Social Studies Teachers' Knowledge of Climate Change: The Role of Social Studies Education

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DOI: https://dx.doi.org/10.47772/IJRISS.2025.9010233

Received: 07 January 2025; Accepted: 11 January 2025; Published: 15 February 2025

ABSTRACT

As the adage says 'when the last tree dies, the last man dies'. This signifies that, climate change can be abated when conscious efforts are put in place to harness the conservation of our natural environment. On the contrary, this present society is preoccupied with industrialization and development which has led us into this current quandary. This current study investigated Social Studies teachers' knowledge of climate change. A simple random sampling technique was employed for 40 public Junior High School teachers. Data was collected using Social Studies Teachers' Knowledge of Climate Change Questionnaire. Descriptive statistics with mean and standard deviation was utilized to analysed and present the data logically. The results of the study revealed that, Social Studies teachers have a robust knowledge of climate change and it measures to curb climate change in our natural environment. The study recommended that, in order to boast climate change education in both schools and communities, teachers should involve learners to perform pro-environmental activities in our environment. Also, the forestry commission, and the environmental protection agency should educate citizens on the need to protect our environment.

Keywords: Climate, Human-induced, Regenerative agriculture, Conservation, Afforestation.

INTRODUCTION

Our natural environment is wrecking as the clock ticks by. The prime impugn that is causing these deteriorations in our natural environment is climate change. As posited by the Sixth Report for the Intergovernmental Panel on Climate Change (IPCC, 2022), climate change is a major canker undermining our natural environment in this current dispensation. Ban Ki Moon (UNESCO, 2010), posited that, the main challenge in the 21st Century is climate change. Ekpoh (2009), assert that, climate change is change in the climatic pattern of a particular place or geographic zone. It is an anomalous deviation in the Earth climate that occurs over a duration that spans from decades. This is validated that, global temperature has induced due to the anthropogenic and natural processes of climate change (Ekpoh, & Ekpoh, 2011).

Environmental degradation and climate change are intertwined menace wrecking our planet Earth (Piguet, 2022). These menaces have induced because our contemporary society is obsessed with industrialization and also look down on the modification in our natural environment and their repercussions (Lubcheno, Heather, & Eli, 2022). In fact, the influx of industrial activities, combustion of fossil fuels, and extraction of natural resources such as diamond, crude oil, gold has been the spine of global economic activities, and illegal mining, deforestation, expansion in agriculture, land-use, and urbanization have overcome practicing afforestation, crop rotation, and cover cropping, leading to far-flung environmental alteration (Wang, et.al, 2021). For instance, deforestation and combustion of fossil fuels have exacerbated greenhouse gas emission and have

severely affected precipitation patterns and global temperature (Piguet, 2022). Climate change is an urgent issue, and its consequences are displaying all over the world in the form of anomalous weather occurrences and related misfortunes, subsuming exacerbated forest fire in the Amazon, United State of America, and in Australia (Piguet, 2022).

Climate change is a spurious challenge, and it consequences are signaling all over the world in the form of deviation in weather conditions, and related misfortunes, which subsume induced forest fire in the United State of America, and in Australia (Marlon, Bartlen, Garvin et.al, 2012; Canadell, Meyer, & Cook, 2021), increase in sea-level rise (Perkins, 2022), hastened melting of glaciers, changes in river flow regime (Gudmundson, Boulanger, & Do, 2021), drought in South Africa (Meza, Rezaei, & Siebert, 2021), and excessive rainfall in China (Sun, Zhang, & Ding, 2022) rising passage of infectious diseases (Ford, Zavaleta-Cortijo, & Ainembabazi, 2022) and loss of biodiversity (Roman-Palacois, & Wiens, 2020). These connote that climate change is a canker to our natural environment and humans, it is significant to find means to adapt and mitigate its consequences before it escalates.

The deterioration of forest cover, agricultural activities, collapse of the ecosystem, and forest reserve had led to loss of bio-diversity, and other significant constituents in our natural environment. Climate change is concurrently happening all over the world. One major avenue to deal with this menace is through continuous education. This is in line with the specific aims of Social Studies curriculum (NaCCA, 2020), which posit that, Social Studies will enable learners to (i) explore and protect their natural environment. It is based on this that NaCCA (2020), Social Studies curriculum views that, Social Studies will enhance learners to develop thorough knowledge, comprehension, skills and competencies to solve issues from multifarious angles. In this context, teachers are recognized as significant climate change agent (Anderson, 2018), who are dubbed as multipliers of knowledge and actions. Social Studies teachers serves as the nucleus in combating the dent of climate change in our natural environment. They are able to throw in a lot of efforts to avert persistent consequences of climate change (Otto, Donges, Doe, Hewitt, Rockstrom, Cremades, Lucht, & Allerberger, 2020). This clarion call for the essence to inquire on Social Studies teachers' knowledge and measures to curb climate change in Assin Foso Municipality.

