Journal of Co-operative and Business Studies (JCBS)
Vol.7, No.2; Publication Date: December. 31, 2023
ISSN: (Online) 2714-2043, (Print) 0856-9037
The current issue and full-text archive of this journal is available at: journals.mocu.ac.tz
Cite this article as: Matto, G. & Njau, L. (2023). Desirable ICTs Interventions for Climate Change Mitigation in Rural Arusha, Tanzania. *Journal of Co-operative and Business Studies,* 7(2), 17-27.

Desirable ICT Interventions for Climate Change Mitigation in Rural Arusha, Tanzania

George Matto[1] and Luka Njau[2]
[1] *ICT Department, Moshi Co-operative University, Tanzania. Email: george.matto@mocu.ac.tz*
[2] *Department of Community Development and Gender, Moshi Co-operative University, Tanzania. Email: luka.njau@mocu.ac.tz*

Abstract

The world is changing due to climate change. Numerous interventions have been put in place to mitigate climate change effects. The use of Information and Communication Technologies (ICTs) is among the instruments for such interventions. However, studies have indicated that the majority of ICT-based solutions lack clear focus on the type of user/community they are targeting. As a result, some of these solutions fail to meet expectations of contributing to mitigation of the climate change effects. It is on these grounds that the present study was conducted to investigate desirable ICTs interventions for climate change mitigation in rural areas. The study employed a cross-sectional research design. Data was collected from 120 randomly selected respondents drawn from four villages in the Arumeru district, Arusha, Tanzania. The collected data were analysed through descriptive and qualitative methods. Findings revealed that 57.5% of the respondents had primary education while 11.7% had not attended any formal education. Moreover, 73.3% of them often use dumbphones, unlike other ICT gadgets like smartphones, tablets and computers. While that was the case, 43.3% of the respondents were unaware of climate change. Evident from the findings is a substantial reliance on basic mobile phones, with a notable lack of awareness about climate change among study participants. It is recommended that there is a need for ICT stakeholders to consider developing mobile-based educational tools and resources relevant to rural contexts. The three factors i.e., literacy level, type of ICT used, and basic understanding of climate change are ideal aspects to be considered when one is planning for the type of ICT interventions for climate change causes, effects, and mitigations especially in rural areas.

Keywords: ICTs, Climate change, Rural areas, Tanzania

1.0 Introduction

Climate change has emerged as one of the biggest environmental challenges facing the world today. Pan *et al*. (2022) and Nasa (2023) indicated that as days go by, the effects of climate change continue to be profound. There have been experiences of more frequent wildfires, longer periods of drought in some regions, depletion of virgin forests, and an increase in the wind intensity and rainfall from tropical cyclones which has resulted from climate change. As per the Food and Agriculture Organization (FAO), climate change is also a growing challenge to food security especially to developing countries that depend on agriculture for their livelihoods (FAO, 2017; FAO, 2019). According to the International Panel for Climate Change (IPCC) (IPCC, 2014) and FAO (2018) climate change impacts have had direct consequences on the economy, food systems, ecosystems, water resources, weather events, health issues, desertification, and sea level rise. Christian Aid (2006) added that climate change has had effects even on political and social stability like displacement of people and conflicts. Recently, the United Nations (UN) pointed out that, if left unchecked, climate change will undo a lot of the progress made over the past years in development (UN, 2022). It will also provoke mass migrations that will lead to

instability and wars.Nonetheless, the magnitude and rate of climate change and associated risks depend strongly on mitigation and adaptation actions (Nasa, 2023).

Several attempts and initiatives have been instituted to mitigate climate change and its associated outcomes. In 2015, the United Nations established 17 Sustainable Development Goals (SDGs) as a global call on action to end poverty, protect the earth's environment and climate, and ensure that people everywhere can enjoy peace and prosperity (UN, 2023). SDG 13 is specifically on climate action. It is calling for urgent actions to combat climate change impacts. To attain sustainable life in society, in connection to other actions, the goal stipulates that it is necessary to integrate climate change measures into specific policies, strategies and planning (Franco *et al*., 2020).

