

Open Distance Learning on climate change in empowering marginalised Nigerian communities to build resilience and adaption

Peter Sanjo Adewale ^{1*} Anthony Kola-Olusanya ², Florence Adeoti Yusuf ³
Jubril Busuyi Fakokunde ⁴, Florence Oluwaseye Adeleke ⁵, Olufunke Favour Akindahunsi ⁶ &
Nasrudeen Ayinde Malik ⁷

¹ Department of Environmental Education, Osun State University, Osogbo, Nigeria, 0000-0002-5342-8719

² Department of Environmental Education, Osun State University, Osogbo, Nigeria, 0000-0001-5915-2971

³ Department of Guidance and Counselling, Osun State University, Osogbo, Nigeria, 0000-0003-0232-583

⁴ Department of Science, Technology and Science Education, Osun State University, Osogbo, Nigeria 0000-0001-6956-9316

⁵ Department of Educational Management, Osun State University, Osogbo, Nigeria 0000-0002-1907-9914

⁶ Department of Arts and Social Science Education, Osun State University, Osogbo, Nigeria, 0000-0002-5041-7088

⁷ Department of Science, Technology and Science Education, Osun State University, Osogbo, Nigeria 0000-0002-5024-2011

*Corresponding author: peter.adewale@uniosun.edu.ng

Abstract

Marginalised communities are vulnerable to climate change (CC) impacts as they often lack the knowledge and resources to mitigate and adapt to the impact of CC. Therefore, this study examined the role open distance learning played in empowering marginalised communities to mitigate and adapt to CC. The study used a descriptive research method, and a multi-stage sampling technique was employed to select 5 marginalised communities in southwest Nigeria based on their vulnerability to climate change impacts and limited access to climate change education and training. 245 participants were randomly selected from the 5 communities comprised of community members, leaders and local government officials. Data was analyzed using frequency count with percentages. The result shows that open distance learning (ODL) has the potential to enhance the resilience of marginalised communities to the impacts of climate change. Distance learning programme on CC are effective in educating marginalised communities on the impact of CC and adaptation strategies. However, lack of access to technology was perceived as a major barrier for marginalised communities in accessing and participating in an open distance learning programme on CC. The researchers recommend that the National Information Technology Development Agency through its framework should advocate and support digital literacy for all in Nigerian marginalised communities. ODL curriculum on CC education should be improved through a community participatory approach.

Keywords: Adaptation, Climate change, Marginalised Communities, Mitigation, Open and Distance Learning

Introduction

Climate change (CC) is one of the major challenges that significantly stress individuals and families, in terms of food security and health. It has the potential to undo development efforts of several decades. While CC impact is a global threat, its

impacts are more tremendously felt by marginalised rural people living in poverty especially those in developing countries of the world. Their vulnerability is due to their high dependence on natural resources for livelihood

sustenance and limited capacity to cope with climate variability (Adedeji et al., 2014). Marginalised people are the disadvantaged, backward classes, minority workers, socio-economically backwards and poverty-stricken people in communities. Their recognition of the significance of education will drive them to struggle to attain empowerment by acquiring educational qualifications and literacy skills that would enhance their living conditions. In Nigeria, marginalised communities are particularly vulnerable to the effects

of CC. They are disproportionately affected by the impacts of CC and their capacity to adapt to these impacts is often limited by factors such as poverty, lack of access to resources and social exclusion therefore, making it imperative to empower the communities (Kharas, et al., 2019).

People are empowered when they have power and control over their own lives as well as getting the support they need. Empowerment refers to a process and outcome that involves enabling individuals, groups and communities to obtain resources that increase their spiritual, political or socio-economic strengths so that they have greater control over their environment and move towards achieving their personal or communal aspirations (Teater, 2014; Stoeffler, 2018). It also refers to the formulation of capabilities in individuals or groups to contribute effectively to their well-being. It is a process by which individuals can utilise the opportunities and prospects available to them effectively irrespective of restraints that surround them.

Open Distance Learning (ODL) refers to an act of teaching and learning opportunities that is flexible, open, sometimes self-paced and open to anyone, anytime and everywhere. It can potentially empower marginalised communities in Nigeria to address the impacts of CC. ODL provides access to education and training opportunities that can enhance the capacity of communities to manage the effects of CC. It also provides training on sustainable agricultural practices, renewable energy technologies and other strategies that

could assist communities adapt to the impacts of CC (Wam, et al., 2022).