Problem Statement

Climate change is a mammoth impugn in our natural environment. Changes in climate are unequivocal, and already undermining living and non-living things in our environment. Climate change is echt, and imperative impugn that is already causing great havoc to our environment (Braman et al., 2010). There is modification happening on the Earth surface that subsumes melting of glaciers, deforestation, sand winning, illegal mining, water pollution and rising temperatures (EPA, 2010; MOA, 2011). Therefore, enlighten learners about the primary causes, effects and measures to avert the challenges posed by climate change is decisive, and the utilization of Social Studies which is environmentally inclined is pivotal in furnishing Social Studies teachers with the needed resources for dealing with the challenges or impugn created by climate change in our natural environment. This is because Social Studies as a subject has the potency to make learners wary about the protection of their environment and the prudent use of resources as it targets.

According to Kwenin (2019); Bordoh, et. al., (2021), affirm that, Social Studies is a multidisciplinary field of study that abduct skills, experiences and knowledge from the humanities and social sciences to spur civic competencies. It boasts learners to make rational and informed decisions about how to display good behavior toward their natural environment and how to bate the environment from any deterioration. Thus, Social Studies makes prudent use of other humanities and Social Sciences such as history, geography, economics, political science and psychology. This evince that, Social Studies education requires citizens to develop adequate knowledge, skills and desirable attitudes and values towards the sustainability of their natural environment. This connote that, Social Studies require citizens to make expedient decisions that will ensure the sustainable development of our society as well as our environment. This is why Social Studies curriculum is poised with furnishing learners with thorough knowledge in protecting our natural environment which will not result in climate change.

However, the researchers' interaction and observation with majority of Social Studies teachers in the Assin Fosu Municipality revealed that, teachers have deficit knowledge in terms of content knowledge and

knowledge about measures to curb the impugn of climate change. The curriculum leaps out several content areas that correlate with climate change. For instance, in the Junior High School curriculum, the content coverage of climate change is vividly not covered. The major strands that colligate with climate change is: environmental issues which is been fragmented and taught at BS7, 8 and 9 (NaCCA, 2020). Here, the strand environment is being accentuated at various levels but both learners and teachers do not delve into climate change in toto. It explicit that, the content of the Social Studies curriculum does not answer the challenges of climate change in our environment. The inference is that; Social Studies teachers are deficient to face up the impugn of climate change. It is against this backdrop that; the current study seeks to investigate Social Studies teachers' knowledge and measures to curb climate change in our natural environment.

Purpose of the Study

The essential objectives of this research were to investigate Social Studies teachers' knowledge on climate change. Generally, the study seeks to:

1. examine Social Studies teacher's knowledge about climate change.
2. identify measures to curb climate change in our natural environment.

Research Questions

The following research questions were considered to guide the study:

1. What is Social Studies teachers' level of knowledge about climate change?
2. What are the measures to curb climate change in our natural environment?

