UNDERSTANDING AND TEACHING CLIMATE CHANGE CONCEPTS IN GEOGRAPHY CURRICULUM AT SECONDARY SCHOOLS IN SENEGAL

By

BABA LIBASSE SOW

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A THESIS SUBMITTED TO THE DEPARTMENT UTG WASCAL, SCHOOL OF AGRICULTURE AND ENVIRONMENTAL SCIENCES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY (PhD) DEGREE IN CLIMATE CHANGE AND EDUCATION OF THE UNIVERSITY OF THE GAMBIA

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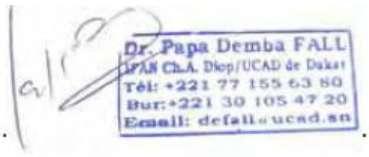
....Dakar, May 26th 2023.....  .....

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Dedication

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List of Acronyms

ANSD- Agence Nationale de Statistique et de la Démographie

APF- *Africa Partnership Forum*

CBD- Convention on Biological Diversity

CEM-Collège d'Enseignement moyen

CH_4- methane

C/N- Carbon and Nitrogen

CO_2- carbon dioxide

FAO- Food and Agriculture Organization (United Nations)

FGD- Focus Group Discussion

GDP- Growth Domestic Product

$GgCO_2eq$- Giga grams CO_2 equivalence

GHG- Green House Gases

IFADEM-Distance Education Initiative for School Teachers

IGU- International Geographical Union

IPCC - Intergovernmental Panel on Climate Change

LPGS-EF- *Lettre de Politique Générale Pour le Secteur de l'Education et de la Formation*

National Determined Contribution (NDC)

NGO- Non-Governmental Organization

N_2O - nitric oxide

OIF-International Organisation of the Francophonie

PANA- Plan d'Action National pour l'Adaptation aux changements climatiques

PAQUET- Programme d'Amélioration de la Qualité, de l'Équité et de la Transparence

Planet'ERE – Planet L'Education Relative à l'Environnement

ppm- parts per million

PSE- Plan Senegal Emergent

PURGES- Projet de Recherche sur la Géographie des Collèges et Lycées du Sénégal

SNDD-National Strategy for Sustainable Development

SPSS - Statistical Package for Social Scientists

SSA- Sub-Saharan African

STATA- Statistics and Data

UN-United Nations

UN CC: Learn- United Nations Climate Change Learning

UNDP- United Nations Development Program

UNEP- United Nations Environmental Programme

UNESCO- United Nations Educational, Scientific and Cultural Organization

UNFCCC- United Nations Framework Convention for Climate Change

UNCCD-United Nations Convention to Combat Desertification

UNICEF-United Nations International Children's Emergency Fund

UNITAR- United Nations Institute for Training and Research

WB- World Bank

Abstract

This study investigates into the teachers' and learners' understanding of climate change concepts in the secondary education from the geography curriculum in Senegal. As a solution to climate change, formal education has been identified as a major tool of changing people's attitude towards the environmental protection. The study is based on a cross-sectional survey of 101 geography teachers and 320 students selected from 16 secondary schools through multistage sampling methods, including simple random and purposive sampling techniques. Data for this study were also collected from 8 school principals and 8 school headmasters, 16 focus group discussions among students and 9 key informant interviews, including 3 senior inspectors of geography, 3 senior geography curriculum designers and 3 senior environmental education officers. The research used a thematic area content analysis template to quantify and analyse climate change content in the geography curriculum for the lower and upper secondary schools. To analyse the data obtained from respondents, a logistic regression model, climate change awareness index, chi-square and independent sample t-tests and descriptive statistics were used for this study. The results of the study reveal that 43% of identified relevant climate change content was not addressed in the secondary geography curriculum, indicating that this current curriculum is inadequate for effective climate change education in schools. Further, the average climate change awareness index for geography teachers was 0.6455 (64.55%), implying that geography teachers fairly understand climate change concepts while, climate change awareness index for students was 0.5343 (53.43%), showing that students scantly understand climate change concepts. There is no significant relationship between climate change content in the geography curriculum and climate change awareness of geography teachers and their students as revealed in the chi-square test for teachers (83.651>0.552) and for students (49.503>0.718). In addition, numerous gaps and misconceptions were found to exist in teachers' and students' understanding of climate change concepts, particularly the scientific processes of climate change causes and its remedies. The findings of the logistic regression model showed that frequency of teaching about climate change, teacher's experience, comprehensive geography curriculum, teacher's knowledge of climate change, and teaching and learning climate change resources positively and significantly influence the effectiveness of teaching about climate change concepts. The study recommends that climate change content should be explicitly integrated into all the geography topics from lower to upper secondary level across all grades. The research also recommends that the Government of Senegal should train geography teachers on climate change education both at in-service and pre-service level and providing the resources required for climate change education. It would be essential to establish environmental clubs in all Senegalese secondary schools with full engagement and active participation of teachers, headmasters, principals and students of all grade levels so as to promoting climate change education, therefore inciting pro-environmental activities in schools and communities.

Keywords: Senegal, Secondary School Geography Curriculum, Climate Change Content, Understanding Climate Change

CHAPTER ONE

INTRODUCTION

1.1 Background Information and Context

Climate change is one of the major challenges facing the global community today. It has been ascertained that global competition in production and consumption among countries, as well as the production and consumption habits of the population exert a great deal of pressure on natural resources and bring about many environmental problems such as climate change which is mainly caused by greenhouse gases (GHGs) emissions through human activities (Galli et al., 2012). Indeed, the Intergovernmental Panel on Climate Change (IPCC) reported that the average global temperature has increased with many unprecedented changes observed over decades to millennia (IPCC, 2022; IPCC, 2014). Climate change is a result of human activities such as fossil fuel combustion, land use activities and deforestation among others (IPCC, 2013). According to IPCC (2007a), although the impact of climate change is global, Africa is one of the regions that are most affected by the changing climate due to the vulnerable nature of the continent in terms of climate variability and climate change. Africa is also at the tip of the spear of climate change impacts mainly due to the interactions of multiple stressors, including extreme poverty, over-dependence on rain-fed agriculture, insufficient public spending on rural infrastructure, poor data availability and quality, and knowledge gaps (IPCC, 2007; UNEP, 2005).

In addition, the climate predictions for African Sahel have indicated greater evapotranspiration, increases in average rainfall, higher frequency of extreme events and

rising temperatures (IPCC, 2014). Sub-Saharan Africa (SSA) region is also noted to be one of the regions that are most vulnerable to many adverse effects of climate change because of her high dependence on rain-fed agriculture for food security and economic growth, coupled with low adaptive capacity (IPCC, 2013; Kutir, 2011). Thus, the global pursuit for sustainable development in the region is under serious threat because of the impact of climate change on lives and livelihoods of the communities (World Bank, 2020; UN, 2010). Moreover, it has been stated that if adequate measures are not taken to mitigate and adapt to the adverse consequences of climate change in sub-Saharan Africa, the region will remain vulnerable to the widespread effects of climate change (FAO, 2009). Further, prediction results showed that a loss of 2 - 7% of Gross Domestic Product (GDP) by 2100 in parts of SSA will occur (FAO, 2009). Climate change has also resulted in low crop productivity and climate change related losses in crop yields are projected to reach 50% in some countries of SSA by 2050 (IPCC, 2007). Also, variations in temperature and rainfall patterns adversely impact the social survival and economic lives in many African countries (APF, 2007). This implies that the main long term impacts, including significant changes in temperature and rainfall patterns in the sub- Saharan Africa zone affect agriculture and water resources sectors, leading to significant reduction in food security and worsening water security and also rising water stress (APF, 2007).

Where people are unprepared or adaptation and mitigation strategies are inadequate, climate change can easily set back development gains by affecting key sectors such as agriculture, water resources, infrastructures and health (IPCC, 2018; FAO, 2014). Further, only immediate and sustained action will stop climate change from causing irreversible and potentially catastrophic damage to our natural environment (Njoku, 2016; IPCC,

2007). Furthermore, it has been pinpointed that Africa is at the lowest ebb of climate change awareness (Onuoha et al., 2021; Akrofi et al., 2019; Lee et al., 2015) and this implies that teaching-learning efforts, which ought to spring climate change awareness and increased climate literacy among people, are highly needed in order to lead to the reduction of societal misconceptions and apathy toward climate change issues (Onuoha et al., 2021). Therefore, the implications of climate change impacts on lives and livelihoods of the communities urge to sensitize and educate people, especially youth on the causes, consequences and appropriate solutions to the changing climate through formal and non formal education approaches for Africa in general and Senegal in particular.

The impacts, effects and risks of climate change can be reduced and managed through mitigation and adaptation processes (IPCC, 2014). Thus, different methods are being used to find solutions to the changing climate. Climate change education is one of the methods that have been recommended (Sharma, 2012; Cherry, 2011; UNFCCC, 2007). Kariuki et al. (2017) ascertained that as a remedy to the current situation, formal education has been identified as a major tool of passing the required knowledge, skills and changing people's attitude towards climate change. It is expected that the human being whom the issue is affecting should understand and be ready to respond by engaging in adaptive and mitigation strategies. In addition, UNESCO (2015) reported that climate change education is a powerful tool for developing such responses and helping people to address the adverse impacts of climate change. It also helps learners understand the causes and consequences of climate change, thus preparing them to live with the impacts of climate change and empowering learners to take appropriate actions to adopt more sustainable lifestyles. This means that a public awareness is crucial to firstly understand the negative effects of

human actions on the environment, and secondly to take action for the prevention and adaptation to climate change (Manteaw, 2012). Consequently, climate change is a problem demanding a great deal of attention by scientists, policymakers, and the public as well; and for this reason, recently there has been a great interest in public understanding of climate change and in educating youth, the future citizens, so as to enable them to successfully cope with this threat (Papadimitriou, 2004). It has been revealed that the gap between the knowledge of climate scientists and the public has been widening (Miléř et al., 2012). Further, providing adequate climate literacy to the next generation remains a challenge because teaching climate change topics requires climate literate teachers in the first place. Thus, teachers have to transform the scientific information about climate change and to transfer it to young people in an understandable manner. Teaching climate change topics at schools could be even counterproductive if the educators are not climate change literate (Dlamini, 2019; Miléř et al., 2012). Tackling climate change and environmental issues requires the synergy of human capital made up of knowledgeable and committed actors. Onuoha et al. (2021) and Rousell and Cutter- Mackenzie-Knowles (2020) argued that there is a consensus on the role of formal education as a tool for addressing and mitigating climate change, especially the education of the innocent younger generation, who will bear the brunt of the consequences of environmentally-unfriendly choices of previous generations.