Consequently, global countries adopted the Paris Agreement to strengthen the universal response to the threat of climate change including limiting global temperature rise (Falkner, 2016). Among other climate change mitigation measures, Information and Communication Technologies (ICTs) have been employed as an enabling tool. For example, China and Brazil employed smart applications like smart grid, mobile phone, and other ICT-enabled technologies for energy efficiency and management, transportation, land use change and forestry emissions mitigation (Niyibizi and Komakech, 2013). At the regional and local levels, countries have been setting local policies and strategies to combat climate change. Tanzania, for example, is implementing the National Climate Change Response Strategy 2021-2026. The strategy guides the country on climate change issues and initiatives triggering integration into sector policies and plans, giving guidance for enhancing adaptation and resilience measures (URT, 2021). There have been several other attempts to try to mitigate climate change. Such attempts include adopting renewable energy sources like solar, wind, and small hydropower projects. Others include helping cities develop more sustainable transport such as bus rapid transit, electric vehicles, and biofuels, and promoting more sustainable uses of land and forests (Global Environment Facility, 2023).

In order to mitigate climate change to be effective, particularly in rural areas, studies show that people need to be well informed on how their actions contribute to climate change. Ospina and Heeks (2012) indicated that the lack of reliable, context-specific, customized, and easy to understand climate change information is one of the most serious constraints for community members to undertake effective responses in the face of the challenges posed by climate change. Thus, along with other uses, ICTs can play a pivotal role in the actions to mitigate climate change. In rural areas of developing countries, Tanzania inclusive, where the majority of its residents are smallholder farmers whereby, for example in Tanzania, smallholder farmers constitute about 67% of rural residents (Kissoly *et al*., 2020)), the application of farmers-based ICT systems can be of paramount importance. This is because, as Ireri *et al*. (2021) explain, ICTs can be applied to enable early warning systems for smallholder farmers in the form of climate-related disasters such as floods, drought, diseases, and pest outbreaks. The systems can use mobile phone networks to disseminate timely alerts and advisories to rural communities enabling them to take appropriate preventive measures. Likewise, as Murshed *et al*. (2020) pointed out, ICTs can facilitate the dissemination of information on alternative energy technologies and or renewable energy technologies such as solar power and biogas. This information may reach rural communities through websites, community radios and mobile phones. Likewise, ICTs can be used to create awareness, provide access to climate change information as well as capacity building in the use of various tools and solutions to identify the effects of climate change (Chimanga and Kanja, 2020).

Furthermore, as described by Niyibizi and Komakech (2013) and Ford *et al*. (2013), in addition to information dissemination, ICTs can contribute to the mitigation of climate change in several other ways. Numerous ICT-based climate change mitigation solutions have been introduced. However, the majority of such solutions are generic. For example, solutions like the Famine Early Warning System Network (FEWS NET) (FEWS NET, 2023) and the Global Observing System (GOS) as provided by the World Metrological Organization (2023) are web-based systems, and Earth Hero (Earth Hero, 2023) and Climate Counts (Climate Counts, 2023) are mobile apps. Developers of these systems assume that all users can browse the web or navigating mobile apps which may not necessarily be the case for rural communities. Moreover, according to Imam *et al*. (2017), climate change governance literature highlights the role of ICTs in climate change adaptation mainly from a conceptual perspective. The

literature hardly presents the ideal ICT tools and solutions that are compatible to the respective communities and rural communities in particular. It is on these grounds that the present study was carried out to investigate underlying ICT interventions for climate change mitigation in rural areas. Specifically, the study focused on three key areas of the rural community perspectives which are community members' literacy level, basic awareness of the community members on climate change and types of ICT tools commonly used and the extent to which such tools have facilitated community members access to climate change-based ICTs services.

2.0 Methodology

The study was conducted using cross cross-sectional research design in which a mixed-methods approach where both qualitative and quantitative techniques were deployed to ensure broad information is collected hence achieving the study objectives. These techniques which are research-based, ensure broad information is collected, and data collected is well corroborated and triangulated (Setia, 2016). The study was conducted in four villages (Losinoni Kati, Lengijave, Ngyeku and Sakila Juu) in Arumeru district in Arusha region, Tanzania. The choice of these villages was based on the fact that the villages are rural-based with reasonable mobile network connectivity. The mobile network connectivity implied that all prospective respondents in the study villages would have at least access to mobile phone services. Furthermore, the villages have in the past benefited from the project that focused on addressing climate change effects through community sensitization on the use of alternative/improved energy technologies. Such technologies focused on promoting the use of improved cooking stoves, hence discouraging the use of traditional open-fire cooking methods that makes use of little firewood and hence conserving the environment and forests.