LITERATURE REVIEW

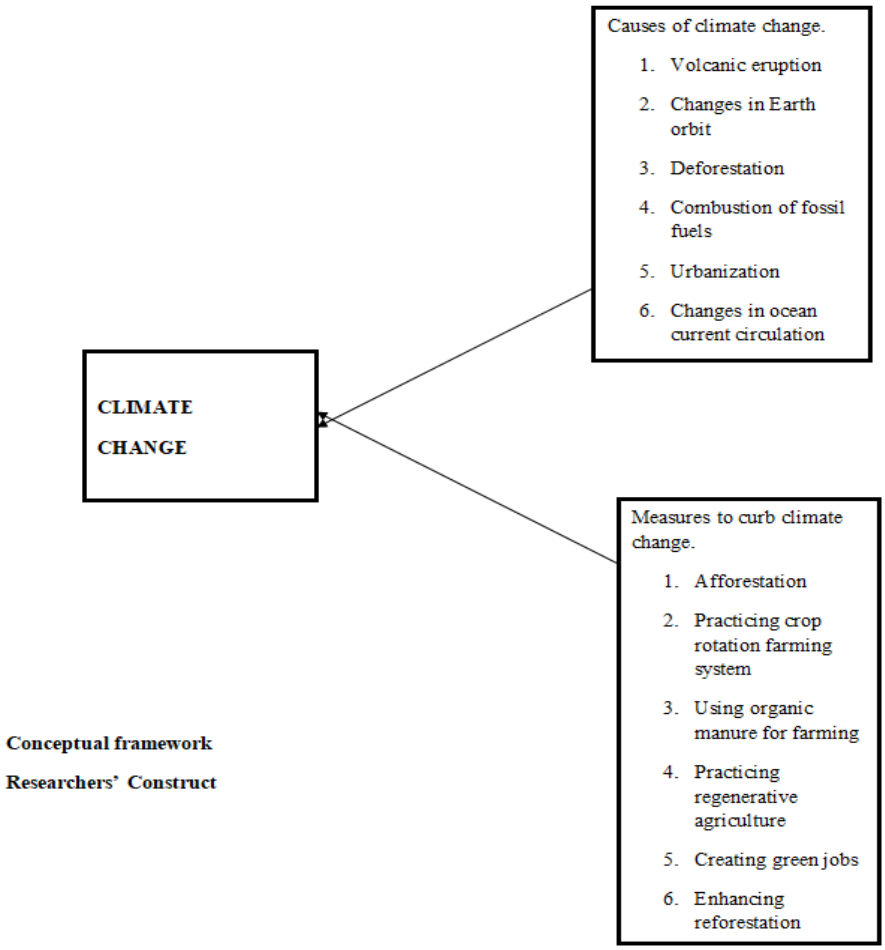
In cognizance to the urgent incorporation of climate change education both inside and outside of the classroom, teachers are inducing their knowledge of climate change in Social Studies. Serrousi, Rothschild, Kurzbaum, Yaffe, and Hemo (2019), investigated teachers' knowledge, beliefs, and attitudes about climate change. Their findings uncovered the lacuna among teachers' knowledge of climate change; teachers content knowledge of climate change was meager. Anyanwu et al. (2015), studied climate change science: The literacy of geography teachers in Western Province, South Africa. Their research divulged that majority of high school geography teachers significantly understands the processes, and causes of climate change rather than its consequences and solutions to this menace. Tolppanen et al. (2020), investigated pre-service teachers' knowledge and perceptions of the impact of the mitigative climate actions and their willingness to act. Their study revealed that pre-service teachers' have minimal knowledge on the causes and repercussions of climate change. Due to deficient knowledge of climate change problems, it blemishing to validate that, knowledge of climate change mitigation is also low. Anyanwu (2019), inquired the level of climate change science literacy among teachers in Seychelles. This study illuminated that majority of teachers have moderate knowledge regarding the causes, effects and solutions. In order to fill the void, continuous climate change education is a pivotal tool in inducing teachers. Ugwu et al. (2021), studied the assessment of climate change knowledge and attitudes among secondary school teachers in Enugu state. Their study underscore that, teachers possess moderate knowledge of climate change. Herman et al. (2017), studied Florida and Puerto Rico secondary Science teachers' knowledge of climate change. The study indicated that many teachers' hold inadequate knowledge about climate change and climate science. Abasto et al. (2023), studied the alternative conceptions about climate change in a group of teachers in Chile: Are Science teachers more knowledgeable than non-Science teachers? The outcome of the study revealed that, both Science and non-Science teachers' knowledge of climate change are at par. This intricate that the content knowledge of teachers regarding climate is very moderate about the various concept of climate change. The varied studies throw more light about the content knowledge and pedagogical knowledge of teachers regarding climate change and the unpreparedness on the part of teachers. The disparity in teachers' knowledge of climate change signifies that majority of teachers' have meager knowledge of climate change. Conversely, the studies indicated the differences in teacher knowledge and awareness of climate change. On the contrary, other teachers exhibited feeble knowledge whilst others displayed potent knowledge of climate change. Ameliorating teachers' knowledge through consistent in-

service training, provision of adequate teaching-learning resources, practicing pro-environmental activities such as afforestation, regenerative agriculture serves as an avenue to induce learners' knowledge and awareness of climate change education.

Conceptual Review

The current state of our natural environment is in dilemma. Climate change is conceived as the most comprehensive global environment (Mccright, 2010), political (Giddens, 1999) and economic (Stern, 2007), impugn that mankind is toiling with. As a result, it has become the prominent discussion throughout the world (Weber, & Patern, 2009). Educating learners on the consequences, causes, and mitigation as well as prudent measures to abate climate change is significant to face up this accumulated human-induced occurrence (Boble, Downing, & Watts, 1994). In addition, education is a cornerstone targeted at furnishing teachers and learners with the maximum competencies and knowledge to combat the menace of climate change and its consequences (UNESCO, 2009). According to (Ofie-Nkansah, 2021; Dyster, 2021), education is the potent conduit for involving learners and preparing them to understand the concept of climate change. Teachers serves as the nucleus in propagating climate change education (Favier, Gorp, Cyvin, & Cyvin, 2021). They are dubbed as climate change agents (Andersen, 2018) who are denoted as multipliers of action and knowledge. They again act as the orchestrators who are obliged to contribute their quote to aid in solving the perilous repercussions of climate change. In this regard, continual climate change education about the challenges and measure to avert it dent will resonate in learners by practicing pro-environmentally friendly activities in our natural environment.

Consequently, furnishing learners with the appropriate knowledge and competencies about climate change should not be restricted only to the classroom but rather learner - centered, participative, flexible, community - based and action, which will enable learners to stimulate their full capabilities to solve the menace of climate change in our environment. This alludes that climate change education epitomize practicing hands-on activities such as afforestation, reforestation, using organic manure for farming, practicing crop rotation, growing cover crops, recycling of waste materials, reduction in combusting of fossil fuels and practicing ecological farming.



Conceptual framework

Researchers' Construct

MATERIALS AND METHODS

Research design and Description of the study area

The descriptive survey design was utilized for this study. The essence of descriptive survey design points out that it allows researchers to collect enormous data, recruits' participants for the study and boast the employment of multivariate methods of instrumentation (Ponto, 2015). This coincide with Frankel and Wallen (2003), who posit that, descriptive survey provides significant view of events and seeks to elaborate respondent's comprehension on information collated at a point in time. The researchers employed this design to determine Social Studies teachers' comprehension of climate change as it exists during the period of the study.