Furthermore, Siegner (2018) posited that teaching climate change within the classroom setting, especially by well equipped teachers using appropriate pedagogical strategies can prompt efficient climate actions from learners. Also, school is considered as the place where the projections of the society for its future are undertaken. Moreover, schools

provide a favourable environment whereby environmental measures such as recycling and sustainable activities can be put in place to promote positive attitudes and behaviours toward climate change. Additionally, Zeeshan et al. (2021) argued that schools are considered as conventional means of education to help in absorbing and sharing common perceptions; and education spreads experiences and homogenizes perceptions. Students also imbibe experiences from parents, peers, their own direct experiences, the curricula, and the teachers, consciously or otherwise, in formulating their perceptions about the environmental problems such as climate change issues (Zeeshan et al., 2021; Crona et al., 2013). It has been also argued that sustainable development is and will continue to be a matter of substantial international interest and concern (Leal Filho et al., 2015). Therefore, in 1992 almost all nations agreed on the UNFCCC (United Nations Framework Convention on Climate Change) declaring the commitment to develop and implement an education about climate change and its effects on national and regional level and to develop and share educational programmes and materials as stated in article 6 of the convention. Meerah et al. (2010) argued that environmental education is an instrument that contributes to behavioural changes within the society, which is ultimately translated into environmental citizenship. Climate change education has the potential and crucial role to play in improving understanding and developing awareness of learners about the aspects of climate change on all levels of formal education. In addition, formal lessons can help to reinforce the concept of climate change and this in turn may influence students' knowledge, attitude and behaviour towards climate change issues (Chew-Hung Chang, 2013).

Education may also help individuals to make informed decisions (Seukwa, 2007), which will benefit the environment, and thus minimise the impact of the changing climate (Dlamini, 2019). Thus, schools are important places where youth can learn about and begin to understand environmental issues and climate change, and school geography is a subject that focuses on this pressing environmental issue. Secondary students are also expected to be instruments of change in this knowledge driven society. Therefore, it is urgent to explore the understanding and teaching of climate change in the secondary education geography curriculum in order to effectively tackle the changing climate. Indeed, geography has been described as a powerful medium for promoting the education of individuals in environmental issues (Ekpoh, 2009). Additionally, it has been intimated that school geography trains future citizens to accurately imagine condition of great world stage, so to help them to think sanely about political and social problems around them (Ozor, 2009; Lidstone and Stoltman, 2007). Geography education would also provide the avenue to address sustainability and environmental issues (Tan and Chang, 2008). Furthermore, the integration of climate change issues across learning areas of the geography curriculum will help to inform and educate today's young people to be responsible in managing their future environment. Geography teachers also have a crucial role in helping students to actively participate to the global efforts tackling climate change and other environmental issues. In other words, education is an essential component and a catalyst for responding to global climate change through raising awareness and promoting knowledge and skills-development and building resilient societies, thus reducing vulnerabilities to climate change of the populations (UNITAR, 2013). Therefore, building capacity and understanding to respond to the changing climate among the population is not only important, but urgent (Eliasson, 2017). Sharma (2012) also argued that education

is considered as a social solution of developing and understanding the relations between nature and modern societies and developing sustainable actions for the preservation of the environment by responsible citizens. In this regard, many countries aim to implement climate change topic into their national curricula and to improve the efficiency of education towards a climate literate society (Miléř et al., 2012). Thus, there are several efforts in promoting and implementing educational, training and public awareness programmes on climate change and its effects on the lives and livelihoods of the populations in Senegal but the knowledge on the teaching and understanding climate change concepts at secondary schools in the country appears to be limited, therefore this study intends to capture the extent of teaching and understanding climate change science at Senegalese secondary schools. To develop local, national and global capacity to manage climate change risks at urban and rural areas and to create awareness about causes, impacts and appropriate solutions to climate change; it is primordial to provide young people the effective and efficient training and educational programmes about climate change and other environmental related issues.

1.2 Problem Statement

Located on the Western coast of Africa between 12.8° and 16.41°N and between 11.21° and 17.32°W, Senegal is a land of climatic and geographic contrasts. The country surrounds The Gambia and shares borders with Mali, Guinea-Bissau, Mauritania and Guinea Conakry. Senegal is a relatively low-lying country; about 90% of the country lies below 100 metres above sea level, and its highest elevation which is located at the southeast region, is just below 500 metres above sea level (Coulthard, 2001). It has been reported that while the country has experienced development gains in recent years, nearly

70% of Senegalese live in multi-dimensional poverty, and the country remains classified as a least developed country (McKune and Serra, 2016; Zamudio and Terton, 2016). Moreover, the primary source of employment in rural areas is rain-fed agriculture, which is dominated by smallholders that often also engage in cattle raising. Fishing is also the key to the overall economy of the country (PANA, 2015; Fall et al., 2010). These characteristics leave the country vulnerable to climate change, which has the potential to derail its development path (ANSD, 2016; Zamudio and Terton, 2016; PANA, 2015). Further, Senegal faces a number of climate hazard risks such as floods, droughts, coastal erosion and sea level rise which pose the greatest threat to the country's development goals (World Bank, 2020).

As much as the solution of climate change relies on political, economic and technological remedies, it also requires more educated individuals who know about climate change issues and the appropriate measures needed in order to effectively tackle this pressing environmental issue. Additionally, environmental and climate change education investment to be made in youth is an investment made in our planet since the future of our planet is in the hands of today's youth (Atasoy and Ertürk, 2008). In this respect, it has been asserted that several efforts were made in environmental education at school through training and educational programmes related to the environment in the Sahel region in general and Senegal in particular (Berthelot, 2007). Despite the efforts made towards environmental and climate change education at school level, it has been reported that educational activities concerning the environment take place in schools but, more often they take place outside the official school curricula, based on the initiative and personal convictions of teachers rather than known and shared institutional aims

(Abaidoo, 2016; Berthelot, 2007). Also, taking climate change and environmental education into account in national education policies is a complex subject that requires an analysis of the context of its establishment, the needs of students and their communities, social representations, pedagogical practices of teachers and those responsible for their supervision, the overall curriculum, the opening of the schools to various partners and the methods of transferring innovations (Dlamini, 2019; Eliasson, 2017). From this perspective, climate change education should be explicitly included in the National Education Policy Act of Senegal because it is a transversal subject which can be taught in all disciplines at school (Diop, 2019; Ndiaye, 2021). This can lead to effective education and training of learners that will have the ability to articulate the knowledge acquired in school to the reality of the environment, hence the environmental citizens who will use their skills, attitudes and knowledge to tackling climate change effectively and efficiently. Efforts have been put in human capacity building with an education sector accounting for 4.65% of GDP in 2018 to the government expenditure of Senegal, while the country is facing significant challenges in improving human capacity building in sustainable development domain in the face of climate change (UNESCO, 2020; République du Sénégal, 2018). Thus, it has been suggested that the government of Senegal should develop more effective climatic change adaptation and mitigation strategies as well as improve dissemination of climate information to the populations in order to increase adoption of effective climatic change adaptation and mitigation tools (Sow et al., 2018).

In addition, various adjustments have been made in secondary education geography curricula in Senegal in order to train young citizens that are able to accordingly act for the preservation of their environment. Indeed, to educate learners on environmental issues and

climate change in Senegal, the current geography programme taught at secondary school which has been launched by the Government in 2006 aimed to enable youth make informed decisions to respond to the changing climate and the other environmental related issues (Diop, 2019; Planet'ERE/Senegal, 2010; Ministère de l'Education Nationale, 2006). Moreover, environmental education is an important aspect of the Plan Sénégal Emergent (PSE) which was set up in 2014 and will end in 2035 and it is expected to raise environmental and climate change awareness of the populations so that they can effectively adapt and mitigate climate change effects at local and national level based on the policy frameworks of the United Nations Framework Convention on climate change education in 1992 (République du Sénégal/PSE, 2014).

However, there appears to be little empirical evidence on how this current geography curriculum at Senegalese secondary school is influencing teachers and learners in their understanding of climate change science. It is asserted that only by helping learners to recognise and understand the multidimensional nature of climate change will enable them to contribute to society's attempts to deal with the rapid natural and human-induced environmental changes. For the learners to have the power to be active citizens and make decisions which effectively address climate change issues at local and national level there is a need for them to be well educated and trained on this pressing environmental issue. It is against this knowledge gap that this study seeks to establish the understanding and teaching of climate change in the secondary education geography curriculum in Senegal.

1.3 Research Questions

The following research questions were used to guide the study:

1. How are the concepts of climate change captured in the geography curriculum in Senegal secondary education?
2. How do teachers understand and interpret climate change concepts captured in the geography curriculum in Senegal secondary education?
3. To what extent do students understand climate change concepts captured in the geography curriculum in Senegal secondary education?
4. What are the factors influencing the effectiveness of teaching climate change concepts in Senegal secondary education geography curriculum?

1.4 Research Objectives

The principal objective of this study is to investigate into the teachers' and learners' understanding of climate change concepts in the secondary education from the geography curriculum in Senegal.

Specific Objectives:

The specific objectives for the study are:

1. To assess the concepts of climate change captured in the geography curriculum in Senegal secondary education.
2. To determine geography teachers' understanding and interpretation of climate change concepts captured in the geography curriculum in Senegal secondary education.

3. To examine students' understanding and knowledge of climate change concepts captured in the geography curriculum in Senegal secondary education.
4. To identify the factors that influence the effectiveness of teaching climate change concepts in secondary education geography curriculum in Senegal.

1.5 Significance of the Study

The results from this study could contribute to the existing body of knowledge about climate change education. The research could be in a better position to contribute to the limited literature on understanding and teaching of the aspects of climate change at secondary schools in Senegal. It would help researchers identify how best understanding and teaching of climate in the secondary education geography curriculum in Senegal can assist learners understand climate change concepts effectively. Also, it could help various stakeholders to understand and appreciate how the public, particularly, literate and intellectuals understand climate change issues. Further, it would be a viable source to make recommendations to education authorities of Senegal to consider effecting certain curricula modifications in order to develop better and strategic communicative tools in combating climate change effectively and efficiently in short and long terms.

Additionally, identifying the potential factors that positively affect the effectiveness of teaching climate change science at Senegalese secondary schools could strive to determine the ways and means of improving upon the teaching and learning climate change concepts in schools and communities at large. Moreover, the involvement of all related stakeholders in education – learners, teachers, principals, headmasters, senior geography inspectors, curriculum designers and environmental officers in the research could go a long way to

better improve the active participation of young people in tackling climate change issues, hence the protection of their environment. Therefore, the perspective of this study is the better understanding of climate change science by both teachers and learners at Senegalese secondary schools and their active participation in preserving the environment under the sustainable development goals initiatives.

Furthermore, the results of this research may have great significance to policymakers. This could inform them about the strengths and weaknesses in the implementation of the current geography curriculum so that appropriate remedies are designed to effectively address the aspects of climate change in schools. Thus, it can inform them about the training and development needs of teachers within the study area, in particular and all the Senegalese secondary schools, in general in the context of climate change and other environmental related issues. This could serve as bases for them to sculpt out appropriate and effective professional development and training to support the in-service teachers to implement climate change education in schools effectively.

The research could inform and influence training education policy on the need to include education for sustainable development and climate change education in professional development programmes in the initial teacher training schools or faculties in the country.

1.6 Scope of the Study

Geographically, the scope of the study covered sixteen secondary schools (eight lower secondary schools and eight upper secondary schools) in eight (8) out of the sixteen (16) Academy Inspections of Senegal. For the purpose of this research, learners in grade ten (10) and thirteen (13) were only considered as they have at least capitalised on knowledge,

skills and attitudes aimed at building the student profile defined in the objectives of the geography curriculum for the Senegalese secondary schools (objectives presented in Appendix 1). Also, geography teachers at lower and upper Senegalese secondary schools were considered in this research because geography is seen as a school subject that considerably pinpoints the human-environment-human relationship, thus climate change issues. Geography is also considered as an interdisciplinary subject that is most suitable to teach students about climate change issues.