Data collection was done through questionnaires, key informants (KIs) interviews, and focus group discussions (FGDs). Data collected from KIs involved four village extension officers, four village community development officers, One District forestry officer, and four retired government officials at village levels. Eight FGDs sessions were conducted as required data was attained. Each FGD comprised six to eight participants. Generally, there is no definitive number of focus group participants. Stewart *et al*. (2007) indicated that six to twelve is an ideal number as too many participants may be difficult to manage. Likewise, fewer than six tend to reveal less information and the discussion may be dull. Quantitative data for this study was collected using a structured questionnaire which was developed and pre-tested before being administered on face-to-face interviews with respondents.

The study population involved all residents of the four selected villages. Stratified sampling and simple random sampling techniques were employed to obtain representative samples. Stratified sampling was used to obtain the four villages. A total of 120 respondents, 40 from each village were involved in the study. To ensure each respondent has an equal chance of being selected, simple random sampling was used to select them. Analysis of the collected data was done based on both qualitative and quantitative techniques. Qualitative data was analysed using content analysis while quantitative data was analysed with the help of SPSS. Data gathered through field notes and recordings were transcribed prior to its analysis. Content analysis was used to analyse the textual data whereby Atlas.ti computer software enabled an analysis of data generated from FGDs and KIs. The data analysis involved scouring for meanings, patterns, surprises, contradictions, and silences in the textual data guided by research questions and theory. Data were then analysed in three stages including computer-assisted data reduction i.e. screening, coding, condensing, and transforming empirical data. The purpose of data reduction was to ensure that data can speak authentically. Secondly, the data display was done involving reduced texts and tables; and thirdly research conclusion was drawn (Taylor *et al*., 2011). Likewise, descriptive analysis was performed on the data that were collected through questionnaires. This therefore generated some descriptive findings in form of frequencies and percentages.

3.0 Discussion

3.1 Gender, Age and Education Level of Respondents

A total of 120 residents from four villages of Losinoni Kati, Lengijave, Ngyeku, and Sakila were involved in this study whereby 40 respondents were picked from each village. In terms of gender, the study involved both males (46) and females (74) as shown in Table 1. In all four villages, the number of women

exceeded that of men. The gender difference suggests that women are more likely to be affected more by climate change effects in the study areas than men hence the possibility of their need to engage in climate change-related aspects. The United Nations acknowledges that women and girls experience the greatest impacts of climate change, which amplifies existing gender inequalities and poses unique threats to their livelihoods, health and safety (UN, 2022). This is because across the world, women depend more on, yet have less access to, natural resources.

Concerning respondents' age, the study focused on study participants ranging from 18 years to over 60, largely representing the working-age population. According to Ritchie and Roser (2024) the working age population ranges from 15 to 64 years. Consequently, respondents were divided into three groups: from 18 to 35 years, 36 and 60 years, and above 60. The findings indicate that out of the 120 respondents, 28 were from 18 to 35 years, 59 were from 36 to 60 years, and 33 were above 60 years, as shown in Table 1. It is worth noting that, a majority of respondents (59) were between 36 and 60 years of age. If intentions are properly executed, this age group can form a nucleus for the adoption of ICTs interventions on climate change mitigation in their communities.

Table 1: Education Level of Respondents

Variable	Category	Frequency	Percentage
Gender	Female	74	61.7
	Male	46	38.3
	Total	**120**	**100**
Age (years)	18-35	28	23.3
	36-60	59	49.2
	Above 60	33	27.5
	Total	**120**	**100**
Education level	No formal education	14	11.7
	Primary	69	57.5
	Secondary education	29	24.1
	College/University	8	6.7
	Total	**120**	**100**

Source: Survey data (2023)

As far as education level is concerned, a study by Geldof (2010) established that literacy and ICTs use are 'tools' that have much in common and are very interdependent. Literate people are more likely to be 'good' users of sophisticated ICT tools and services than illiterates. In other words, ICT usage is likely to be affected by the literacy levels of the users. Thus, to establish the underlying ICT interventions for people in the study area, it was necessary to establish their level of literacy. In this study literacy levels were determined based on the respondents' educational attainment: respondents were categorized as illiterate if they had not attended any formal education; possessed low literacy if they had attended primary education; considered literate if they had attained secondary education; and classified as highly literate if they had received college or university education. The findings, as pointed out in Table 1, revealed that the majority of the respondents either possessed a low level of literacy or were illiterate. This is indicative whereby 69 (57.5%) respondents had only primary education and 14 (11.7%) respondents had not attended any formal education (Figure 1). Drawing upon Geldof argument (2010), it is likely that most rural residents are not 'good users' of sophisticated ICT tools and services. This further corroborates the findings of Salemink *et al*. (2017), suggesting that the constrained dissemination of technologies and the comparatively lower levels of education and skills in rural regions adversely affect the adoption and utilization of ICTs.