This study was conducted out in the Assin Fosu Municipality in the central region of Ghana. This Municipality is in the northern corner of the region. The Municipality is situated in the semi-deciduous vegetation zone. The topography of this area is a valley with few isolated hills. The main occupation of the inhabitants is farming, trading and service.

Population

The population for the study comprised of 40 social studies teachers in public Junior High Schools in the Assin Fosu Municipality. Assin Fosu Municipality was selected for the study due to the fact that, majority of the teachers though have earned the essential qualifications (diploma in basic education, bachelor's degree and master's degree), in Social Studies, the qualification alters from one to another in terms of scope of content of their qualification. Simple random sampling was employed for 40 Social Studies teachers. It was utilized in this present study because it offered equal opportunity for respondents to be selected in the sample from the population (Acharya, Prakash, Saxena, & Nigam, 2013). Simple random sampling is impartial in its selection process. It represents the actual population. On the contrary, it is cumbersome and rarely utilized. Also, it is difficult to utilize when the population is dispersed and heterogeneous. However, the outcome of the research can be inferred for all Social Studies teachers within the Assin Fosu Municipality.

Instrument for data collection

Questionnaire was utilized to collate data for this study. The questionnaire was a self-inventory with a three-point Likert-type scale titled Questionnaire on Social Studies Teachers' Knowledge on Climate Change (QSSTCCC) with 1=adequate, 2=uncertain, 3=inadequate. The questionnaire was in three sections, section A, B, and C. Section A required respondent to provide bio-graphic data such as teaching experience, age, gender educational qualification. Section B demanded respondents to point out their level of knowledge of climate change whilst Section C required respondents to indicate the measures to curb climate change in our natural environment. The items in section B and C were examined on 1 to 3 Likert-type scale (1=adequate, 2=uncertain, 3=inadequate). The weights were summed up to get the average for the worthy mean value (1+2+3=6; 6/3=2). This signifies that, the mean value of 2 denote that respondents were uncertain with the statement or items and a mean value from 1.0 to 1.9 meant respondents had inadequate knowledge on climate change while mean value of 2.1 to 3.0 meant that respondents' knowledge was adequate. The utilization of questionnaire was favored because it enhanced an extensive coverage of respondents and made it easily accessible for me to contact respondents. It made respondents to answer the items swiftly. On the contrary, it consumes time and energy. However, five questionnaires were not returned.

DISCUSSION OF FINDINGS

This chapter indicates the outcome and discussion of this current study. The logical presentation of the results encompasses: Social Studies teachers' knowledge on climate change, and measure to curb climate in our natural environment.

Table 1: Teachers' knowledge on climate change

Statement	Adequate	Uncertain	Inadequate	Mean	Standard Deviation
1. The natural causes of climate change includes earthquakes, permafrost and forest fires.	25	09	05	2.51	0.72
2. Nitrous oxide, hydrofluorocarbons, carbon dioxide are all examples of greenhouse gases.	33	06	01	2.80	0.46
3. The causation of climate change in our natural environment are human-induced activities and natural processes.	34	05	01	2.83	0.44
4. Climate change is the shift in the climatic pattern mainly caused by greenhouse gases.	35	03	02	2.96	0.50
5. Heatwaves, wildfires, severe storms, droughts and flood are all effects of climate change.	39	01		2.97	0.16
6. Alteration in temperature, changing seasonal variability are all signs of climate change.	33	06	01	2.80	0.46
7. Emphasizing on renewable energy such as solar, wind and water energy.	32	08		2.80	0.40
8. Climate change education is a conduit to avert climate change in the environment.	35	05		2.87	0.33
9. Fossil fuels remains the primary source of emission into the atmosphere.	37	02	01	2.90	0.37
10. Afforestation and reforestation are relevant in averting the canker of climate change.	37	O2	01	2.90	0.37

Source: Field Data, 2024.

The results from **Table I** explicitly indicates that, majority of the respondents (N=40, M=2.97, SD=0.16), had adequate knowledge that heatwaves, wildfires, severe storms, droughts, and floods are all effect of climate change. This statement concurs with the findings of Fawzy, Osman, Doran, and Rooney (2020), posit that the numerous human-induced activities in our natural environment have attributed to a lot of repercussion of climate change which pose several detriments on living and non-living things. Similarly, the United Nations Climate Change secretariat (UNCC, 2019), also affirm that heatwave, floods, droughts, severe storms, and wildfires are all climate hazard in our natural environment.

Secondly, majority of teachers (N=40, M=2.96, SD=0.50), had adequate knowledge of climate change as the shift in climate pattern mainly caused by greenhouse gas. This aligns with the findings of Fawzy, Osman, Doran, and Rooney (2020), validate that greenhouse gas emissions induce heat to be trapped in the Earth atmosphere, causing a lot of modification in weather and climate pattern in the earth surface. Ekpoh (2009), defined climate change as any long-term alteration in the pattern of average weather of a specific geographic zone. It is an anomalous deviation in the Earth climate system. The Intergovernmental Panel on Climate Change (IPCC, 2007), evince that, the warming of the Earth surface is been linked to the quantity of carbon dioxide, hydrofluorocarbons, nitrous oxide in the atmosphere. All these are examples of greenhouse gases.