1.7 Definition of Key Terms

Climate: A narrow sense as the average weather (the classical period is 30 years), or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years (IPCC, 2012).

Climate change: Refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer) (IPCC, 2007c). UNFCCC (2007) reported that the changing climate is a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere which is in addition to natural climatic variability observed over comparable time periods.

Climate variability: Includes more than individual weather events and may result from natural internal processes within the climatic system (internal variability) or to variations in natural or anthropogenic external forces (external variability) (IPCC, 2007).

Adaptation: An Adaptation is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007a).

Mitigation: An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2007b).

Understanding: knowledge about a subject, situation, etc. or about how something works (Cambridge English Dictionary). Also, according to the Oxford dictionary the word understand is defined as perceive the intended meaning of (words, a language, or a speaker), it can refer to interpret or view (something) in a particular way, or be sympathetically or knowledgeably aware of the character or nature of.

Teaching: in education, it is the concerted sharing of knowledge and experience, which is usually organized within a discipline (Cambridge English Dictionary).

Geography: It is a field of science devoted to the study of the lands, features, inhabitants, and phenomena of the Earth and planets (American Heritage Dictionary).

Curriculum: A plan of action that is aimed at achieving desired goals and objectives (Stotsky, 2012). It is a set of learning activities meant to make the learner attain goals as prescribed by the educational system. Generally, it includes the subjects and activities that a given school system is responsible for.

Secondary School: A school intermediate between elementary school and college and usually offering general, technical, vocational, or college-preparatory courses (American Heritage Dictionary).

CHAPTER TWO

LITERATURE REVIEW

This chapter reviews literature on the various issues, concepts and theories which are related to this study. It reviews concepts such as climate change, climate change education, understanding climate change, knowledge, awareness, risk perceptions, beliefs, engagement, and responses to climate change. Educational policies on climate change in Senegal, content of climate change education, curriculum concept, and importance of geography education in understanding climate change were reviewed in this section. The chapter also reviews some theories related to this research and particularly emphasised on Activity Theory which underpinned this study. The current knowledge in this research is critically summarised in this chapter, along with any strengths and limitations found in earlier work. Possible weaknesses are also eliminated, and possible strengths supporting this research are highlighted. It offers the setting in which this study is situated. The major objective is to develop a framework for analysing the study's findings.

2.1 Conceptual Review

2.1.1 Climate Change Concepts

Climate change is an altered state of the average climate that can be identified by changes in the mean and/or variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2007). The United Nations Framework

Convention on Climate Change (UNFCCC) in 2010 defines climate change as a change of climate which is attributed directly or indirectly to human activities that alter the composition of the global atmosphere and which are in addition to natural climate variability observed over comparable time periods. The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 2022 emphasized that climate change refers to any change in climate over time, whether due to natural variability or as a result of human activities such as deforestation, burning of fossil fuels and land use which release greenhouse gases (GHGs) into the atmosphere. It is unequivocal that human influence has warmed the atmosphere, ocean and land, and widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred (IPCC, 2022).

The last three decades have been warmer than any preceding decade since 1950 (IPCC, 2014). It has been reported that the primary cause of observed changes in Earth's climate over the recent past, as well as predicted future changes, are anthropogenic greenhouse gas emissions, namely carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) among others, produced since the beginning of the industrial era (IPCC, 2014). Additionally, several studies suggest the positive relationship between the increase of the temperature and the increase of the concentration of the greenhouse gases in the atmosphere. As reported by IPCC (2007) it is generally accepted that the anthropogenic climate forcing is the main cause of the changing climate. This means that the changing climate is caused by the emission of greenhouse gases in the atmosphere. Furthermore, the increasing concentrations of greenhouse gases in the atmosphere are mainly due to the 80% increase in annual CO2 emissions since 1970 (IPCC, 2007). The greenhouse gases trapping heat in the atmosphere include carbon dioxide, nitric oxide, and methane among others.

Therefore, the concentrations of carbon dioxide, methane, and nitrous oxide in the atmosphere have considerably increased (IPCC, 2013). Also, the concentration of carbon dioxide (CO2), has continued to increase from its preindustrial concentration of approximately 278 parts per million (ppm) to over 391 ppm in 2012, with the rate of rise now at 1.8 ppm per year. The emissions of CO2 from fossil fuel and land use change recently are about 35,000 million metric tons per year and, if this trend is not addressed, it is predicted that this increase will continue considerably. It is almost certain current greenhouse gas levels have resulted in an increase in extreme weather across the globe, including extreme rain events, and heat waves among others (IPCC, 2022). Thus, the adverse impacts of climate change are also observed on lives and livelihoods of the populations of Senegal in particular.

2.1.2 Senegal, Climate Variability and Climate Change

In Senegal, rainfall has experienced in recent decades a significant decline punctuated by a shift of isohyets from north to south, while temperatures have increased. It has been stated that since the 1950s, rainfall has decreased by around 30%, punctuated by a very high variability from one year to another and from one region to another (PANA, 2015). In Dakar, for example, there is a drop of 50% compared to 7% in Kédougou between 1950 and 2000. Additionally, the overall temperature trend is marked by an average warming of 1.6 ° C with regional disparities. The highest increase is observed in northern Senegal with 3.0 ° C in Linguère and the lowest increase in the south with 0.7 ° C in Kédougou (PANA, 2015). Also, Senegal has experienced rises in average temperatures of about 0.9°C since 1960 with an average of 0.2° per decade. UNDP (2008) reported that there are also decreases in rainfall by 10-15 mm per decade and a shortening of the rainy season,

increases in daily rainfall and in the frequency of short dry spells. Moreover, climate models predict for Senegal an increase by the 2060s of 1.1-3.1°C in mean annual temperatures from the observed (1970-99) with a mean of 27.8°C, and a decrease in annual precipitation. The models also predict greater climate variability, including the frequency and proportion of rainfall coming in intense and extreme rainfall events (UNDP, 2008). Thus, most of the models projecting the rainfall trends of the coming decades show an overall drying of Senegal, yet with high inter annual variability that will occur (Boko et al., 2007). The total emission of greenhouse gas from the main sectors in Senegal in 2005 was estimated at 13083.74 Giga grams CO2 equivalence (GgCO2eq) of which about 40% is from the energy sector, 48.6% from agriculture sector, 7.4% from waste, and 4.13% from industrial processes (PANA, 2015).

Further, some of the sub-Sahara Africa countries like Senegal are likely to lose cereal production potential by the 2080s due to the adverse impacts of climate change (Fischer et al., 2005). Senegal's agricultural sector employs more than 69% of the workforce in 2013 and represents about 17.5% of the of the country's Gross Domestic Product GDP in 2013 (FAO, 2015). The agricultural sector remained the primary means of livelihood for the population in Senegal. Recently, over 65% of Senegal's arable land is cultivated, and it is expected that by 2050, almost all arable land will be cultivated. In addition, the agriculture sector consists primarily of rain-fed agriculture, which is especially vulnerable to increases in temperature, changes in timing and amount of rainfall, and increases in the frequency of dry spells and droughts. Therefore, these consequences are likely to have negative impacts on agricultural production as well as health, environment, and the economic development. It has also been ascertained that in the Senegal River Valley,

Niayes, and Lower and Upper Casamance regions, agriculture and fisheries are vulnerable to declines in rainfall, coastal erosion, salt water intrusion, and floods resulting in food insecurity for the communities (FAO, 2011). Regarding the adverse impacts of climate change on lives and livelihoods of the populations in Senegal, the need of the hour is to make people, especially the youth to be effectively aware of climate change issues, thus building community capacity for adaptation strategies to mitigate the effects of climate change through schools curricula among others. Hence, climate change education at formal and non-formal level can play an important role in tackling the changing climate, therefore giving a large opportunity to have an informed public that will make wiser and more accurate decisions in combating this pressing environmental issue. Additionally, as stated by IPCC in 2013, education is a vital part of climate change adaptation and mitigation processes because with proper educational and awareness programmes on climate change issues, people can change their behaviours toward the environment positively. Thus, students should be prepared to face these climate change challenges in order to enable informed decision making and appropriate actions in combating climate change (Monroe et al., 2013).

2.1.3 Understanding Climate Change Concepts

Weber and Stern (2011) define understanding climate change as a set of cognitions about what climate and climate change mean, what the essential attributes of climate are, how these attributes are connected to each other, what causes climate change, what the consequences of climate change will be, and the degree of confidence that should be placed in various knowledge claims about climate change phenomenon. Within research literature, the phrase ‘understanding climate change’, has been used in a variety of ways,

with researchers identifying and investigating several conceptions of what it means to understand climate change. As such, exploring individual's understanding of climate change concepts could be more important if investigating the understanding of the phenomenon of climate change incorporate broadly defined and conceptualized definitions of the term 'understanding' climate change such as knowledge; awareness; risk perceptions; beliefs; engagement and responses in an attempt to explore the multiple ways an individual may understand climate change issues (Nicholls, 2016). This provides a useful basis for investigating the diverse influences on individuals' understanding of climate change, thus giving insight into teaching and understanding climate change concepts in geography curriculum at secondary schools.

Further, there are several studies that have used climate change awareness index method, Likert scale approach and relating individual's ideas about climate change issues in order to investigate climate change understanding of a considered individual (Odoom, 2020; Carr et al., 2015; Christensen and Knezek, 2015; Gbetibouo and Mills, 2012). Therefore, this research uses the climate change awareness index method with relating respondents' ideas about climate change issue in order to achieve its objectives. Hence, the foundation of teaching and understanding climate change science at secondary schools is explored. Following, study investigating teaching and understanding of climate change concepts in the secondary geography curriculum is considered.

2.1.4 Knowledge, Awareness, Risk Perceptions, Beliefs, Engagement, and Responses about Climate Change

Understanding climate change can be defined in terms of knowledge about climate change, including acquiring and employing factually correct knowledge of climate change (Wolf and Moser, 2011). This implies knowledge of the causes and consequences of climate change, or knowledge of the physical processes and the mechanisms for climate and how they are connected (Whitmarsh, 2009; Bulkeley, 2000). It can also be knowledge about the potential mitigation or adaptive strategies that may be employed (Papadimitriou, 2004). In addition, knowledge about climate is to gain experiences and a basic understanding of the environment and its related problems (Vega 2004; UNESCO, 1978).

Awareness of climate change is identified as having "heard of" or being familiar with the term climate change or global warming (Leiserowitz, 2008). Awareness is also described as an action to global issues and sustainable development and, therefore, connects it to education (Manteaw, 2012). Further, awareness is to acquire concern and sensitivity towards the environment and its associated problems such as climate change. Moreover, raising awareness is often lauded as a key aim of climate change information or education programmes on climate change. It has been reported that Article 6 of the UNFCCC urges all countries to promote and facilitate education and public awareness of climate change (UN, 1992). In other words, widespread awareness of climate change is seen as an important factor in minimising long term vulnerability to the changing climate.