ODL enables people of all ages and economic statuses to learn and acquire skills to survive. As noted by Wam, et al., (2022) democratising education is needed for environmental sustainability and increased sustainable citizenship. Informal education has the potential to democratise education but may sometimes fail to reach the targeted vulnerable and less privileged. ODL can be of particular interest to people who live in remote areas where formal education may not reach, including the marginalised and vulnerable people. According to Deisenrieder, et al., (2019), democratic, open learning systems and effective CC education are absent in formal schooling but promoted in ODL. ODL encourages participatory CC education initiatives which increase CC awareness, CC-friendly consumption and eco-friendly behaviour among school-age children. Warm, (2022) further emphasised that ODL can improve students' scientific literacy both in terms of knowledge and in a socially practicable sense for improvement of the health of the environment.

Environmental awareness, environmental sustainability and accessibility to homes and communities are promoted and increased through ODL. Since ODL tries to eliminate physical barriers to accessing education, adopting an online learning strategy could be effective in educating marginalised communities on CC issues. Furthermore, online learning has solidified its position in education around the world in recent years, particularly during and after COVID-19. Virtual platforms and settings are crucial to online learning, as they facilitate teaching and learning between educators and learners. Online learning advocates contend that despite its many obstacles, it can provide access for students who could not completely benefit from in-person learning. Open Distance Learning enables people from various backgrounds including the vulnerable and marginalised community to learn about environmental issues and sustainable practices. If the appropriate online learning platforms are put in

place, students who are marginalised due to their location, social status, and economic standing may experience significant progress. However, there are problems with the way online learning platforms are made, particularly with quality control, the available resources, the support that can be offered, and the price of internet connectivity (Ferri, et al., 2020).

Modupin (2014) identified the development and the gains through open and distance learning for environmental education. The scholar emphasized that ODL can improve access to environmental education through e-course materials and the open nature with which the programme is run. Due to ODL's nature of convenience and flexibility of study, the system can be used as a tool for learners who are marginalised to develop environmental sustainability skills, initiatives, innovation, capacity and the potential to become environmental sustainability citizenry. ODL provides opportunities to those who could not access the conventional education system in the mainstream due to finance, marginalisation, geographical location and academic qualifications. ODL education uses many teaching materials to assist the students. Such materials include study guides, course books, assignments, lecture notes and tutor-graded assignments.

CC is a phenomenon that threatens global food security and health. Its challenges are becoming rougher and tougher than ever imagined. CC interferes with all aspects of human life including schooling and school infrastructures. In Nigeria, noted that many children are absent from school during heavy rains, especially in the villages with no means of transportation apart from trekking (Rwobusiisi, 2021).

Creating the needed CC awareness is the main objective of CC education. This awareness could be made possible via corresponding topics in the Social Studies curriculum. Anyanwu and Njoku (2023) recommend that effective and efficient integration of concepts and learning experiences of both subject matters (i.e CC and social studies),

is a *sin qua non* if man's survival problem is to be addressed. With the advent of online distance learning, educational opportunities have increased and the need for education has been met by providing more access to experts, curricula and learning resources. There have been notable changes in teaching approaches because of distance learning (Boling, et al., 2012). As online learning platforms are democratised, it is critical to guarantee equitable access to challenging learning opportunities. The creation of an online curriculum and instructional protocols are examples of equitable treatment (Tate & Warschauer, 2022).

Online distance education is taking the place of traditional classroom instruction (Oncu & Cakir, 2011). These new strategies have the potential to democratise education by providing access to learning for marginalised people. The world's most vulnerable populations still do not have equal access to internet technology because they do not have the 'digital capital' needed to access online learning materials. Wainwright, (2009) admitted that understanding CC requires the development of a scientific research programme that will cut across fields of study in atmospheric science, oceanography, hydrology, geology, ecology, and environmental science. Ekanem (2015) opined that education in the 21st century emphasises the use of tools and technologies in training, assessing learning and for students' interaction within and outside the classroom environment for proper understanding and prospects.

Technology can be regarded as knowledge about a specific product or production technique. ODL typically utilises a variety of multimedia resources, including printed materials, video lectures, interactive online modules, and virtual classrooms to deliver instruction and facilitate learning. With the advent of online distance learning, educational opportunities have increased and the need for education has been met by providing more access to experts, curricula, and learning resources. There have been notable changes in teaching approaches because of distance learning (Boling et al., 2012).

