pp. 367–385, 2015.
- [16] C. Remy, S. Gegenbauer, and E. M. Huang, "Bridging the Theory-Practice Gap: Lessons and Challenges of Applying the Attachment Framework for Sustainable HCI Design," *Proc. ACM CHI'15 Conf. Hum. Factors Comput. Syst.*, vol. 1, pp. 1305–1314, 2015.
- [17] A. Spagnolli *et al.*, "Eco-feedback on the go: Motivating energy awareness," *Computer (Long. Beach. Calif.)*, vol. 44, no. 5, pp. 38–45, 2011.
- [18] R. J. Yun, A. Aziz, and B. Lasternas, "Design Implications for the Presentation of Eco- feedback Data," *Arch. Des. Res.*, vol. 28, no. 4, pp. 95–106, 2015.
- [19] P. Kotzé, G. Marsden, G. Lindgaard, J. Wesson, and M. Winckler, *Interaction – INTERACT 2013 14th IFIP TC 13 International Conference*, no. 1, 2013.
- [20] D. Fallman, "Design-oriented Human — Computer Interaction," no. 5, pp. 225–232, 2003.
- [21] E. Blevis, "Sustainable Interaction Design: Invention & Disposal, Renewal & Reuse," pp. 503–512, 2007.
- [22] N. Makelberge, "Computing Against the Grain," *Des. Philos. Pap.*, vol. 1, no. 4, 2003.
- [23] L. Bonanni, D. Busse, J. Thomas, E. Blevis, M. Turpeinen, and N. J. Nunes, "Visible - Actionable - Sustainable: Sustainable Interaction Design in Professional Domains," *Proc. CHI 2011*, pp. 2413–2416, 2011.
- [24] M. Bibri, "Sustaining ICT for Sustainability," 2009.
- [25] E. I. T. O. · EITO, "The impact of ICT on sustainable development," pp. 250–283, 2002.
- [26] P. Madden and I. Weißbrod, "Connected ICT and sustainable development. Available at <https://www.forumforthefuture.org/project/connected/overview>. Accessed on 12-12-2018," 2008.
- [27] C. Calero and M. Piattini, "Introduction to Green in software engineering," *Green Softw. Eng.*, pp. 1–327, 2015.
- [28] D. Pargman, E. Eriksson, M. Höjer, U. G. Östling, and L. A. Borges, "The (Un)sustainability of Imagined Future Information Societies," *Proc. 2017 CHI Conf. Hum. Factors Comput. Syst. - CHI '17*, pp. 773–785, 2017.
- [29] S. Ilstedt, E. Eriksson, and M. I. A. Hesselgren, "Sustainable Lifestyles – How Values Affect Sustainable Practises," vol. 7, no. 7, 2017.
- [30] A. Hankel, "Understanding Higher Order Impacts of Green ICT," *2nd Int. Conf. ICT Sustain. (ICT4S 2014)*, no. Ict4s, pp. 385–391, 2014.
- [31] N. Shedroff, *Design is the Problem: The Future of Design Must be Sustainable*. Rosenfeld Media, 2009.
- [32] G. Lami and L. Buglione, "Measuring software sustainability from a process-centric perspective," *Proc. 2012 Jt. Conf. 22nd Int. Work. Softw. Meas. 2012 7th Int. Conf. Softw. Process Prod. Meas. IWSM-MENSURA 2012*, pp. 53–59, 2012.
- [33] S. Oyediji, A. Seffah, and B. Penzenstadler, "Sustainability Quantification in Requirements Informing Design," *6th Int. Work. Requir. Eng. Sustain. Syst.*, vol. i, 2017.
- [34] R. Jeffries, J. R. Miller, C. Wharton, and K. Uyeda, "User interface evaluation in the real world: a comparison of four techniques," *Proc. SIGCHI ...*, pp. 119–124, 1991.
- [35] C. Stary, T. Riesenecker-Caba, and J. Flecker, "User interface evaluation: a comparison of 18 techniques when implementing the EU-Directive on Human-Computer Interaction," *Comput. Interact. 1996. Proceedings., Sixth Aust. Conf.*, pp. 328–329, 1996.
- [36] D. Wenham and P. Zaphiris, "User interface evaluation methods for internet banking web sites: a review, evaluation and case study," *Human-computer Interact. theory Pract.*, no. 1999, pp. 721–725, 2003.
- [37] K. Park, "... for Comparative Evaluation of User Interface Designs Using Usability Criteria and ...," *Int. J. Ind. Ergon.*, vol. 23, no. 5–6, pp. 379–389, 1999.
- [38] NIBSS Enterprise Intelligence Unit, "Electronic payments fact sheet for jan-jun 2017," 2017.
- [39] Kunle Azeez, "Cashless: Nigeria faces 48,000 ATMs infrastructure shortfall," *New Telegraph*, Nov-2017.
- [40] A. Al-Hawari, M & Ward, "The effect of automated service quality on bank financial performance and the mediating role of customer satisfaction," *Mark. Intell. Plan.*, vol. 24, no. 2, 2006.
- [41] E. J. Mwaikali, "Assessment of Challenges Facing Customers in Automated Teller Machines in the Banking Industry in Tanzania: A Case of Some Selected Banks in Tanzania," *Int. J. Res. Bus. Technol.*, vol. 4, no. 3, pp. 480–488, 2014.
- [42] E. O. C. Mkpojiogu and E. A. Augustine, "The user experience of atm users in nigeria: a systematic review of empirical paperS," *Int. J. Sci. Eng. Appl.*, 2018.
- [43] B. A. Akinnuwesi, F. E. Uzoka, and A. P. Obasa, "Enhancing automated teller machine with multi-lingual and multi-denominational software functionalities," *Int. J. Electron. Financ.*, vol. 7, no. 2, pp. 97–114, 2013.
- [44] B. B. Kawulich, "The History of Participant Observation as a Method," *Forum Qual. Sozialforsch. / Forum Qual. Soc. Res.*, vol. 6, no. 2, pp. 1–19, 2013.
- [45] N. Brikci and J. Green, "A Guide to Using Qualitative Research Methodology," pp. 1–36, 2007.
- [46] S. Oyediji, A. Seffah, and B. Penzenstadler, "A catalogue supporting software sustainability design," *Sustainability*, vol. 10, no. 7, pp. 1–30, 2018.
- [47] J. Nielsen, "Enhancing the explanatory power of usability heuristics," *Conf. companion Hum. factors Comput. Syst. - CHI '94*, p. 210, 1994.
- [48] N. Jakob, "Ten Usability Heuristics. Available at [http://www.useit.com/papers/heuristic/heuristic\\_list.html](http://www.useit.com/papers/heuristic/heuristic_list.html). Accessed on 12-12-2018." [Online]. Available: <http://portal.acm.org/citation.cfm?doid=259963.260333>.
- [49] H. J. Berkhout Frans, "Impacts of Information and Communication Technologies on Environmental Sustainability: speculations and evidence," vol. 5.
- [50] L. M. Hilty and B. Aebischer, "ICT for Sustainability: An Emerging Research Field What Is Sustainability?," *ICT Innov. Sustain. Adv. Intell. Syst. Comput. 310*, no. August, pp. 1–34, 2014.