Awareness of climate change in some cases also refers to an individual holding some insight into the causes and consequences of climate change which may or may not include

a general awareness that there are ways to mitigate and/or adapt to the effects of climate change (Nicholls, 2016). Additionally, Leiserowitz (2008) ascertained that never having heard of the term 'climate change' does not necessarily indicate individuals are unfamiliar with changes to their local climate. Thus, people may have observed, attempted to explain or adapt to changes in their local climate, but not have the exposure to climate change science, and the language and theories this would provide. Also, it is important to note that awareness in terms of understanding climate change does not include having experiences with climate change if the individual is unaware that those experiences are related to climate change and that there is a collective scientific knowledge being amassed on the issue (Pelham, 2009).

Risk perceptions of climate change refer to the process of discerning and interpreting signals from diverse sources regarding climate change events, and forming a subjective judgement of the probability and severity of current or future harm associated with these events (Graham et al., 2020; Slovic and Peters, 2006). Further, risk perceptions of climate change are seen as a measurement of understanding within climate change literature or an individual's assessment of the perceived seriousness of the threat that climate change poses, as well as, perceptions relating to the urgency or serious of the threat and personal concern over threat to oneself and family in general (Leiserowitz, 2008). O'Connor et al. (1999) also defined risk perceptions as the perceived likelihood of negative consequences to oneself and society from one specific environmental phenomenon such as global warming. It has been argued that risk perceptions and knowledge influence individuals' willingness to take action in relation to climate change issues. Moreover, accurate knowledge about climate change has been reported as a significant influence on climate

change risk perceptions and also, lack of knowledge about potential consequences of climate change can lead to lower risk perceptions even in areas that are at increased risk (Reser et al., 2012).

The term belief refers to the attitude we have whenever we take something to be the case or regard it to be true or untrue (Schwitzgebel, 2010; Lemos, 2007). In the context of climate change, individual's beliefs relating to the occurrence of climate change, the validity of climate change science, including reliability and availability of evidence, and attribution of cause, for example anthropogenic, natural or a combination of the two, can be discussed in order to have a better people's understanding about the changing climate (Wolf and Moser, 2011; Whitmarsh, 2009). Individuals do not disagree about climate change because one knows more about a topic than the other; rather individuals' cultural predispositions will shape their perceptions and beliefs about who the credible sources of knowledge are (Kahan et al., 2011). In addition, individuals recognise or identify credible sources of knowledge as those sources that share their worldviews. Further, Maibach et al. (2009) argued that ideological and political beliefs strongly influence the way in which individuals engage with climate change science. In this regard, environmental values, political affiliation and religious beliefs seem to be linked to climate change beliefs (Whitmarsh, 2009). Thus, individual's beliefs need to be taken into account when investigating people's understanding about climate change issues.

Engagement with climate change refers to an individual's attention to climate change, including active thinking about and interest in the issue, attention to individual actions, and personal connections (Wolf and Moser, 2011). It has also been argued that engagement towards tackling climate change is defined as a state of personal connection

that encompasses cognitive, affective and/or behavioral dimensions, or what people feel, know and do about the changing climate (Lorenzoni et al., 2007). Further, it is not enough for people to know about climate change in order to be engaged; they also need to care about it, be motivated and able to take actions that combat climate change (Nicholls, 2016). In addition, Wibeck (2013) asserted that individuals have an important role to play in mitigating and adapting to climate change with individual and collective engagement. Importantly, Kollmuss and Agyeman (2002) ascertained that knowing, caring, and doing are not related in a linear manner, that is increased knowledge does not necessarily lead to an increase in caring, leading to behaviour change. Thus, some personal and social barriers have been identified as factors influencing the degree of individual engagement with climate change such as values, experiences, social context, and knowledge about issues (Lorenzoni et al., 2007). Moreover, the way in which climate change is communicated can serve to hinder personal engagement with the issues. For example, O'Neill and Nicholson-Cole (2009) argued that fear shocking or inducing images of climate change have been shown to increase an individual's concern over climate change; nevertheless the same images also tend to disengage individuals as they may leave them feeling overwhelmed and disempowered. Additionally, Moser (2007) posited that individuals tend to feel more engaged with an issue when they understand the extent of their vulnerability, feel informed about the risk, have clear goals and strategies to reach their targeted goals.

Responses to climate change include people's opinions or understanding about appropriate and effective reactions to climate change, including personal actions and/or policy preferences (Nicholls, 2016). Further, Leiserowitz (2008) argued that

understanding of climate change in terms of responses to climate change refers to on how individuals ascribe perceived responsibility for action, effectiveness of individual, collective and government actions, as well as preferences for a wait and see approach to action, a need for immediate and major action, or the enactment of the precautionary principal approach to uncertain risk related to climate change. In addition, people who are aware of and accept climate change believe something should be done to minimise short and long term effects through mitigation and adaptation measures (Ashworth et al., 2011). Bulkeley (2000) also argued that individuals feel morally responsible to act on climate change even in the face of inaction by larger groups and government, but these actions can be limited by institutional factors with which individuals feel they have no control over. Therefore, perceived efficacy of individual actions may limit actions taken on an individual scale in reducing climate change impacts on their lives and livelihoods. Moreover, Gifford (2011) and Howell (2011) reported that individuals may not be effectively responding to climate change due to structural barriers, financial barriers, and factors within the physical environment, and psychological barriers. It is therefore worthy of it to discuss climate change education broadly. The next section discusses climate change education and its implications.

2.1.5 Climate Change Education

Climate change education promotes learning about the causes and effects of climate change as well as possible responses, providing a cross-curricular and multidisciplinary perspective, therefore developing competences in the field of climate change mitigation and adaptation, with the aim to promote climate-resilient development and reduce the vulnerability of communities in the face of an uncertain future (UN CC: Learn, 2013).

Despite all the massive scientific facts and predictions of climate change, there is a gap in effectively translating these facts in a way that influences peoples' behaviour and attitudes in their daily activities (Odoom, 2020). Thus, UNESCO (2005) asserted that education is seen as the viable variable because of its transformative function where teachers and education institutions can play in the preparation of students towards sustainability under the changing climate. In this regard, as a cross-cutting topic, climate change concepts can be taught at all levels within the school system. Indeed, several studies have been conducted about climate change education from primary school to higher education. Thus, climate change education trends could be described based on the three main levels of education such as primary school, secondary school and higher education. For the primary school, some basic concepts related to environment, weather, climate and the importance of protecting the environment could be taught to the learners, while at secondary school, the basic environmental and climate related concepts learned at primary school could be deepened through practical activities inside and outside the school. Indeed, considerable results have been observed in many countries with significant climate literacy level of learners such as in Singapore, United States and Canada among others. In higher education, the learners can deeply go with the help of their institutions through the physical science, as well as social, political and economic aspects of climate change so that they can become considerable human resources in the field of climate change, therefore promoting sustainable development at local, national and international level. In addition, higher education sector is most in need of developing a systemic approach for climate change education (Leal Filho, 2010a). Thus, the following Figure 2.1 summarizes climate change education process from primary school to tertiary education.

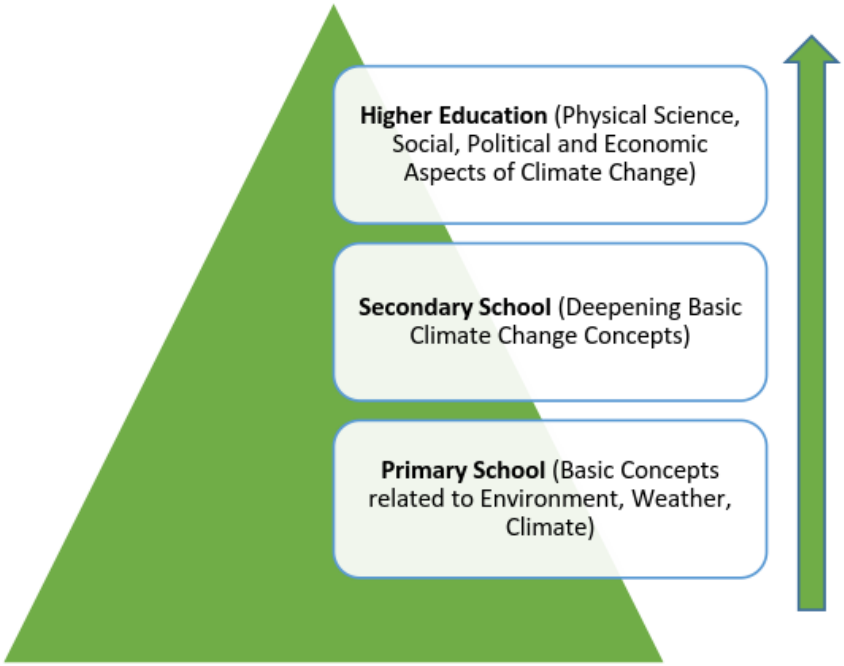

Figure 2.1: Climate Change Education Process from Primary School to Higher Education (Source: author, 2022)

Further, United Nations' Paris agreement of the United Nations Framework Convention on Climate Change (UNFCCC) under the Articles 6 and 12, urges the United Nations member states to actively promote, formulate, develop, encourage and implement educational, training and public awareness programmes with reference to environmental and climate change education and the associated negative effects on man and his environment (UN, 2015), thus implying the relevance and instrumentality of education in tackling the changing climate. In this regard, three scenarios have been suggested as to where climate change education could belong; where could be developed as an integral

element of education for sustainable development and therefore be treated as interdisciplinary; where it could be treated as independently as a major theme in science and the last scenario as a fusion of the two-scenario treated independently under the umbrella of education for sustainable development (Læssøe et al., 2009).

However, the underscoring purpose of climate change education is to advancing sustainability and thus fit under the broader umbrella of education for sustainable development. Additionally, climate change education in the framework of education for sustainable development is one of the four core programmes within the UNESCO's climate change initiatives (UNESCO, 2010). UNESCO (2015) reported that this represents an innovative education which makes use of relevant educational strategies to help people in a larger spectrum, especially the youth, understand, tackle, alleviate, and adapt to the impacts of climate change, stimulate the need for attitudinal and behavioural changes essential for realizing a sustainable world, and raise a generation conscious of their influence on climate change. This helps the learners to recognise the causes and effect of the changing climate, prepares them to adapt to its impact and empowers them to take informed decisions to live a sustainable lifestyle (Odoom, 2020). Climate change is a major theme within the sustainable development umbrella. Leal Filho et al. (2018) also expressed that embedding the sustainable development goals within and across the curriculum will contribute not only to extending and enhancing human capital, but will also yield an increase in the numbers taking action and aiming to live sustainably, thus this could have significant impact on securing achievement of the goals and a better future. Indeed, climate change education refers, on the one hand, to the knowledge that should be transmitted to mitigate the effects of climate change and adapt to a constantly changing

environment and, on the other hand, to the skills required to modify our attitudes and behaviours towards the environment. In other words, education is held to be central to sustainable development, public understanding and awareness of sustainability is one of the major thrusts of education for sustainable development (Dlamini, 2011).

Climate change education has the role to arouse the interest and reinforce the understanding and alertness to the realities of the changing climate. Wals (2014) argued that climate change requires a change of mind or self-transformation. UNESCO (2013) posited that climate change education has the role to engender self-transformation by awakening our thinking that our 'business as usual' way of doing things is in no way going to help avoid the threat of climate change but rather going to aggravate the global warming with its repercussive effects on humanity and as such, each person should play his or her part in helping to avoid this looming threat, therefore providing continuous engagement and repetitive reflection which helps the learner to navigate through this path and hence underscore transformation. Therefore, the underscoring goal for self-transformation to climate change is to affect societal and personal transformation, therefore promoting sustainable development.