3.2 Gender, Age and Education Level of Respondents

3.2.1 Types and extent of ICTs uses

In addition to capturing the gender, age and education level of respondents, the study went further to establish types and extent to which ICTs are used among respondents. It was necessary to capture this aspect to ascertain common types of ICT tools used by respondents and the extent of its use. This information would help to suggest potential ICT based interventions for climate change mitigation in those rural areas. To achieve this, nine categories of potential ICTs tools/services were presented to respondents. These included: radio, TV, computers, smartphones, dumbphones (basic phones), tablets, websites, social media platforms, and information systems. A four-point Likert scale ranging from "very often", to "never used", was used to gauge respondents' extent of use of each of the presented ICT tools/services. Additionally, respondents had an opportunity to specify any other tools they were utilizing.

The findings revealed that, the most commonly used tool was dumbphones as indicated by 88 (73.3%) respondents. 22 respondents (18.3%) use dumbphones often, and 10 (8.3%) rarely use it. None of the respondents indicated to have never used the dumbphones. Radio was the next most used tool, where 31 respondents (25.8%) use it very often, 51 respondents (42.5%) often use it, while 38 respondents (31.7%) rarely use it and none of the respondents have never used it. This implies that the majority of respondents in the study areas used mobile phones (dumbphones) which were, unlike smartphones, had little to no computing or internet capacity. This in turn was likely to limit them from accessing climate change related information and knowledge. Most of respondents also indicated to use TV to a relatively larger extent compared to the rest of ICTs tools/services as shown in Figure 1. On the other hand, many respondents (above 50%) indicated to have never used computers (96, 80%), information systems (85, 70.8%), tablets (83, 69.2%) and websites (74, 61.7%) and social media platforms (66, 55%). This implies also that the majority of the respondents in the study areas had limited access to the modern ICTs tools and solutions.