Also, majority of teachers (N=40, M=2.90, SD=0.37), had adequate knowledge that, fossil fuels remains the source of emissions into the atmosphere. This statement conciliates with finding of Fang Wang et, al. (2023), assert that fossil fuel is the primary source of anthropogenic emissions to the atmosphere.

Furthermore, on the statement that afforestation and reforestation are relevant in averting the canker of climate change, majority of the respondents had adequate knowledge of the statement (N=40, M=2.90, SD=0.37). This

is in line with the findings of Fang Wang et, al. (2023), posit that in reducing emissions and averting the dents of greenhouse gases from the Earth atmosphere requires the significant urgency to boast afforestation and reforestation program in our natural environment. These pro-environmentally friendly program or activities serves as carbon sinks, wind breaks, and provide quality oxygen quantity which is good for human respiration.

In addition, majority of teachers (N=40, M=2.87, SD=0.33), expressed that they have adequate knowledge that climate change education is a conduit to avert climate change in our natural environment. This statement concurs with the study of Nepras, strejckova, and Kroufek (2022), both elaborate that climate change education is designed to furnish learners with the requisite competencies, knowledge and skills that will make learners agents of climate in order to abate the spurious dents of climate change in our environment. By Implication, Social Studies teachers' adequate knowledge of climate change will be transformed into pragmatic practice. Thus, teachers will teach climate change logically by involving learners to understand the causes, effects and perform hands-on activities to bate or mitigate the impugn of climate change in our natural environment.

Table 2: Measures to curb climate change.

Statement	Adequate	Uncertain	Inadequate	Mean	Standard Deviation
1. Practicing regenerative agriculture	37	03		2.93	0.26
2. The enforcement of reforestation program.	31	07	02	2.73	0.55
3. Efficient urban planning is a means to prevent climate change.	24	15	01	2.57	0.55
4. Practicing crop rotation and growing cover crops is a measure to curb climate change	29	09	02	2.67	0.57
5. Public education on conserving our natural environment is a measure to prevent climate change.	36	03	01	2.87	0.40
6. Appreciating our natural environment is a way to avert climate change	28	10	02	2.65	0.58
7. Creating green jobs	36	04		2.90	0.59
8. Soil carbon sequestration is also a way to prevent climate change	25	13	02	2.57	0.59
9. The utilization of organic manure as a source of fertilizer is a way of curbing climate change	29	11		2.73	0.45

Source: Field Data, 2024.

The outcome from **Table 2** obviously outline that, majority of teachers (N=40, M= 2.93, SD=0.26) had adequate knowledge that regenerative agriculture is an avenue to curb climate change in our natural environment. Khangura, Ferris, Wagg, and Bowyer (2023), posit that regenerative agriculture aids in the reduction of greenhouse gases in the atmosphere. These gases alter the Earth atmosphere which leads to drastic changes in the climatic pattern of the Earth. In addition, Rhodes (2017), assert that, regenerative agriculture has a net positive impact on our natural environment vis-à-vis a prudent means to curb climate change in our environment.

Majority of teachers (N=49, M=2.90, SD=0.59) had adequate knowledge that, practicing reforestation is a measure to prevent climate change. This statement aligns with the findings of Locatelli et, al. (2023), posit that, reforestation is a means to mitigate climate change through carbon sequestration. They reiterated that, reforestation has a biophysical manifestation on climate through canopy conductance, volatile organic compound emission, and evapotranspiration processes. All these conserves our natural environment from the detriment of climate change menace. Similarly, Bonan (2008), assert that forest controls the world's climate

through biological, physical and chemical processes which includes exchange of water, energy, and carbon dioxide and other chemical constituents in the atmosphere. Bonan (2008), iterate that forest preserve the high rate of evapotranspiration, (Denman et.al.,2007), also assert that, forest balance the carbon uptake within the atmosphere, and serve as a carbon sink that bate the carbon dioxide content in the atmosphere.

In addition, majority of teachers (N=40, M=2.90, SD=0.59) had adequate knowledge that public education on conserving our natural environment is a measure to prevent climate change. This statement affirms with the findings of Alam (2018), evince that conscious and engaged education about conserving our natural environment is an antidote to abate the menace of climate change in our natural environment.

Further, majority of teachers (N=40, M=2.73, SD=0.45), had adequate knowledge that utilization of organic manure as a source of fertilizer is a way of curbing climate change in our natural environment. This statement concurs with the findings of Hobley et, al. (2018), posit that adding organic manure such as cow dung, chicken droppings induces the organic matter components in the soil. Soil organic matter do not contain any chemical components that emit into the atmosphere to cause heat to be trapped in the atmosphere.