The literature on technology in education like that



of Ahmad & Nisa, (2016) has highlighted the significance of utilising technology to support education. Technology is an integral element of the world today. Technological tools should take into consideration a multitude of features that facilitate access for many users, technologies that are focused on users and their needs, wireless technologies, tools that support synchronous and asynchronous communication, and tools for social networking and information access.

The impact of CC on education, infrastructure and global health systems cannot be ignored. Needed action must be taken to mitigate the impacts of CC on man. Achievement of inclusive quality education as stated in Sustainable Development Goal 4 of the United Nations may provide the needed solutions to this global threat. The major aim of environmental education (EE) is to create awareness and take needed action to mitigate and adapt to climate change. Therefore, this study examined the role ODL plays in empowering marginalised communities to mitigate CC, the barriers that prevent access and participation in open distance learning programme on CC and likely strategies to overcome the barriers in Southwest Nigeria.

Materials and Method

The study focused on marginalised Nigerian communities, specifically in southwest Nigeria that are highly vulnerable to climate change impacts. Therefore, a mixed-methods approach combining both qualitative and quantitative methods to achieve the research objectives was employed.

Figure 1: Map showing the Southwest of Nigeria.

Source: Aderogba et al., 2012

Research Design:

To assess the role of ODL in empowering marginalised communities to mitigate CC, the study used descriptive research design.

Study Location:

The Southwest area of Nigeria is predominantly the Yorubas and vulnerable to CC impacts. This area is constantly experiencing severe weather events like erosion and flooding which hinder the movement of people during raining season (Abdulhamid, 2011).

Sample and Sampling Technique:

A multi-stage sampling technique was employed to select 5 marginalised communities in southwest Nigeria based on their vulnerability to climate change impacts and limited access to climate change education and training. 245 participants were randomly selected from the 5 communities comprising of community members, leaders and local government officials.

Procedure for Data Collection:

Questionnaires and interview methods were used to collect data from the respondents. The questionnaires which were structured survey questions were distributed to the respondents while interviews using semi-structured questions used to conduct the interviews were conducted through phone calls and WhatsApp platforms.

Data Analysis:

Descriptive statistics were used to analyse quantitative data collected through questionnaires.

Ethical Considerations:

informed consent was obtained from respondents before the commencement of the interview and distribution of the questionnaire to collect data. Respondents were given a free opportunity to opt out of the study anytime during the study. Nigeria and Osun State University ethical guidelines for research were followed in the conduct of this study.

3. Results

The findings of this study provide valuable insights into the role of ODL in empowering marginalised communities to mitigate CC, the barriers that prevent access and participation in open distance learning programme on CC and likely strategies to overcome the barriers in Southwest Nigeria. The results presented below highlight the key outcomes of the study.

Demographic characteristics of respondents

Figure 2 shows the locations of residents. The study was carried out in selected states in Southwest Nigeria. Osun State has the highest number of respondents followed by Ogun then Lagos State. Osun has the highest number of respondents because the state is a typical rural state in Nigeria. a larger percentage of the respondents were females as females are the most vulnerable gender to CC impact, especially in marginalised rural areas (Figure 2). All the age groups were represented in the study (Figure 3).