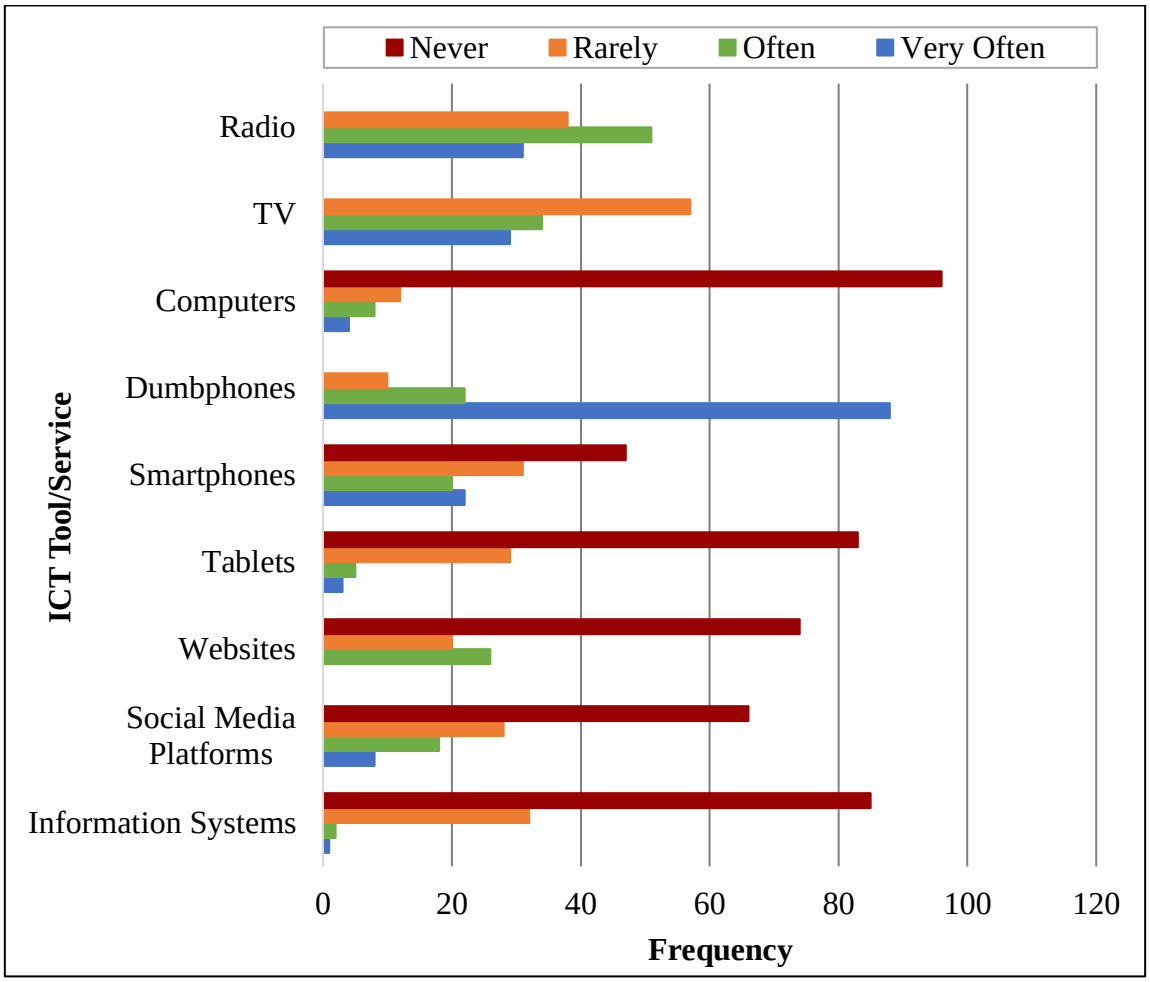

Figure 1: Extent of use of various ICT tools/services (*Source*: Survey data, 2023)

The findings on the extent of ICTs usage were cross-tabulated against education level to establish how literacy levels affect ICT tools use. Once more, the findings affirmed Geldof (2010) assertion that literate individuals are more inclined to be proficient users of advanced ICT tools and services compared to illiterate ones. This was evident from the fact that none of the respondents who had no formal education often used computers, smartphones, tablets, websites, social media platforms and information systems, whereas the opposite was observed for those who attended college or universities (Table 2).

Table 2: Cross-tabulation of Education level with ICT Tools/Services used "Very often"

ICT Tools/Service	Education Level			
	No formal education	Primary education	Secondary education	Tertiary education (College/University)
Radio	5 (35.7%)	13 (18.8%)	10 (34.5%)	3 (37.5%)
TV	4 (28.6%)	7 (10.1%)	12 (41.4%)	6 (75%)
Computers	0 (0.0%)	0 (0.0%)	1 (3.4%)	3 (37.5%)
Dumbphones	11 (78.6%)	52 (75.4%)	20 (69.0%)	5 (62.5%)
Smartphones	0 (0.0%)	5 (7.2%)	11 (37.9%)	6 (75%)
Tablets	0 (0.0%)	0 (0.0%)	2 (6.9%)	1 (12.5%)
Websites	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Social Media Platforms	0 (0.0%)	1 (1.4%)	4 (13.8%)	3 (37.5%)
Information Systems	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (12.5%)

Source: Survey data (2023)

Conversely, nearly all respondents who had never attended formal education had never used computers, smartphones, tablets, websites, social media platforms and information systems unlike those who attended college or university whom almost none of them indicated to have never used these ICT tools/services (Table 3).

Table 3: Cross-tabulation of Education level with "Never Used" ICT Tools/Service

ICT Tools/Service	Education Level			
	No formal education	Primary education	Secondary education	Tertiary education (College/University)
Radio	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
TV	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Computers	14 (100.0%)	64 (92.8%)	18 (62.1%)	0 (0.0%)
Dumbphones	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Smartphones	10 (71.4%)	37 (53.6%)	0 (0.0%)	0 (0.0%)
Tablets	14 (100.0%)	59 (85.5%)	10 (34.5%)	1 (12.5%)
Websites	14 (100.0%)	60 (87.0%)	0 (0.0%)	0 (0.0%)
Social Media Platforms	13 (92.9%)	53 (76.8%)	0 (0.0%)	0 (0.0%)
Information Systems	14 (100.0%)	69 (100.0%)	2 (6.9%)	0 (0.0%)

Source: Survey data (2023)

3.2.2 Factors contributing to the low extent of ICTs uses

Hiring the right people enables an organization to bring in employees who add value. It is not possible just to hire anyone; the organization wants people who are fit for the job. Organizations do their utmost best to hire exceptional people because they add the most value to the business. Commonly used selection instruments are structured and unstructured interviews, IQ tests, personality assessments, work tests, peer assessments, and reference checks. These (pre-employment) assessments are used to uncover three key candidate characteristics (Redman & Wilkinson, 2009).