Furthermore, Ogbuigwe (2010) ascertained that climate change programmes are mainly concerned with the facts of climate, especially the scientific basis of predictions and despite all these activities being in place, there is still not effective capacity to bring the understanding of climate change facts to the public in a manner that influences their day-to-day actions and habits. This implies that education comes in as the relevant variable which can help the public to learn and develop dynamic skills, appropriate knowledge and change of behavior for successful climate change adaptation and mitigation (Aladag,

2010). Education also provides a benchmark, which can enable individuals and communities to make informed decisions and take action for climate resilient sustainable development (Lenglet, 2009). Therefore, policy makers should seriously take education sector through engaging it in any existing climate change frameworks that can utilise education as both a mitigation and adaptation strategy based on the major climate treaties such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol which have articles calling on governments to support education for climate change (Anderson, 2010; Boon, 2010; Home and Fien 2010; Padolsky, 2006).

Education offers the best opportunity for youth who are future leaders of tomorrow to be empowered to be able to sustain their livelihoods and that of the future generations. Additionally, Dlamini (2019) and UNESCO (2010) reported that what children learn today will shape tomorrow's world. Young people are also the future policy makers, administrators and leaders, and when not properly empowered, can become the future destroyers of the society and environment (Ozor, 2010). Further, climate change education at all levels and in both formal and non-formal settings is needed, instilling climate change awareness and understanding of climate change at a young age is ultimately the best way to achieving lasting change in behaviours and attitudes coupled with the local context and traditional knowledge and practices (Anderson, 2010). Thus, content of climate change education is relevant and important in the teaching-learning climate change process. The next discussion is tuned to content of climate change education.

2.1.6 Content of Climate Change Education

Climate change education is most often defined narrowly focusing on climate literacy and environmental education at school (Anderson, 2012). Further, climate change education is not limited to relevant content knowledge on climate change and environmental education, disaster risk reduction and sustainable consumption and lifestyles, and social issues, but also, it should focus on the institutional environment within which that content is learned to ensure that schools and education systems themselves are climate-proofed and resilient as well as sustainable and green (Anderson, 2012). Therefore, the institutions in which climate change education is advocated should stand for what it advocates for and it should serve as a model of what it advocates for or it trains for the profit of people and the nature. Additionally, it has been identified three-dimensional roles for climate change education which include mitigation, adaptation and understanding and attentiveness towards the changing climate in order to achieve sustainable development (UNESCO, 2013).

Adaptation focuses on capacity building to enhance resiliency and lessen the degree of vulnerability of the individuals and communities at large to counteract the impact of the changing climate (UNESCO, 2013). Anderson (2012) reported that these may include disaster risk reduction education, flood management behaviour and drought resistance farming systems among others. Thus, it becomes urgent to reduce the communal and individual vulnerability to climate change impact. This may extend to re-orienting of traditions and cultural practices of the learners in order to better adapt to the adverse impacts of the changing climate. Alertness and understanding dimension of climate change education focuses on helping learners to understand what is happening to the

climate, understand the driving force behind the changing climate and preparing learners to be alerted and mindful of the changes occurring (UNESCO, 2013).

Climate change mitigation involves developing learners' knowledge on the causes and effects of climate change, developing the skills necessary and dispositions for rectifying the causes (Anderson, 2010). It has been noted that human-induced climate change is caused by human activities that involve greenhouse gas emissions into the atmosphere. This implies that education on mitigation should involve development of knowledge and skills on activities that prevent or limit greenhouse gas emission and also, it should promote activities that serve as carbon sink (Odoom, 2020). Thus, the relevant content knowledge for climate change education classroom should include the causes (human-induced and natural), effect (health, economic, social), mitigation (societal and personal actions to reduce greenhouse gas emission), and adaptation and appropriate disaster risk management measures (Field et al., 2019). Therefore, in this regard, it is important to consider the existing educational policies on climate change. Thus, the following section discusses the educational policies on climate change issues.

2.1.7 Educational Policies on Climate Change

The inclusion of climate change education into the school curriculum was suggested at the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992, which was attended by representatives of governments, international and non-government organisations as well as civil society (Knight, 2008). Further, at this conference, the global plan of action, commonly known as Agenda 21, which was adopted by delegates, provided a comprehensive set of principles to assist governments and other

institutions in implementing sustainable development policies and programmes. Indeed, the Principle 10 of Agenda 21, states that environmental issues are best handled with participation of all concerned citizens, at the relevant level, thus playing an important role in fostering connections between human rights and environmental agendas at the national level (Dlamini, 2011; Knight, 2008). Therefore, based on this principle, this study strongly believes that education has a significant role to play in tackling the impact of climate change in Senegal.

In an attempt to enhance the comprehension of climate change globally, three international treaties came out of the United Nations Conference on Environment and Development in Rio such as the Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD), and the United Nations Convention to Combat Desertification (UNCCD), and collectively these are known as the Rio Conventions (UNICEF, 2007). Moreover, there is a huge responsibility of the Secretariat of these international organisations to support member states (parties to the convention) to form and implement national policies to address these environmental threats and risks to human security (UNESCO, 2010). As regards, there are several international and regional treaties and instruments which are relevant to issues related to climate change and young people that have emerged. Thus, Senegal, has developed its National Adaptation Plan of Action and others relevant climate change policies in order to combat this environmental issue.

The Johannesburg World Summit on Sustainable Development in 2002 also underpinned the need to integrate sustainable development into education systems at all levels so as to promote education as a key agent for climate change, and recommended the adoption by

the United Nations General Assembly of the United Nations Decade of Education for Sustainable Development (UNICEF, 2007). Indeed, as suggested by United Nations Decade of Education for Sustainable Development (2005-2014), climate change education for sustainable development demands a reorientation away from entirely focusing on providing knowledge in a specific domain, towards dealing with interlinked problems and promoting action competencies for complex issues. Furthermore, the Article 6 of the UNFCCC addresses education, training, public awareness, public participation and access to information in relation to climate change in engaging all stakeholders and major groups (UNFCCC, 2010). Thus, climate change international institutions and organisations provide a benchmark for individuals, regions, countries, and the entire world a strong base for action to protect health, and all spheres of life from the impact of climate change (Dlamini, 2019). However, in some developing countries such as Senegal at present it appears that there is no coherent dialogue as how to expand climate change agenda in order to include education as a tool in mitigation and adaptation measures. Indeed, policymakers in Senegal seem to not fully engage the education sector in combating climate change, despite the considerable existing climate change education frameworks which have been globally established already.

Ekpoh (2009) argued that in the global education community, several stakeholders such as UNICEF, UNESCO, and UNEP among others are incorporating components of climate change education agenda and helping schools and communities to integrate climate change and environmental education into the curricula. Therefore, it is important to note that climate change education at both primary and secondary school level has the potential to play a crucial role in developing awareness and improving understanding about this

environmental issue, thus driving attitude, behavior changes and important environmental value, which may contribute toward climate change mitigation (UNESCO, 2009; UNEP, 2006). In the next section, climate change education policies in Senegal are discussed.

2.1.8 Climate Change Education through Programmes of Education for Sustainable Development in Senegal

There is a clear desire to promote sustainable development activities and climate change education in Senegal. Indeed, the country has been engaging very early in the ratification of international conventions such as the adoption of the United Nations Charter on Sustainable Development, the adoption and implementation of the Agenda 21 of Rio, the creation of a National Commission for Sustainable Development in 1995 and the establishment of a National Strategy for Sustainable Development (SNDD) in 2005. Moreover, in this SNDD framework, education has an essential role to play, thus this has enabled planners to introduce education for sustainable development into the basic school curriculum as early as 2005 (Ndiaye, 2021). Therefore, Senegal can be considered as one of the leaders of education for sustainable development in West Africa through the United Nations Decade of Education for Sustainable Development (2005-2014), and many programmes of the OIF (International Organisation of the Francophonie) and IFADEM (Distance Education Initiative for School Teachers) among others. Additionally, in its Constitutional Law n ° 2016-10 of April 05, 2016 on the revision of the Constitution, Senegal reaffirmed its commitment at the international level, by including sustainable development in its Supreme Charter, thus promoting environmental education for the populations, especially the youth in line with the Paris agreement on climate change and sustainable development goals pathways.

However, in Senegal the promotion of environmental and climate change education is clearly mentioned in official documents but, it is very difficult in practice to highlight concrete implementations at schools. Also, there is no official training programme dedicated to climate change education at elementary school (Ndiaye, 2021). There are efforts that have been made for climate change and environmental education at Senegalese secondary school through learning programmes which deal with geography, natural sciences, and civic education. Further, UNESCO in collaboration with the Ministry of the Environment in charge of sustainable development and the Ministry of National Education organized in 2017 an inter-ministerial conference on climate change issues. The Government of Senegal also gives much more importance to the issues of environmental education and its integration into the education system, thus providing knowledge, attitudes and practices of environmental management across the country (PAQUET, 2013). However, an implementation gap remains regarding the existing environmental policies, thus the practical aspects of those environmental programmes and projects leave a lot to be desired.

Moreover, Ndiaye et al. (2020) and UNESCO (2017) posited that based on the premise that we all have a role to play in solving global problems, education for sustainable development has emerged as the cornerstone of action on climate change. Therefore, climate change education for sustainable development can help to use the knowledge, skills and values essential in order to make our society healthy, more equitable and more ecologically viable (Ndiaye, 2021; Sauvé, 2006). This implies that climate change education programmes content is crucial in achieving effective teaching-learning process about the issues of climate change. Thus, it is relevant to understand what the content of

climate change education is and discuss on the relevance of pedagogic content knowledge in climate change education; hence the next section of the discussion turns to the relevance of pedagogic content knowledge in climate change education.

2.1.9 The Relevance of Pedagogic Content Knowledge in Climate Change Education

Pedagogic content knowledge refers to teachers' knowledge of how to represent and explain subject matter covered in the classroom, such that it is most clear and understandable to learners (Archambault and Crippen, 2009; Seukma, 2007; Shulman, 1987). Thus, in the context of climate change, it is important for teachers to have a clear understanding of the subject matter so that the correct information is relayed to learners. Further, teachers should also have an understanding of future projections, natural and anthropogenic factors related to climate change impact (Hestness et al., 2013). McCaffrey and Buhr (2008) argued that in terms of climate change education, sound teacher content knowledge is crucial. Furthermore, this implies that if teachers develop a robust pedagogic content knowledge, their own misconceptions will be corrected (Dlamini, 2019). In other words, it is important that teachers do not hold minimal misconceptions about climate change issues, as there is a danger of teachers passing on such incorrect conceptions to students. Nevertheless, UNEP (2011) and UNESCO (2010) reported that it is also important that teachers are able to extend climate change as a subject of study beyond the scientific facts, to give learners the relevant tools and practical knowledge to successfully adapt to, and mitigate the changing climate. In addition, climate change education can be effective when it occurs within appropriate teaching and learning methods (Odoom, 2020).

The following section, thus discusses teaching and learning methods in climate change education process.