More so, majority of teachers (N=40, M=2.73, SD=0.55), had adequate knowledge that the creating of green jobs is an avenue to curtail the impugn of climate change in our natural environment. This is in line with the findings of Badea et.al., (2022), posit that it is significant to protect our natural environment and the means to avert the menace of climate change is creating of green jobs that preserve and protect the quality of our environment. Colijn (2022), concur that, green jobs support the socio-ecological transition activities which subsume the use of renewable energy and reduction of non-renewable energy resources in our natural environment.

Implications of the study

This current study elaborates in toto teacher's robust knowledge and measures to bate climate change in our contemporary society is pivotal in ensuring the sustainability of our natural environment. Education plays a pivotal role in promulgating climate change education. Climate change education subsumes (i) skills needed to scrutinize, elaborate, and informed scientific data, (ii) pro-environmental attitudes towards the environment, (iii) content knowledge of climate change. Social Studies teachers' knowledge of climate change serves as a springboard in enlarging learners horizon on climate change- it's causes, repercussions and measures to curb it in our natural environment. Although, Social Studies teachers serves as the nucleus in promoting and solving the canker posed by climate change, in reciprocity their vast knowledge beget in learners implementing pro-environmental activities such as planting cover crops, diversifying crop rotation, retaining crop residues, reforestation and afforestation, and regenerative agriculture. These varied activities ensure that our natural environment is devoid of any deterioration, feel secured and protected.

CONCLUSION

In a nutshell, majority of Social Studies teachers' have adequate knowledge of climate change and it measures. This alludes that, Social Studies teachers at the Junior High School level will be able to educate and inform learners about the causes, effects and measures to curb climate change in our natural environment. Since consistent education increases the holistic understanding of the causes, effects and measures to curtail climate change, teachers should be poised to imbibe in learners the need to preserve and conserve our natural environment from deteriorating, and also motivating learners to acts as environmental literate who partake in practicing pro-environmental activities that will aid the future sustainability of the natural environment.

RECOMMENDATION

It is recommended that the enormous knowledge of climate change by Social Studies teachers should be transformed into performing hands-on activities in and outside the school ambience. Performing afforestation and reforestation exercise in and outside the school environment, mass education on climate change during relevant school events such as Parent Association Meeting, SPAM (school performance and appraisal meetings), and assigning project to learners such growing trees in the environment. Similarly, relevant stakeholders such as the Forestry commission and the Environmental Protection Agency should have depth

corroboration with the schools so that learners can be involved, informed and motivated to be environmental literate citizens in our contemporary society.

REFERENCES

1. Abasto, V., Larraín, A., Vergara, C., & Cofré, H. (2023). Alternative Conceptions About Climate Change in a Group of Teachers in Chile: Are Science Teachers More Knowledgeable Than Non-Science Teachers? ECNU Review of Education. 0 (0).
2. Andersen, P. (2008). Children as intergenerational environmental change agents: Using a negotiated Protocol to foster environmentally responsible behaviour in the family home. Environ. Educ. Res. 24, 1076.
3. Anyanwu, N. R. (2019). The Level of Climate Change Science Literacy among Teachers in Seychelles: Implications for the Blue Economy. Asian Journal of Interdisciplinary Research.2(2)
4. Anyanwu, R., Grange, L.L., & Beets, P. (2015). Climate change science: The literacy of Geography teachers in the Western Cape Province, South Africa. South African Journal of Education. 35(3)
5. Alam, A. (2018). Protection and conservation of environment: An Important role of education. i-manager's Journal of Educational Technology. 15(3)
6. Bordoh, A., Nyantakyi, F., Otoo, A. K., Boakyewa, A., Owusu-Ansah, P., & Eshun, I. (2021). Effective Teaching of Social Studies Concepts in Basic Schools in Ghana. Universal Journal of Social Sciences and Humanities, 1(1), 46–53.
7. Braman, L. et al. (2010). Climate change adaptation: integrating climate science into humanitarian work. International Review of the Red Cross. 92:879 Pp. 693-712
8. Bonan, G. B. (2008). Forests and climate change: Forcings, feedbacks, and the climate benefits of forests. Science (New York, N.Y.), 320(5882), 1444–1449.
9. Bohle, H. G., Downing, T. E., & Watts, M. J. (1994). Climate change and social vulnerability: Toward a sociology and geography of food insecurity. Global Environmental Change. 4, 37-48.
10. Canadell, J.G., Meyer, C.P., Cook, G.D., et al. (2021). Multi-decadal increase of forest burned area in Australia is linked to climate change. Nat. Commun. 12, 6921.
11. Colijn, B. Green Jobs in Europe and the Increasing Demand for Technical Skills. Neujobs Working Paper No. 4.2. 2014. Available online: https://www.transition-europe.eu/fr/publication/green-jobs-europe-and-increasing-demand-technical-skills (accessed on 20 June 2022).
12. Climate Change Education in the Primary and Lower Secondary Education: Systematic Review Results. (2022). Sustainability, 14, 14913. https://doi.org/10.3390/ su142214913
13. Climate Education in Sustainability Management Education System. Sustainability. 13, 1241. https://doi.org/10.3390/su13031241
14. Denman, K. L., Brasseur, G., Chidthaisong, A., Ciais, P., Cox, P., Dickinson, R. E. Zhang, X. (2007). Couplings between changes in the climate system and biogeochemistry. In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L.
15. Miller (Eds.). Climate Change 2007: The Physical Science Basis. (pp. 499–587). Cambridge: Cambridge University Press.
16. Dyster, A. In Recent Months, Climate Change Education Has Hit the Headlines. 2013. Available online: http://www.leftfootforw ard.org/2013/07/education-is-the-key-to-addressing-climate-change/ (accessed on 1 May 2021).
17. Ekpoh, I. J. (2009). Climate, society and environment. Calabar: St. Paul publishing co.
18. Ekpoh, U.I. & Ekpoh, I.J. (2011). Accessing the level of climate change awareness among secondary school teachers in Calabar Municipality, Nigeria: Implication for management effectiveness. International Journal of Humanities and Social Science, 1(3): 106-110
19. Fawzy, S. Osman, A. I., Doran, J. & Rooney D.W. (2020). Strategies for mitigation of climate change: a review. Environmental Chemistry Letters https://doi.org/10.1007/s10311-020-01059-w
20. Fang Wang et, al. (2023). Climate change: Strategies for mitigation and adaptation**.** The Innovation Geoscience 1(1): 100015.
21. Favier, T., Gorp, V. B., Cyvin, J.B., & Cyvin, J. (2021). Learning to teach climate change: Students in teacher training and their progression in pedagogical content knowledge. J. Geogr. High. Educ. 45, 594–620.