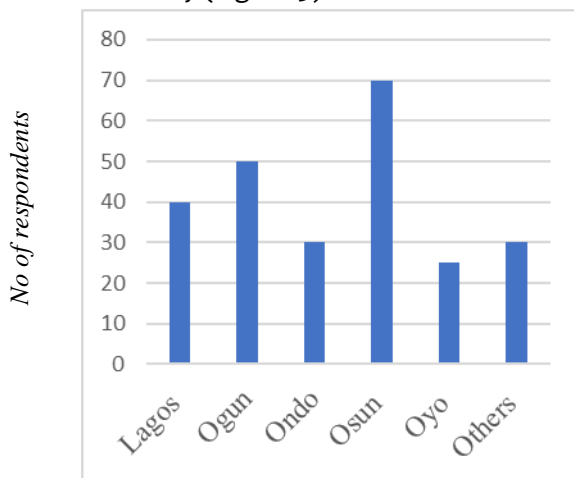


Figure 2: Chart showing the location of the respondents

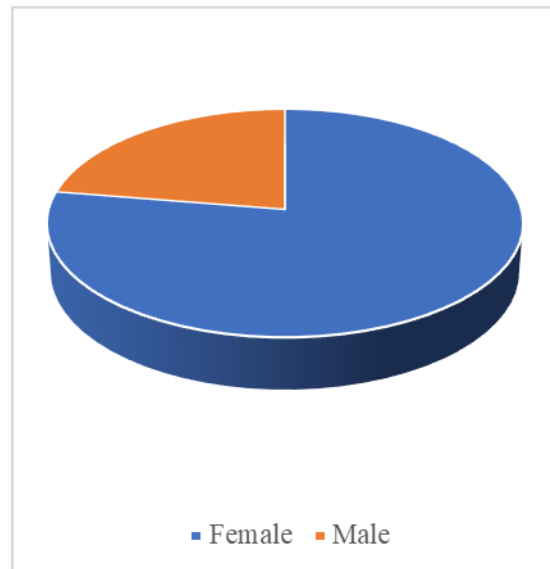


Figure 3: Chart showing the gender of the respondents

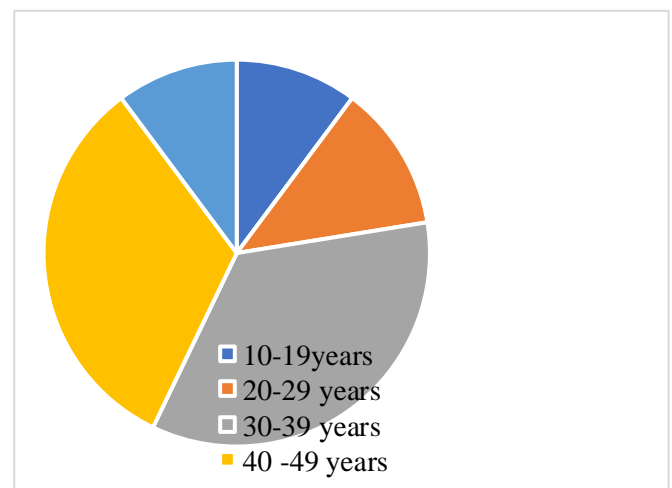


Figure 4: Chart showing age of respondents

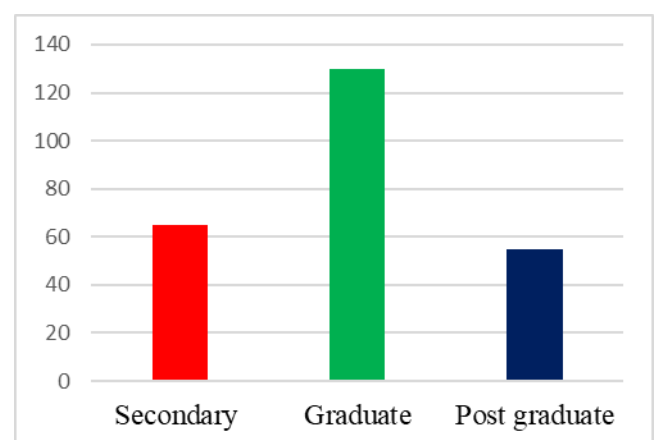


Figure 5: Chart showing the educational level of respondents.

The lowest level of education of the respondents was secondary school. Most of the respondents in the study are graduates. They have received one form of education or the other, especially through online platforms (Figure 5). From Figure 6 most of the respondents were civil/public servants. Table 1.

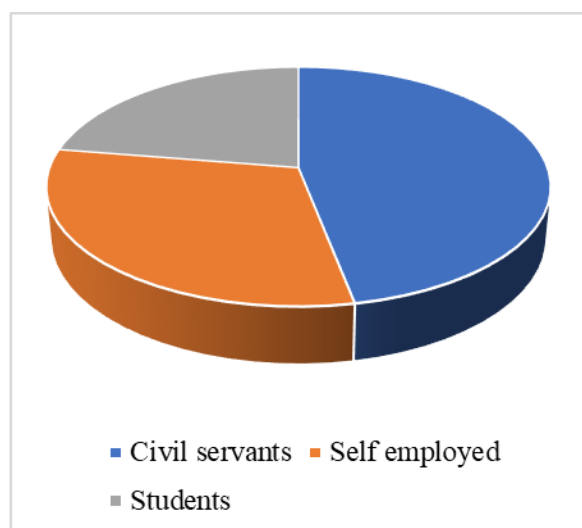


Figure 6: Chart showing the occupation of the respondents.