The study sought to find out specific reasons as to why some ICTs tools/services were not used to a large extent by respondents in the surveyed villages. The findings showed that a significant portion of respondents (47.2%) cited affordability as primary reason for not using the identified tools, indicating that such tools were too expensive for them to afford. This implies that many respondents in the study areas lack financial capacity, making it difficult to access ICTs devices such as smartphones, computers, tablets and others. It was also difficult for the respondents to access internet services and meet its associated costs such as costly internet bundles. Moreover, 24.0% have never used them because they don't know how to use the tools, 24.2% have never used because the tools are not available in their places, and 4.6% have never used these tools because they don't know how the tools can help them. The findings from FGDs with community members revealed lack of enabling infrastructures such as power supply and knowledge to operate ICT tools as also among the reasons why some of the tools have never been used. It was revealed that access to consistent and reliable electricity was limited in the study areas making it difficult to power and sustain ICTs infrastructure. Moreover, inadequate internet connectivity was also reported to be a challenge in the study areas. This implies that community members in the study area have not managed to benefit to a large extent from the ICTs opportunities and thus less likely to access climate change information and knowledge benefits offered through such technologies.

This translates into realities that community members mainly smallholder farmers in the study area were not in a position to access ICTs related early warning systems for climate related disasters, extension services and technologies among other benefits. The findings were supported by one of the KIs who said that: *I understand and appreciate the role of ICTs such as internet and mobile phones in providing us with valuable climate change information such as weather forecasts and agricultural best practices on online platforms. Nonetheless, majority of us are not knowledgeable enough on how to access technologies. We are also lacking supporting infrastructure to enable many smallholder farmers to benefit from ICTs*" KI 1, May, 2023.

3.3 Respondents' Awareness on Climate Change

The study went further to establish if respondents are aware of climate change and its causes. The findings revealed that the majority of respondents about 68, (56.7%) were aware of the term 'climate change', while 52 (43.3%) were not aware. Those who indicated to be aware of climate change were further asked to indicate what they think causes climate change. The findings showed that 26 of the respondents admitted that cutting down trees causes climate change. While this is the case, Kulindwa (2018) highlighted that many rural residents still rely on traditional three-stone firewood stoves and charcoal stoves for cooking, contributing to significant deforestation due to high consumption of wood and charcoal or tree products. Other causes of climate change as per respondents were environmental degradation (18 responses), overgrazing (23 responses) and overpopulation (1 response). Even though the majority of the respondents were aware of climate change and its causes, most of them were not knowledgeable about the causes, effects and mitigation strategies of climate change appropriate to their local contexts. One of the KIs acknowledged that: "*We have been hearing on climate change from media and development officials but we do not exactly know as to what are the actual causes, effects and appropriate mitigation interventions relevant to our environments*" KI 2, May, 2023.

3.4 Respondents' Awareness on Climate Change

The study established the literacy level of respondents, revealing that 57.5% had only primary education, while 11.7% had not attended formal education. Additionally, it was found that the majority of respondents (73.3%) very often use dumbphones, unlike other ICT gadgets like smartphones, tablets, and computers, prompting further investigation into suitable ICT-based interventions for this demographic. Tulaskar (2020) suggested that for low-literacy groups it is important to consider the interaction designs of the systems or solutions developed for them. In that line, interventions that use simple system interactions and low-cost technologies such as SMS or USSD-based solutions, which could be offered via basic phone technologies were considered to be appropriate. Tummers *et al* (2019) suggested that with such a category of users, solutions provided should be in an easy and understandable way, unlike complex latest technologies.

Regarding a reasonably large portion of respondents having low awareness on climate change, the underlying ICTs interventions, as suggested by Ofoegbu and New (2021) should focus on information dissemination regarding climate change mitigation. Solutions such as community-based climate information centers, kiosks or documentaries, as proposed by Matto (2018) to facilitate the access to agricultural information to illiterate farmers can be adopted. In addition to other ICT interventions, Bakibinga-Gaswaga (2020) recommended providing access to radio and television for enhancing climate change information dissemination and access.