2.1.10 Teaching and Learning Methods in Climate Change Education

Climate change education involves attitudinal and behavioural change; selection of teaching strategy is of great concern (Odoom, 2020). Therefore, it has been pointed out that the focus of any educational campaign with regards to climate change should be learning and not teaching (Boakye, 2015). Further, in the quest of searching for appropriate methods in educating about climate change, three pedagogical processes for learning climate change have been identified such as local observation of phenomenon, experiential learning and conceptual change theory (Pruneau et al., 2003). Thus, local observation of phenomenon concerns with creating appropriate platforms for the learners to observe a phenomenon in order to construct or shape their ideas. While, the experiential learning involves learning by interacting with the environment, therefore it is the process by which the learner constructs knowledge bias affective and cognitive interactions with the biophysical and the built environment. With the conceptual change theory, it involves conceptual development where initial ideas held by students are shaped into the more scientific notion. Here, the initial idea or conceptions are enriched and restructured, thus the initial idea is either replaced or strengthened. Though, these three pedagogical processes complement each other (Pruneau et al., 2003).

Climate change education involves attitudinal change, therefore the teaching and learning should touch both the mind (that is the knowing area involving conceptual) and the heart (that is the seeing area which involves perceptual) in order to achieve the

learning objectives (Bryan, 2011). Moreover, Sterling (2014) stated that the psychomotor skills (kinesthetic/doing) of the learner are not left behind since the learner engages in physical activities to support the manifestation of cognitive or affective domain. Further, Beach et al. (2019) attested that the use of stories and videos in teaching climate change has been also practically proven effective. Also, Field et al. (2019) and Boakye (2015) reported that the use of graphical representations and videos, stories, observation, field trips, project, and enquiry-based teaching coupled with discussion and creating a platform for learners to engage in democratic process of thinking, implementing, agreeing, and evaluating concrete changes individually and in a group through debates are encouraged in teaching and learning climate change issue. In school system, it is also important to take into account curriculum conceptualization when teaching-learning climate change concepts are concerned. Thus, the next section discusses the curriculum concept.

2.1.11 Curriculum Concept

According to Collins English Dictionary (2003) curriculum from the Latin word means the path, the way, and the course. Curriculum is also the entire programme of the schools' work, thus it is of all that the students could learn, this is what they must learn, and of all the things we could teach, this is what we must teach (Adeyinka, 1988). Further, it has been attested that curriculum is seen as a plan of learning (Voogt et al., 2019). Conceptualization of curriculum and its development process, implementation and evaluation are as varied from one philosopher to another; from one educator and/or educationist to another and from one generation to another in time and space (Moyinoluwa, 2013). However, Moyinoluwa (2013) asserted that there is the common understanding that curriculum is a set of planned and organized material designed for an

intended learning outcome, considered as adequate for any functional expectations of people in space and time. Therefore, this definition appears simplistic and less inclusive of many factors that continually present issues to developers and operators of a given curriculum package.

In the context of this research, the curriculum makers need to base their work upon the Senegal National Education Orientation Law in 2004 whose its main objective is to train free men and women, able to create conditions for their development at all levels, to contribute to the development of science and technology and to adopt effective solutions to the problems of national development. Thus, the secondary geography programme in 2006 was born out of this desire to contribute to the training of committed citizens armed with the knowledge and skills necessary to act in their communities and environment positively (Diop, 2019). Despite of all the efforts made in curriculum conceptualization and its development process, it has been noted that there are important differences between the planned and intended curriculum by a state or a nation for each subject area and for the various levels of educational ladder (Moyinoluwa, 2013). There are determinants of curriculum such as society, knowledge, learners and learning theories and principles which need to be essentially and consistently considered in developing, revising and communicating a curriculum.

Ultimately, schools provide a favourable environment that promotes positive attitudes and behaviour towards climate change, thus formal lessons can also help reinforce the concepts of climate change which in turn influence students' knowledge, skills, attitudes and behaviour towards climate change (Ronald et al. 2017; Chang, 2013). Therefore, geography education is seen to considerably contribute to education about the aspects of

climate change. As regards, the study employs content analysis approach in order to assess climate change concepts captured in the secondary geography curriculum in Senegal. Thus, the next section of the discussion examined the importance of geography education in understanding climate change.

2.1.12 Importance of Geography Education in Understanding Climate Change

According to Ofsted (2008), geography is an interdisciplinary subject and its practical nature helps learners to understand change, conflict and key issues which impact their lives presently and which will affect their future. Also, if the aspiration of schools is to create young people who are active and well-rounded citizens, there is no more relevant subject than geography (Ofsted, 2008). Indeed, geography education can help the youth, the citizens of tomorrow to understand the management of risk, appreciate diversity, be aware of environmental issues and promote sustainability, and respect human rights and social inclusion. Additionally, Lambert and Morgan (2010) ascertained that geography as a discipline is pivotal in the school curriculum because it is both forward looking and progressive, and at the same time seeks to conserve tradition. IGU (1992) suggested that geography education is indispensable to the development of responsible and active citizens in the present and future world.

Geography is the school subject that pinpoints the human-environment-human relationship (Onuoha et al., 2021; Gritzner, 2003). Sweeny (2011) also alluded that geographer possesses the required synthesis skills for integration of spatial insights, which could help learners to be more sensible towards their environment. Further, geography as a school subject could equip learners with values, skills and knowledge in attaining

environmentally-friendly behaviour, which in turn can reduce the burden of the changing climate. Therefore, climate change has been rightly situated within geography curricula across the globe, making geography an important school subject (Onuoha et al., 2021). Additionally, it is important to do a comparison of geography curricula across countries to determine their advancement of sustainability, thus implying prospects of attainment of sustainability in the era of climate change through effective implementation of geography curriculum (Lidstone and Stoltman, 2007).

In the context of Senegal, the secondary geography curriculum concerning the lower and upper secondary schools contains the concept of environment, thus emphasising on the learner's environment and living environment, whose understanding of the mechanisms should facilitate understanding of the complexity of the overall environment, including climate change issues (Ministère de l'Education Nationale, 2006). This seems to indicate that teaching and learning climate change concepts at Senegalese secondary schools through the secondary geography programme has a significant basis which could help learners to understand this environmental issue effectively. Timera (2004) also related that there is the desire to train citizens concerned with preserving the environment at Senegalese schools. In addition, in Senegal secondary education, geography is a subject that contains climate change as a topic and it is a compulsory subject in the general education system of the country. Further, in the recent general policy for education and training sector entitled *Lettre de Politique Générale Pour le Secteur de l'Education et de la Formation,* (LPGS-EF 2018-2030), it has been postulated that the learner should be dedicated and active in preserving the environment within the sustainable development pathways (République du Sénégal, 2018). Moreover, PURGES (2020) opined that the

secondary geography programme in Senegal plays a role in understanding contemporary phenomena such as climate change, and it is recommended that geography teachers should make their students aware of the risks caused by climate change since they are able to grasp the issues and to transmit them to their learners, thus showing the importance given to the subject. Additionally, objectives linked to recent issues such as climate change and sustainable development are taken into account in the current secondary geography programme (Thiaré, 2020; Mbodji, 2017; Camara, 2015), thus this pinpoints the relevance of secondary geography education in enhancing learners' climate literacy in Senegal. Therefore, knowing how climate change science is taught and understood at secondary schools in Senegal through the geography programme is one of the objectives of this research. The next section considers empirical evidence on teachers' and students' understanding of climate change concepts.

2.2 Empirical Review

2.2.1 Teachers' and Students' Understanding of Climate Change Concepts

Generally, there are several studies that have broadly investigated the teachers' and students' understanding of climate change concepts in the literature. It has been revealed that pre-service and in-service teachers as well as students hold various misconceptions about climate change, and also possessed low level of awareness and understanding about the changing climate (Onuoha et al., 2021; Dike and Amadi, 2016). There are misconceptions and misunderstandings that people, of all ages, hold of many aspects of climate change issues in terms of causality, possible consequences, and possible solutions (Odoom et al., 2020; UNESCO, 2012). Dlamini (2019) argued that these misconceptions

and misunderstandings are probably due to, among other things, the complexity of the science involved, and the uncertainties and the controversies surrounding them. Therefore, by understanding these misconceptions, teachers are in a better position to devise strategies for successfully addressing them in the classroom and the communities at large.

Although there are many advocates of having climate change education incorporated in the educational system, the misconceptions and misunderstandings about climate change are not only held by learners but by teachers as well (Graham et al., 2020). For instance, a study conducted in Dakar department revealed the main concern for the selected geography teachers is to articulate the causes and consequences of climate change with its impact on the surrounding environment of the learners (Diop, 2019). Ndiaye et al. (2020) also reported that primary teachers in Senegal are unable to exactly spell out five causes of climate change. Raymond et al. (2015) also reported that the majority of the selected geography teachers at high school in the Western Cape Province of South Africa have significantly demonstrated high literacy levels in climate science, with their literacy levels higher in climate processes and causes of climate change than climate change impacts and solutions. Further, the most commonly observed misconception among in-service teachers is confusion between the greenhouse effect and global warming, also observed among pre-service teachers (Herman et al., 2017). In addition, another misconception is the erroneous attribution of the responsibility for global warming to the phenomenon of the depletion of the ozone layer, which is observed among in-service teachers, as well as pre-service teachers (Graham et al., 2020; Seroussi et al., 2019). Furthermore, the belief that there is no human responsibility for climate change is an important misconception found among pre-service teachers, as well as in-service teachers (Plutzer and Hannah, 2018).

Additionally, Higde et al. (2017) reported that in some cases, some pre-service teachers were even found to ignore climate change itself. Plutzer and Hannah (2018) reported that 13 to 16% of teachers in the United States still think that climate change is due to natural causes and many others say they are unsure about this environmental issue.

Teachers have been confusing between climate change and the normal transition from one season to another (Odoom, 2020). Dlamini (2019) and Karami et al. (2017) have shown the misconceptions held by pre-service teachers on the causes of climate change and also the difficulty for teachers to differentiate between weather and climate. Also, there has been found lack of distinction between weather and climate from people due to media reportages which tend to discuss climate change in the context of local weather-related issues (Seroussi et al., 2019). In addition, Weber (2010) ascertained that though climate change is statistical base people sometimes rely on personal experience which could also lead to the erroneous conclusion and also, observations are spaced in time and memory of past events can be misleading. This explains that climate change cannot be easily determined by personal experience as it could easily lead to erroneous conclusion (Weber, 2010).

Further, UNESCO (2010) stated that quality education is the hallmark of climate change education and can be achieved through strengthening the teacher. Indeed, teachers play a crucial role in student academic performance; however, this depends on the knowledge of the teacher in the relevant area of his or her work (European Commission, 2012). Thus, UN CC: Learn (2013) asserted that strengthening teachers' capacity in delivering accurate information, integrating local content, promoting critical thinking about and acting on climate change mitigation and adaptation is crucial in promoting climate change

education. This should also include the cultivating favourable grounds for educators to increase their understanding of climate change and sustainability issues and the required pedagogical skills support (UN CC: Learn, 2013). Therefore, teachers are one of the population influencers especially when students are concerned and as such their knowledge and perception in climate change will have a greater impact on the population (Seroussi et al., 2019; Dal et al., 2015).