Open distance learning for CC mitigation in marginalised communities

Table 1 below shows the analysis of the role of open distance learning in empowering marginalised communities to mitigate and adapt to the impacts of CC. It can be seen from the table that 81% of the respondents agreed that open distance learning

programme are useful to keep marginalised communities informed on the impacts of climatic change, while 36% disagreed with it. Also, the table reveals that 85% of the respondents opined that ODL flexibility and learner-friendly approach permit the marginalised communities to embrace the programme and appropriate it for their well-being while 20% were disconcerted. Furthermore, almost all the participants agreed that the ODL programme on CC provides opportunities for marginalised communities to collaborate and share knowledge while 6% disagreed with it. Eighty-eight percent of the respondents thought that ODL programme on CC empowers marginalised communities to act on CC mitigation and adaptation while 12% disagreed with it (Table 1).

Furthermore, majority (90%) of respondents agreed with the statement that ODL programme can enhance the resilience of marginalised communities against CC. On the other hand, 55% of respondents felt strongly that free and easy access to open distance learning programme on CC will broaden the knowledge of marginalised communities on CC while another 43 % of the respondents agreed with the statement. This amounts to 98% of the respondents who believed that ODL on CC will broaden the knowledge of marginalised communities on CC (Table 1). Moreover, from Table 1, 92% of the respondents believe that utilising distance education media immensely will enhance participation in the learning programme on CC.

Table 1. Role of open distance learning in CC mitigation in marginalized communities

Item	SA Freq	A Freq	D Freq	SD Freq	Freq
1 Open distance learning programme are useful to keep marginalised communities who are unable to access the information elsewhere informedn the impact of CC.	60 24%	140 57%	40 16%	25 10%	
2 Open distance learning flexibility and learner-friendly approach permit the marginalised communities to embrace the programme and appropriate it for their well-being.	85 35%	110 45%	40 16%	10 4%	

3	Open distance learning programme on CC provides opportunities for marginalised communities to collaborate and share knowledge.	100 41%	130 53%	15 6%	0 0%
4	Open distance learning programme on CC empowers marginalised communities to act on CC mitigation and adaptation.	85 35%	130 53%	25 10%	05 2%
5	Open distance learning programme on CC has the potential to enhance the resilience of marginalised communities to the impacts of CC.	75 31%	145 59%	25 10%	0 0%
6	Free and easy access to open distance learning programme on CC will broaden the knowledge of marginalised communities on CC	135 55%	105 43%	05 2%	0 0%
7	Utilisation of distance education media in an immense way will enhance participation in the learning programme on CC	110 45%	115 47%	20 8%	0 0%

Strategies to overcome the barriers that prevent access and participation in Open Distance Learning Programme on CC

Lack of access to technology is perceived by the respondents as a major barrier for marginalised communities in accessing and participating in open distance learning programme on CC. On the other hand, creating awareness and campaigning for open distance learning programme on CC among marginalised communities was strongly agreed to by only 33% of respondents, while another 57% of the respondents agreed with the statement (Table 2). Tailoring open distance learning programme on CC to the specific needs and contexts of marginalised communities was seen as important by 98% of respondents, while 2% of the respondents disagreed with the statement.

Additionally, majority (94%) of respondents agreed that open distance learning programme on CC should be complemented by face-to-face interactions to enhance their effectiveness, while 6% agreed with the statement. All the respondents believed that promoting sustainable practices among marginalised communities through open distance learning programme on CC that include practical and hands-on activities was seen as important. This suggest that while there is a recognition of the importance of open distance learning programmes on CC among marginalised communities, there are still challenges that need to be addressed to make these programme more effective

Table 2. Strategies to overcome the barriers that prevent access and participation in Open Distance Learning Programme on CC

S/N	Item	A			
		Freq	Freq	Freq	Freq
1	Lack of access to technology is a major barrier for marginalised communities in accessing and participating in open distance learning programme on CC.	105 43%	140 57%	0 0%	0 0%
2	Creation of awareness and campaign of open distance learning programme on climatic change among the marginalised communities.	80 33%	140 57%	25 10%	0 0%
3	ODL should address the needs of vulnerable marginalised communities.	130 53%	110 45%	05 2%	0 0%

4	For ODL to be effective, it must incorporate face to face interactions.	105 43%	125 51%	15 6%	0 0%
5	For ODL to promote sustainable practices it should be practical oriented.	125 51%	120 49%	0 0%	0 0%

SA= strongly agree; A = agree; D = disagree, SD= strongly disagree

The following illustrate the qualitative result of the study.