22. Fraenkel, J. R. & Wallen, N. E. (2003). How to design and evaluate research in education. (5th ed). Boston: McGraw-Hill.
23. Ford, J., Zavaleta-Cortijo, C., Ainembabazi, T., et al. (2022). Interactions between climate and COVID-19. Lancet Planet. Health 6, E825−E833.
24. Giddens, A. (2009). The politics of climate change, Polity Press, Cambridge, UK.
25. Gudmundsson, L., Boulange, J., Do, H.X., et al. (2021). Globally observed trends in mean and extreme river flow attributed to climate change. Science 371, 1159−1162.
26. Hobley, E.U., Honermeier, B., Don, A., et al. (2018). Decoupling of subsoil carbon and nitrogen dynamics after long-term crop rotation and fertilization. Agr. Ecosyst. Environ. 265, 363−373
27. Herman, B.C., Feldman, Allan., & Vernaza-Hernandez, V. (2017). Florida and Puerto Rico Secondary Science Teachers' Knowledge and Teaching of Climate Change Science. Int J of Sci and Math Educ 15,451–471.
28. IPCC. Summary for Policymakers. In Global Warming of 1.5 C; Masson-Delmotte, V., Zhai, P., Roberts, H.O.P., Skea, D., Shukla, J., Pirani, P.R., Moufouma-Okia, A., Péan, W., Pidcock, C., Connors, R., et al., Eds.; An IPCC Special Report on the Impacts of Global Warming of 1.5C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change; World Meteorological Organization: Geneva, Switzerland, 2018.
29. Intergovernmental Panel on Climate Change (2001). Climate Change 2001: Impacts, adaption and vulnerability. Summary for policy makers (A Report of working group 11 of the intergovernmental panel on climate change)
30. Intergovernmental Panel on Climate Change (IPCC). 2022. Climate Change 2021. The Physical Science Basis. Available online: https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC AR6 WGI Full Report.pdf (accessed on 17 February 2022).
31. Kagawa, F., & Selby, D., (2010). Education and Climate Change, 1st ed.; Kagawa, F., Selby, D., Eds.; Routledge: New York, NY, USA, 2010; 241–245.
32. Khangura, R.; Ferris, D.; Wagg, C.; Bowyer, J. (2023). Regenerative Agriculture-A Literature Review on the Practices and Mechanisms Used to Improve Soil Health. Sustainability**,** 15, 2338.https://doi.org/10.3390/su15032338
33. Kwenin, I.A. (2019). Integrated Nature of Social Studies in Junior High Schools in Ghana: Pedagogical Implications. International journal of innovative research & development. 8(9).
34. Locatelli1, B., Catterall, C., Imbach, P., Kumar, C., Lasco, R., Marín-Spiotta8, E., Mercer, B., Powers, J., Schwartz, N., & Uriarte, M. (2015). Restoration Ecology. 23, 4, 337–343
35. Lubchenco, J., Heather, T., and Eli, F. (2022). Accounting for nature on earth day (2022). The White House.
36. Marlon, J.R., Bartlein, P.J., Gavin, D.G., et al. (2012). Long-term perspective on wildfires in the western USA. Proc. Natl. Acad. Sci. USA 109, E535−E543.
37. Mccright, A. M. (2010). The effects of gender on climate change knowledge and concern in the American public. Population & Environment, 32, 66-87.
38. Meza, I., Rezaei, E.E., Siebert, S., et al. (2021). Drought risk for agricultural systems in South Africa: Drivers, spatial patterns, and implications for drought risk management. Sci. Total Environ. 799, 149505.
39. Ministry of Agriculture (2011). Agriculture Sector Programme of Plan on Adaptation to Climate Change. Addis Ababa, Ethiopia.
40. National Council for Curriculum and Assessment (NaCCA) Ministry of Education (2020). Social Studies Curriculum for B7- B10. Ghana
41. Ofei-Nkansah, K. Promoting Rights in the Fight Against Climate Change. (2013). Available online: http://library.fes.de/pdf-files /bueros/ghana/10516.pdf (accessed on 23 February 2021).
42. Otto, I.M.; Donges, J.F.; Cremades, R.; Bhowmik, A.; Hewitt, R.J.; Lucht,W.; Rockström, J.; Allerberger, F.; McCaffrey, M.; Doe, S.S.P.; et al. Social tipping dynamics for stabilizing Earth's climate by 2050. Proc. Natl. Acad. Sci. USA **2020**, 117, 2354–2365.
43. Piguet, E. (2022). Linking climate change, environmental degradation, and migration: An update after 10 years. Wiley Interdiscip. Rev. Clim. Change 13, e746.