4.0 Conclusion and Recommendations

The study was carried out to investigate underlying ICT interventions for climate change mitigation in rural communities. In order to achieve its intended objective, the study focused on three key factors with regard to the rural community perspectives; community members' literacy level, basic awareness of the community members on climate change, and types of ICT tools commonly used and the extent to which such tools have facilitated community members access to climate change-based ICTs services. It was revealed that a significant portion of rural residents had lower levels of education, with many either lacking formal education or having completed only primary education. Moreover, the majority of rural residents primarily use basic phones (dumbphones) resulting in limited exposure to websites, tablets and smartphones. While this was the case, the study revealed that most of the respondents possessed only a basic level of knowledge and understanding about climate change. It is recommended that since most rural residents own dumbphones, there is a need for the government, private sector, Non-Governmental Organizations (NGOs) working in rural areas and other ICTs stakeholders to consider developing mobile-based educational tools and resources relevant to rural contexts. This should include SMS-based programs that can deliver regular climate change-related information and tips. Moreover, there is a need to consider developing interactive voice systems that provide audio-based climate change lessons accessible through basic phones. This will ensure that the majority of rural communities access climate change-related information and knowledge and other skills easily and less costly.

There is also a need to organize some training for community members in the study areas to capacitate them on how to use digital devices like tablets, computers and smartphones. This should include hands-on training on how to use such devices, access websites and navigate relevant climate change-related resources. To be effective such training may be provided in collaboration with the local community centres, schools, religious institutions and other organizations working in rural areas.

The study indicated that the three factors - literacy level, type of ICT used and basic understanding of climate change - are crucial aspects to consider when planning ICT interventions for addressing climate change causes, effects and mitigation, particularly in rural areas. The study thus calls upon implementers of ICT interventions, including policy makers, central government bodies, ICTs

stakeholders, individuals and the private sector, to take into account these factors when planning initiatives for climate change mitigation in rural areas.

References

Bakibinga-Gaswaga, E., Bakibinga, S., Bakibinga, D. B. M., & Bakibinga, P. (2020). Digital technologies in the COVID-19 responses in sub-Saharan Africa: policies, problems and promises. *The Pan African Medical Journal*, *35*(Suppl 2).

Chimanga, K. and Kanja, K. (2020). The Role of ICTs in Climate Change Adaptation: A Case of Small Scale Farmers in Chinsali District. Mathematics and Computer Science. Vol. 5, No. 6, pp. 103-109. doi: 10.11648/j.mcs.20200506.11.

Climate Counts (2023). https://qualitywaterlab.com/climate-counts/

Earth Hero (2023). https://www.earthhero.org/en_GB/

Falkner, R. (2016). The Paris Agreement and the new logic of international climate politics. *International Affairs*, *92*(5), 1107-1125.

FEWS NET (2023). Monitoring & forecasting acute food insecurity. https://fews.net

Food and Agriculture Organization (FAO), (2017). The state of food insecurity in the world. Available from http://www.fao.org.

Food and Agriculture Organization (FAO), (2018). The state of food insecurity in the world. Available from http://www.fao.org.

Food and Agriculture Organization (FAO), (2019). The state of food Food and Agriculture Organization (FAO), (2019). The state of food insecurity in the world. Available from http://www.fao.org.

Ford, J. D., Berrang-Ford, L., Lesnikowski, A., Barrera, M., & Heymann, S. J. (2013). How to track adaptation to climate change: a typology of approaches for national-level application. Ecology and Society, 18(3).

Franco, I. B., Tapia, R., & Tracey, J. (2020). SDG 13 Climate Action: Climate Education: Identifying Challenges to Climate Action. *Actioning the Global Goals for Local Impact: Towards Sustainability Science, Policy, Education and Practice*, 219-228.

Geldof, M. (2010). Literacy and ICT: Social Constructions in the lives of Low-literate Youth in Ethiopia & Malawi (Doctoral dissertation, Royal Holloway, University of London).

Imam, N., Hossain, M. K., & Saha, T. R. (2017). Potentials and challenges of using ICT for climate change adaptation: a study of vulnerable community in riverine islands of bangladesh. *Catalyzing Development through ICT Adoption: The Developing World Experience*, 89-110.