The impact of ODL on participants' knowledge, attitudes and practices related to climate change. The results shows that the ODL programme was effective in increasing participants' awareness and knowledge of CC. This is evident in the quotes from the participants who reported gaining deeper understanding of CC causes, effects and adaptation strategies. This has increased their level of awareness and knowledge which are crucial in empowering marginalised communities to build resilience and adaptation to CC. By understanding the risks and impacts of CC, communities can better prepare and respond to climate-related disasters.

Moreover, the respondents' attitudes towards CC were reported to be positive. Many reported a greater sense of responsibility and urgency to address CC as well as an increased willingness to adopt climate-resilient practices. In addition, majority of the respondents believed that change in attitude and perception, ODL programme can have impact on communities' ability to adapt to CC. Many respondents reported that adopting climate-resilient practices such as using energy-efficient stoves and promoting sustainable agriculture. By adopting climate-resilient practices, communities can reduce their vulnerability to climate-related disasters and improve their overall well-being. The results also highlight the challenges and opportunities associated with implementing the ODL programme on CC. Participants reported challenges such as limited access to technology and internet connectivity as well as opportunities such as increased access to CC information and networking with other communities.

Discussion of Findings

The study examined the role of ODL in empowering marginalised Nigerian communities to mitigate and adapt to CC impact and determine the strategies to overcome the barriers that prevent access and participation in ODL programme on CC. Regarding the effectiveness of ODL in educating marginalised

communities on CC and their adaptation strategies, it was observed that ODL has the potential to enhance the ability of marginalised communities to cope with the impacts of CC. Open distance learning programmes on CC have proven to be highly effective in educating marginalised communities, especially as they break the barrier of time, space and distance. The findings revealed that the ODL programme can provide a good avenue to keep marginalised communities informed on the impacts of CC. This is in line with the view of Modupin (2014) who emphasised that ODL could improve access to environmental education through e-course materials.

The results also showed that access to ODL has the potential to enhance the ability of marginalised communities to cope with CC impact. ODL is effective in promoting CC education and environmental sustainability (Caetano et al., 2018). Moreover, the findings showed that the flexibility and learner-friendly approach of the programme permits the marginalised communities to embrace the programme and appropriate it for their well-being. Furthermore, the findings also showed that access to open distance learning programme on CC will broaden the knowledge of marginalised communities on CC, this is in agreement with Wam (2022) who expressed that democratizing education is needed for environmental sustainability. Also, it was discovered that ODL programme on CC empowers marginalised communities to adopt CC adaptation strategies; this was supported by Allen et al., (2009).

Accessibility to technology, engagement in practical and hands-on activities as well as awareness creation of ODL programme among marginalised communities are part of the strategies that can be adopted to overcome the barriers that prevent access and participation in open distance learning programme on CC. The use of multi-media in reaching the unreached is an effective means of disseminating CC education. Lack of access to technology is a major barrier for

marginalised communities in accessing and participating in Open Distance Learning Programme on CC. The findings strengthened Ekanem (2015) who opined that education in the 21st century emphasises the use of tools and technologies in training, assessing learning and for students' interaction within and outside the classroom environment for proper understanding and prospects.

Similarly, the findings approved that ODL programme on CC should be complemented by face-to-face interactions to enhance their effectiveness. The findings also established that the ODL programme on CC should include practical and hands-on activities to promote sustainable practices among marginalised communities. The findings agreed with Wainwright (2009) who admitted that understanding CC requires the development of a scientific research programme that will cut across fields of study in atmospheric science, oceanography, hydrology, geology, ecology and environmental science.

Conclusion

This study concluded that an open distance learning programme is useful in keeping marginalised communities who are unable to access information elsewhere informed on the impact of CC. Open distance learning programme on CC have the potential to empower and inform marginalised communities, while also providing opportunities for collaboration and knowledge sharing. ODL has the potential to assist the marginalised communities to cope with the impact of CC on people's livelihood. It is effective in educating marginalised communities on CC mitigation. Open distance learning can provide access to education and training that might not otherwise be available. However, poor access to technology is perceived as a main barrier for marginalised communities in accessing and participating in open distance learning programme on CC.