Other researches indicate that students struggle with the scientific complexity of climate change, while it has been posited that young people are portrayed those to be hardest hit by the effects of climate change (Graham et al., 2020). Moreover, a study conducted at the University of Cape Coast, Ghana reported that the selected students generally do not understand basic concepts of climate change (Abaidoo, 2016). A study conducted in Dakar department, Senegal, revealed that there is a need to teach learners about climate change issues in order to help them to accordingly act for the preservation of their environment (Diop, 2019). There are misconceptions about climate change among grade 11 learners in the Tshwane metropolitan municipal area, South Africa, as they conflate climate change and the greenhouse effect (Lekgeu and Davis, 2017). It has been asserted that understanding and perception of climatic change of children was still somewhat distorted (Odoom, 2020). Further, the way in which the science of climatology describes and explains this complex phenomenon, and the scientific viewpoints that differ when attempting to identify the causes and consequences of climate change, exacerbates chances of misunderstandings developing among the public and learners (Lekgeu and Davis, 2017).

Moreover, misunderstandings about climate change are a worldwide phenomenon (Graham et al., 2020). Thus, climate change education is designed as the remedy for public distrust and lack of interest in climate change (Wibeck, 2013). Despite a large amount of literature concerning teachers' and students' understandings of climate change concepts in other parts of the world, studies on teaching and understanding climate change at Senegalese secondary schools are rare. Hence, that is one of the reasons of this research to contribute in filling this knowledge gap. It can be noticed that climate change education at school encounters significant challenges which hinder its effectiveness. The next section, thus discusses the barriers that can affect the effectiveness of teaching and learning climate change concepts at school.

2.2.2 Identified Barriers in Teaching Climate Change Science in School Curriculum

There are challenges associated with climate change education, as it is a topic which everybody has an opinion eventually based on false knowledge and misconceptions (Dlamini, 2019). Thus, for climate change education, it is relevant that teachers have an understanding of the different barriers that can be encountered so that their teaching can be effective and efficient. In addition, teachers' attitudes, motivation and skills fully contribute to effective teaching of climate change concepts at school (UNESCO, 2010). The following Table 2.1 summarizes identified barriers to climate change education in the literature.

Table 2. 1. Identified Barriers in Teaching Climate Change Concepts

Identified Barriers in Teaching Climate Change Concepts	Study
Limited teacher's understanding about climate change concepts	Crayne, J.A. (2015). Teaching Climate Change: Pressures and Practice in the Middle School Science Classroom. Master of Science, Environmental Studies Program and the Graduate School of the University of Oregon.
Limited relevant teaching and learning resources	Vujovic, J.O.S. (2013). FET Geography teachers' knowledge and perceptions of climate change and an evaluation of the textbooks used for climate change education. Master's Thesis. Johannesburg: University of the Witwatersrand.
Mass media, as an influencing factor	Robinson, Z. P. (2011). Environmental Issues. New York: Merrill Publishers.
Climate change education rooted in traditional educational approaches	Haslett, S., France, D. & Gedye, S. (2011). Pedagogy of Climate Change.
Incomplete integration of climate change concepts into school curricula and all educational agendas and policies	UNESCO. (2015). Climate change education and awareness. htt://www.unesco.org.
Teachers' reluctance to teach climate change topic because of its political and controversial aspect	Berger, P., Gerum, N. & Moon, M. (2015). Roll up Your Sleeves and Get at It! Climate Change Education in Teacher Education. Can. J. Environ. Educ. 2015, 20, 154–172.
Abounding misconceptions about the causes and effects of climate change among educators, young people and local communities	Ochieng, M.A. & Koske, J. (2013). The Level of Climate Change Awareness and Perception among Primary School Teachers in Kisumu Municipality, Kenya. Int. J. Humanit. Soc. Sci., 3, 174–179.
	Wachholz, S., Artz, N. & Chene, D. (2014). Warming to the idea: University students' knowledge and attitudes about climate change. Int. J. Sustain. High. Educ, 15, 128–141.

Therefore, it is important and urgent for climate change education to be fully incorporated into the school curricula so that to explicitly provide an explanation about the concepts of climate change. To achieve its fourth objective, this study uses the logistic regression model in order to determine the factors that influence the effectiveness of teaching climate change science within the Senegalese secondary schools. The subsequent section addressed the theoretical review which is relevant to the objectives of this research.

2.3 Theoretical Review

Several theories have been proposed to investigate understanding and teaching about climate change concepts at school. Some theories such as Social Representation Theory, Identity Process Theory and Activity Theory, and their relevance to the objectives of the study are discussed in this section. Social Representation Theory is a system of values, ideas and practices which seek to establish a social order to enable individuals orient and master themselves in their material and social world (Moscovici, 1973). Further, Social Representation Theory is mainly concerned with how individuals, groups, and communities collectively make sense of socially relevant or problematic issues (Marková, 2008). Additionally, Social Representation Theory helps to explain how social issue are interpreted and accepted or rejected in society (Abaidoo, 2016). Thus, Jaspal et al. (2014) argued that the application of Social Representation Theory in the studies of climate change is proving very potent. Climate change is often an elusive, invisible, and abstract object that people struggle to completely comprehend (O'Neill and Hulme, 2009). As a result, most climate change research, particularly in the social sciences, are concerned with how the issue is portrayed in society and how people react to it (Jaspal et al., 2014). The social representation theory substantially addresses this question. Nevertheless,

Voelklein and Howarth (2005) opined that Social Representation Theory has some flaws because it does not explain how people's perceptions and understandings are converted into conduct. Potter and Edwards (2000) asserted that this scenario makes it difficult to explain people's responses to the issue after it has been presented in society. Dunwoody (2007) demonstrated that social representations of climate change cannot guarantee action, owing to socio-psychological factors that may push individuals to accept or reject the subject being portrayed. Therefore, the concerns that Social Representation Theory does not adequately address appear to be solved by Identity Process Theory, which has a better chance of reconciling social representation and behaviours. Indeed, this theory contributes to understanding how perceptions and information are converted into action. The Identity Process Theory highlights present as well as potential obstructions that may psychosocially prevent a person from taking action. According to Leiserowitz (2007) and Leiserowitz et al. (2010b), groups with similar risk representations, values, and socio-demographic characteristics may respond similarly to climate change representations. However, according to Jaspal et al. (2014), this may operate only at the community level but may neglect the active role of identity in understanding human or the individuals' responses to climate change. Regarding the Activity Theory, the study considers it as the main theoretical framework which can help the researcher go through a thorough assessment of the research problem. Indeed, theoretically, the study is hinged on the Activity Theory which was developed by Engeström in 1987. Activity Theory is a practical framework which can be used to underpin the complex and dynamic problems of human research and practice. Also, it has been argued that the key concept of Activity Theory arises through an understanding of human consciousness as it has been shaped by experience and the subjectivity of human awareness. Activity Theory is a conceptual

framework based on the idea that activity is primary, that doing precedes thinking, which goals, images, cognitive models, intentions, and abstract notions like definition and determinant grow out of people doing things (Morf and Weber, 2000). Indeed, Activity Theory is geared towards a practice which embodies a qualitative approach that offers a different lens for analysing learning processes and their outcomes; therefore, it quite neatly focuses on human activities in areas such as those in the field of education (Hashim and Jones, 2007). Furthermore, Activity Theory has inspired theoretical reflection in education field which in general incorporates approaches involving human activity. As a focus of analysis, the Activity Theory is being holistically rich in terms of understanding how people do things together with the assistance of tools within intricate and dynamic environments (Liaw et al., 2007; Korpela et al., 2002). Additionally, Activity Theory can be seen as a framework for analysing data, and providing means for observing the emergence of patterns in human activity in terms of achieving goals and purposes of a programme. In other words, Activity Theory views the core within a dialectic process between subjectivity and objectivity, learning and doing, individual and collective, technical and social, and also tacit and explicit knowledge (Crawford and Hasan, 2006). Therefore, it has been reported that the original triangular representation of activity was expanded in order to enable an examination of systems of activity at the macro-level of the collective and the community, in preference to a micro-level concentration on the agent or individual actor operating with tools (Engeström, 1999).

Indeed, this Activity Theory approach represents the way in which Engeström brought together cultural artifacts with human actions in order to dispense with the individual and social dualism through the image of a triangle. Hasan (1998) stated that Activity Theory

uses the whole activity work as the unit of analysis, where the activity is broken into the analytical components of subject, tool and object, where the subject is the person being studied, the object is the intended activity, and the tool is the mediating device by which the action is executed. Thus, this expansion of the basic triangle aims to represent the collective and social elements in an activity system through the addition of the elements of community, division of labour and rules, while emphasizing the importance of analysing their interactions with each other (Engeström, 1999). Further, the object represented in the framework which is depicted with the help of an oval indicating that object-oriented actions are always, implicitly or explicitly, characterized by surprise, ambiguity, interpretation, sense making, and potential for change. Contradictions are important within activity systems as they are the driving force of change, and therefore, of development (Robinson, 2011; Engeström, 1999). Through a collaborative learning environment, the student is encouraged asking questions, explaining and justifying opinions, articulating and reasoning, and elaborating and reflecting upon the received knowledge (Hashim and Jones, 2007). Therefore, it is crucial to educate the young people about the global climate change that will affect every citizen, the economy, and the urban and suburban development patterns.

In addition, Engeström (1999) ascertained that the activity or practice is considered as the unit of analysis for activity theory, not individual activity. Moreover, the process of social transformation has been considered in the systems, therefore including the structure of the social world in the analysis, taking into account the conflicting nature of social practice. Indeed, the motive force of change and development is driven from instability (internal tensions) and contradictions in the activity systems. Also, it is not only the

subject, but the environment that are modified through mediated activity based on the transitions and reorganisations within and between activity systems, thus leading to evolution. Furthermore, conceptual tools have been developed in order to understand dialogues, multiple perspectives, and networks of interacting activity systems (Engeström, 1999).

Activity Theory provides a worthwhile framework for understanding the field of education. Hashim and Jones (2007) reported that Activity Theory is useful because it describes activities as hierarchical in nature and provides a model for decomposing activities into actions and operations. Therefore, Activity Theory views activity not as a simple individual action but as being culturally and historically located. Hence, in other words, Activity Theory stems from its fundamental view of purposeful activity in a cultural-historical context as the fundamental unit for the study of human behaviour in general. The discussion in the next section is centred on the existing gap in literature on understanding and teaching climate change at secondary schools.

2.4 Existing Gap in Literature

In conducting this study, a wide range of studies were examined. It was determined that the majority of research focused on questions related to students' and teachers' understandings of climate change (Onuoha et al., 2021; Graham et al., 2020; Dlamini, 2019; Dike and Amadi, 2016). Notably, only a small number of researches on climate change teaching in schools have been carried out in Senegal (Ndiaye et al., 2020; Diop, 2019). The studies discussed in this chapter reveal knowledge gaps on how curriculum contributes to raising public awareness of climate change, particularly school students.

Studies that have evaluated the degree of integration of climate change topics into the curriculum, for instance, are few. The limited studies that have been conducted, particularly in Senegal, have focused mostly on primary school. The investigations were unable to determine the primary climate change topics included in Senegal's secondary school curricula at this time. This study set out to conduct a content analysis on the geography curriculum for secondary schools in an effort to determine the extent to which climate change topic is included in the existing secondary school geography curriculum.