International Panel for Climate Change (IPCC) (2014). Global and Sectoral Aspects. (Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change). Climate Change 2014: Impacts, Adaptation, and Vulnerability., 1132.

Ireri, D. M., Awuor, M., Ogalo, J., & Nzuki, D. (2021). Role of ICT in the dissemination and access of agricultural information by smallholder farmers in South Eastern Kenya. *Acta Inform Malaysia*, *5*, 31-41.

Kissoly, L., Fasse, A., & Grote, U. (2020). Intensity of commercialization and the dimensions of food security: the case of smallholder farmers in rural Tanzania. *Journal of Agribusiness in Developing and Emerging Economies*, *10*(5), 731-750.

Kulindwa, Y. J., Lokina, R., & Ahlgren, E. O. (2018). Driving forces for households' adoption of improved cooking stoves in rural Tanzania. Energy strategy reviews, 20, 102-112.

Matto, G. (2018). Agricultural information access and the use of ICTs among smallholder farmers. Research Report Series, *5*(6), 59-72.

Murshed, M., Chadni, M. H., & Ferdaus, J. (2020). Does ICT trade facilitate renewable energy transition and environmental sustainability? Evidence from Bangladesh, India, Pakistan, Sri Lanka, Nepal and Maldives. *Energy, Ecology and Environment*, *5*(6), 470-495.

Nasa (2023). The Effects of Climate Change. Global Climate change https://climate.nasa.gov/effects/

Niyibizi, A., & Komakech, A. (2013). Climate change mitigation in developing countries using ICT as an enabling tool. In *Climate-smart technologies: integrating renewable energy and energy efficiency in mitigation and adaptation responses* (pp. 19-32). Berlin, Heidelberg: Springer Berlin Heidelberg.

Ofoegbu, C., & New, M. (2021). Collaboration relations in climate information production and dissemination to subsistence farmers in Namibia. *Environmental Management*, *67*(1), 133-145.

Ospina, V. and Heeks, R. (2012). ICT-Enabled Responses to Climate Change in Rural Agricultural Communities, Climate Change, Innovation & ICTs Project Strategy Brief.http://www.niccd.org/wp-content/uploads/2017/11/ICTs_and_Climate_Change_in_Rural_Agric_Communities_Strategy_Brief.pdf.

Pan, S., Carter, L., Teem, Y. and Sandeep, M. (2022). Digital sustainability, climate change, and information systems solutions: Opportunities for future research. *International Journal of Information Management,* Volume 63.

Ritchie, H. and Roser, M. (2024). Age Structure. Our World in Data. https://ourworldindata.org/age-structure

Salemink, K., Strijker, D., & Bosworth, G. (2017). Rural development in the digital age: A systematic literature review on unequal ICT availability, adoption, and use in rural areas. *Journal of Rural Studies*, *54*, 360-371.

Setia, M. S. (2016). Methodology Series Module 3: Cross-sectional Studies. *India Journal of Dermatology*, 61(3), 261–264.

Stewart, D. W., Shamdasani, P. N. and Rook, D. W. (2007). *Focus Groups: Theory and Practice* (2nd ed.). Thousand Oaks, CA: Sage. 200pp.

Taylor, B., Sinha, G. & Ghoshal, T. (2011). Research Methodology: A Guide for University, SWC Publications.

The United Nations (UN) (2022). Explainer: How gender inequality and climate change are interconnected [unwomen.org/en/news] site visited on 24.06.2023.

The United Nations (UN) (2023). The 17 Goals. https://sdgs.un.org/goals.

The United Republic of Tanzania (URT) (2021). National Climate Change Response Strategy (2021-2026). Vice President's Office, Division of Environment, Government Printer, Dodoma. Tanzania. https://www.vpo.go.tz/uploads/publications/en-1640772745-NCCRS%202021-2026_%20Final_PK.pdf

Tulaskar, R. (2020). Study of Instructional Illustrations on ICTs: Considering persona of low-literate users from India. In *Proceedings of the 2020 Symposium on Emerging Research from Asia and on Asian Contexts and Cultures* (pp. 53-56).

Tummers, J., Kassahun, A., Tekinerdogan, B. (2019). Obstacles & features of farm MIS: A literature review. Comp. Elect. Agric. 157, 189–204.

World Metrological Organization (2023). The Global Observation System. https://public.wmo.int/en/programmes/global-observing-system