Recommendations based on the study:

It is recommended that ODL curriculum on CC education should be improved through a community participatory approach. Moreover, efforts should be geared towards creating awareness about open distance learning and CC education. The National Information Technology Development Agency (NITDA) through its

framework should advocate and support digital literacy for all in Nigeria. It is important that local government authorities in each state should provide more support for marginalised communities by providing electricity and internet facilities that will enable people in such areas to connect successfully with ODL programme on CC.

Competing interests: All the authors affirm that there are no competing interests.

References

- Abdulhamid, Y. (2011). The Impact of Climate Change in Nigeria. *Computer Engineering and Intelligent Systems*, 2(4), 18-26.
- Adedeji, A., Reuben, O. and Oatoye, O. (2014). Global Climate Change. *Journal of Geoscience and Environment Protection*, 2, 114-122 <http://dx.doi.org/10.4236/gep.2014.22016>
- Aderogba, K., Oderinde, F., & Bakare, H. (2012). Spatial assessment of fresh water supply in Southwest Nigeria. *Journal of Geography and Regional Planning*, 5(1), 6.
- Allen, Urwin, Ayers, J., & Forsyth, T. (2009). Community-Based adaptation to climate change. *Environment: Science and Policy for Sustainable Development*, 51(4), 22-31. <https://doi.org/10.3200/env.51.4.22-31>
- Anyanwu, J., & Njoku, C. (2023). Integrating Climate Change Education into Social Studies Curriculum at The Basic Education Level. *International Journal of Education, Learning and Development*, 11(2), 33-40. <https://doi.org/10.37745/ijeld.2013/vol11n23340>
- Boling, E. C., Hough, M., Krinsky, H., Saleem, H. M., & Stevens, M. (2012). Cutting the distance in distance education: Perspectives on what promotes positive, online learning experiences. *The Internet and Higher Education*, 15(2), 118-126. <https://doi.org/10.1016/j.iheduc.2011.11.006>
- Caetano, F. J. P., De Oliveira, C. P., De Araújo, M. F. F., & Rêgo, M. C. F. D. (2018). Towards Climate Change Awareness Through Distance Learning—Are young Portuguese and Brazilian university students vigilant? In *Climate change management* (pp. 261-273). https://doi.org/10.1007/978-3-319-70199-8_15
- Deisenrieder, V., Kubisch, S., Keller, L., & Stötter, J. (2020). Bridging the action gap by democratizing climate change education—the case of kidZ 21 in the context of Fridays for Future. *Sustainability*, 12(5), 1748.

- Ekanem, E. J. (2015). Problems and prospects of education. *Journal of Education and Practice*, 6(30), 66-71.
- Ferri, F., Grifoni, P., & Guzzo, T. (2020). Online learning and emergency remote teaching: Opportunities and challenges in emergency situations. *Societies (Basel, Switzerland)*, 10(4), 86. doi:10.3390/soc10040086
- Kharas, H., McArthur, J. W., & Ohno, I. (Eds.). (2019). *Leave no one behind: time for specifics on the Sustainable Development Goals*. Brookings Institution Press.
- Modupin, C. (2014). Capacity Development Through Open and Distance Learning: A Case Study of National Open University of Nigeria's Environmental Science and Resource Management Programme. *International Women Online Journal of Distance Education*, 3(4), 22-32.
- Oncu, S., & Cakir, H. (2011). Research in online learning environments: Priorities and methodologies. *Computers & Education*, 57, 1098-1108.
- Rwobusiisi, S. T., Dhliwayo, A., Kiwonde, F., Makewa, L. N. & Kalulu, R. (2021). An assessment of the extent of inclusion of climate change in secondary school curricula in Africa: A content analysis. *Journal of Research Innovation and Implication in Education*, 5(3), 71 – 83.
- Stoeffler, W. S. (2018). *Community Empowerment*. V A. R. Cnaan, & C. Milofsky, Teater, B. (2014). *An introduction to applying social work theories and methods*. Berkshire: Open University Press.
- Wainwright, J. (2009). *Earth-System science*. In N. Castree, D. Demeritt, D. Liverman, & B. Rhodes (Eds.), *A companion to environmental geography* (pp. 145-167). Oxford: Wiley-Blackwell.
- Wam, H. K., Gozdzik, A., Aspholm, P. E., & Junczyk, T. (2022). Democratizing education: Open schooling engaged the less privileged in environmental sciences. *PLOS ONE*, 17(4), 1-19. e0266655. <https://doi.org/10.1371/journal.pone.0266655>