44. Perkins, S. (2022). How much of the Earth's ice is melting? New and old techniques combine to paint a sobering picture. Proc. Natl. Acad. Sci. USA 119, e2213762119
45. Ponto, J. (2015). Understanding and evaluating survey research translating research into practice. 6(2).
46. Pilotti, M.A.E., & Al Ghazo, R. (2020). Sustainable Education Starts in the Classroom. Sustainability 12, 9573, doi:10.3390/su12229573.
47. Roman-Palacios, C., &Wiens, J.J. (2020). Recent responses to climate change reveal the drivers of species extinction and survival. Proc. Natl. Acad. Sci. U.S.A. 117, 4211−4217.
48. Rahi, S. (2017). Research design and methods: A systematic review of research paradigms, sampling issues and instruments development. International Journal of Economics & Management Sciences, 6(2), 1-5. DOI: 10.4172/2162-6359.1000403
49. Rhodes, C. J. (2017). The imperative for regenerative agriculture. Sci. Prog. 100, 80–129. doi: 10.3184/003685017X14876775256165
50. Seroussi, D.E, Rothschild, N, Kurzbaum, E, Yaffe, Y, & Hemo, Tahel. (2019) Teachers' Knowledge, Beliefs, and Attitudes about Climate Change. International Education Studies.12 (8).
51. Stern, N. (2007). The economics of climate change: The Stern review. Cambridge University press.
52. Stanef-Puicˇa, M.-R.; Badea, L.; S, erban-Oprescu, G.-L.; S,erban-Oprescu, A.-T.; Frâncu, L.-G.; Cret,u, A. Green Jobs—A Literature Review. Int. J. Environ. Res. Public Health **2022**, 19, 7998. https://doi.org/10.3390/ijerph19137998
53. Stevenson, R.B.; Nicholls, J.; Whitehouse, H. (2017). What Is Climate Change Education? Curric. Perspect. 37, 67–71.
54. Sun, Y., Zhang, X.B., Ding, Y.H., et al. (2022). Understanding human influence on climate change in China. Natl. Sci. Rev. 9, nwab113.
55. Tolppanen, S., Claudelin, Anna., & Kang, J. (2021). Pre-service Teachers' Knowledge and Perceptions of the Impact of Mitigative Climate Actions and Their Willingness to Act. Research in Science Education. 51, 1629–1649.
56. Ugwu, N. F., Familoni, J. K., Anibueze, A. U., Onyekwere, O. K., Ajewole, P. I., Nwogu, O. F., & Ibeneme, C. B. (2021). Assessment of Climate Change Knowledge and Attitude among Secondary School Teachers' in Enugu State. Trends in Educational Studies Journal. 13(2)
57. UNCCS (2019). Climate action and support trends, United Nations Climate Change Secretariat. https ://unfcc c.int/sites /default/files /resou rce/Clima te Actio n Suppo rt Trend s 2019.pdf.
58. UNESCO. World Conference on Education for Sustainable Development, Bonn, Germany. 2009. Available online: https://www.ohchr.org/EN/Issues/ Education/Training/Compilation/Pages/ 21. World Conferencen Education for Sustainable Development Bonn Declaration (2009) (accessed on 14 December 2021).
59. UNESCO. UNESCO (2010). Strategy for the Second Half of the United Nations Decade of Education for Sustainable Development; UNESCO: Paris, France.
60. United States Environmental Protection Agency (EPA) (2010). Climate Change Science Facts. www.epa.gov/climatechange.
61. Wang, F., Harindintwali, J.D., Yuan, Z., et al. (2021). Technologies and perspectives for achieving carbon neutrality. The Innovation 2, 100180, 10.1016/j.xinn.2021.100180.
62. Weber, C. L. & Peters, G. P. (2009). Climate change policy and international trade: Policy considerations in the US. Energy Policy, 37, 432–440.
63. Xing, X., Wang, R., Bauer, N., et al. (2021). Spatially explicit analysis identifies significant potential for bioenergy with carbon capture and storage in China. Nat. Commun. 12, 3159.