Research gaps were also identified in the review of teachers' knowledge of and instruction in climate change. The study found that there has been little research into teachers' knowledge of climate change. In terms of teacher awareness, the study discovered that secondary school teachers and their students have been the subjects of research in the Dakar district, Senegal (Diop, 2019). The study had found that the district's teachers had a limited level of awareness about climate change. However, this research noted a gap in that Diop's study who had not included environmental education experts and geography curriculum designers in the discussion about climate change education in schools. Additionally, her study did not link climate change understanding among teachers to the curriculum. Due to these reasons, the purpose of this study was to determine the level of knowledge about climate change among a sample of Senegalese secondary school geography teachers, as well as to make an effort to connect this knowledge to the secondary school geography curriculum.

Due to the scant amount of research that has been conducted in Senegal, the review of students' comprehension of climate change has primarily focused on other countries, which is what inspired this study. There is a gap in secondary schools due to the

awareness of climate change that has been observed and examined in elementary students. All the studies failed to establish climate change understanding among secondary schools students and link the same to exposure to secondary school curriculum. This study identified that gap and aimed to determine students' understanding of climate change in Senegal's secondary schools. It also sought to identify the relationship between that climate change understanding and the secondary school geography curriculum.

Further, the research reviewed literature on factors affecting the effectiveness of the teaching about climate change at school. This study established that most of the available research investigated into factors hindering the teaching of the aspects of climate change within school curriculum. The research highlighted some existed gaps as far as studying the situation through the use of regression analysis among variables is concerned. Thus, this contributed to intensifying the dialogue on how to better tackle challenges that affect the effectiveness of the teaching about the aspects of climate change in schools. The following section is dedicated to the theoretical framework of this study which is based on the Activity Theory, considered as a suitable underlying structure in helping to go through a thorough assessment of the research problem.

2.5 Theoretical Framework

As a Party to the United Nations Framework Convention on Climate Change (UNFCCC), Senegal has developed its national adaption plans on climate change named National Adaptation Plan of Action (NAPA) in 2006 and its National Determined Contribution (NDC) in 2020 aiming to identify the sectors such as: agriculture, fishing, forestry, transport, waste management, energy and industry which need urgent actions towards

controlling the impacts of climate change on the lives and livelihoods of the populations. The country has also developed three (3) national communications on climate change so far. The third national communication of Senegal which was developed in 2015 aims at helping Senegalese to effectively deal with climate change in short and long term periods. In these policy documents (third national communication, NAPA and NDC) some policy objectives and strategies have been developed for the sectors that are vulnerable to climatic change in Senegal such as agriculture, water resources, coastal zones, wetlands, tropical and woodland forests. In order to achieve these climate change policy objectives, Senegal, as one of the United Nations' member states, is obligated to implement climate change education and training, therefore to reduce its vulnerability and increase its adaptive capacity to climate change. Thus, education and teaching can be seen as a major vehicle that can help communities to develop an understanding of climate change concepts and take attitudinal changes towards combating the changing climate (UNESCO, 2010).

In order to establish how climate change concepts have been taught and understood at Senegalese secondary schools from the geography curriculum, the conceptual framework of this research was developed in line with the Engeström Activity Theory, shown in Figure 1.1. It has been stated that Activity Theory is appropriate for education research because it is not merely a methodology but it is a conceptual framework valuable in the analysis of human practices on the multiple dimensions of individual activities and social interactions (Scanlon and Issroff, 2005; Kuutti, 1996). Indeed, Engeström (1987) reported that any theory of learning must answer at least four principal questions: (1) who are the subjects of learning, how they are defined and located? (2) why do they learn, what makes them make

the effort? (3) what do they learn, what are the contents and outcomes of learning? and (4) how do they learn, what are the key actions or processes of learning?

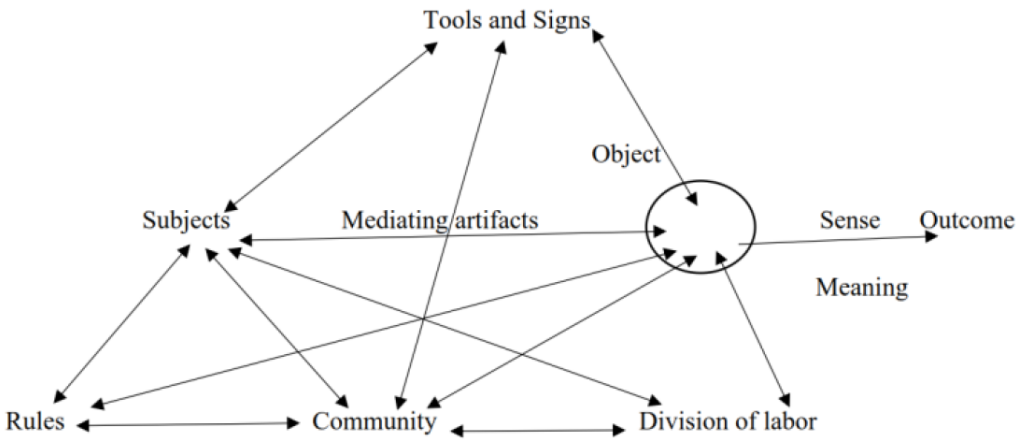

Figure 2.2. Engeström's Activity Theory (adopted from Engeström, 1987)

The framework shows the linkages between the components which are represented in the Figure 1.1. The components of the investigation of this study are equated against all the analytical components that are represented in the Figure 1.1. Therefore, the object represents learners who have been investigated in attempt to establish their understanding of climate change concepts in the secondary education geography curriculum in Senegal. Further, outcomes represent the learning and assessment objectives of the secondary education geography curriculum in Senegal which were evaluated to establish if they do address climate change concepts. It has been asserted that learning and assessment objectives indicate the concept which the learner is expected to be able to tackle after going throughout the learning process; they can be general or specific (Dlamini, 2019). In addition, in curriculum development, developing objectives is a major activity which is

followed by selection of the content which refers to the topics and sub-topics in a course or subject. Hence, the formulation of the objectives and the selection of the content go together in many cases.

Rules also illustrate the curriculum with all its components, that is, the topics that expose learners and teachers to the concepts of climate change. Nevertheless, lessons on key climate change topics such as the greenhouse effect, global warming, weather-related disasters, the causes, and local and global consequences of climate change in general are not enough, therefore it is crucial that climate change mitigation and adaptation strategies to be developed and implemented with stakeholders' participation in the education sector at local and regional level, thus addressing disaster risk reduction, emergency preparedness and relevant sustainable development strategies.

Additionally, tools indicate the teaching methodologies and strategies employed by geography teachers in their classes in order to deliver the course or topic on climate change concepts. Indeed, there are methodologies and strategies that can be used to raise climate change awareness such as field excursions, assignments, local events messaging through youth radio programmes, media campaigns, music and theatre, environment day celebrations, conferences, and other programmes and events within and outside of school that are able to complement formal curricula and significantly strengthen the learning and teaching on climate change issues. Also, the implication of the private sector and non-governmental organisations (NGOs) that are working on climate change issues in the learning activities could help the leaners to better understand the phenomenon of climate change, therefore participating in actions and advocacy concerning climate change challenges.

The components of subject and division of labour in the framework are equated against teachers. Indeed, the geography teachers were investigated in this research in an attempt to establish their understanding of climate change concepts. It has been stated that the human resources can be seen as the most important asset of any country. Furthermore, it seems that there are teachers and other education stakeholders in Senegal who do not have adequate capacity to implement climate change education in schools; therefore it is an urgent need for the country to effectively build human capacity on climate change in line with the sustainable development goals. Further, curriculum support materials are important so that to help the teacher and the learner to efficiently and effectively achieve the set objectives in the programme. Thus, a teacher's guide, a learner's manual and other print and non-print materials are the commonly-used curriculum support materials. This represents a complete package of the curriculum. It appears that there is a limited number of experts in the area of climate change, so it is crucial to have a complete package of the curriculum in teaching climate change concepts in order to help learners to better comprehend this pressing environmental issue.

Therefore, UNESCO (2009) reported that there are implications of climate change that pertain to education and ought to be taken into account such as: all levels and forms of existing educational and teaching and learning programmes need to be reviewed and re-oriented to address the causes and consequences of climate change; climate change requires educators to include new content into education, training and public awareness programmes; creativity, problem solving and social transformation skills need to be developed and nurtured; positive, participatory action and solution-centered approaches to education and learning need to be developed.

Moreover, educating students about the issues of global climate change is a challenge for educators because the traditional didactic strategies are inappropriate and so new innovative instructional approaches and techniques should be created (Papadimitriou, 2004). Traditional ways of teaching which are largely based on the transmission of knowledge are inappropriate as they do not help learners to use the knowledge learned to understand real issues from everyday life and take adequate actions in order to solve them. In other words, the challenge of education for global climate change is to make these global issues meaningful to learners, by focusing on individual contributions to the problems, and then, using problem-solving and decision-making strategies to develop, redirect and refine the thinking and the learning (Odoom, 2020; Dlamini, 2019). Therefore, instruction in hands-on and computer-based classroom activities, project work and field trips, can be helpful for the leaners to understand climate change concepts effectively.

It is urgent and important for Senegal to implement climate change education which is considered as an essential method that can help communities to develop an understanding of climate change phenomenon, thus leading to effective and efficient climate actions for the protection of the environment. Further, education, especially curriculum and teaching, has been cited by numerous authors as an important pillar in addressing the major challenge for learners to minimise the causes of climate change within their communities (Offorma, 2006). In addition, climate change is not simply an environmental problem that can be addressed by regulating greenhouse gas emissions, but it is about human development, social justice, equity, human security and the capacity of individuals and

communities to respond to threats to their social, environmental and human rights (O'Brien, 2009).

CHAPTER THREE

METHODOLOGY

This chapter elucidates the methodology used in this study for both data collection and data analysis. Therefore, it presents the location and description of the study area, study design, sampling procedures, methods, and tools of data collection. Further, it contains information on the empirical models used in the research, considered ethical issues and the reliability of data collection instruments used in this research.

3.1 Location of the Study Area

The study was carried out in eight (8) Academy Inspections of Senegal which were randomly selected. In Senegal, within the education system, the Academy Inspections implement policies for the development of the education and training sector at the district level, to effectively contribute to the achievement of the objectives of national and regional programmes concerning the national education orientation law in force (Ministère de l'Education Nationale, 2012). For this study, in each selected Academy Inspection, one (1) public lower secondary school and one (1) public upper secondary school were randomly selected. Therefore, the following lower secondary schools CEM HLM Grand Yoff, CEM Martyrs C de Thiaroye, CEM Modou Awa Balla Mbacké, CEM de Ngalléle, CEM Ciré Ba, CEM Maciré Ba, CEM Gadapara, CEM 4 de Fatick were randomly selected from Dakar, Pikine-Guédiawaye, Louga, Saint Louis, Matam, Kédougou, Kolda and Fatick Academy Inspections respectively. Also, in these eight (8) selected Academy

Inspections, respectively, eight (8) upper secondary schools were randomly selected for this research such as Lycée Aminata Sow Fall, Lycée de Keur Massar, Lycée de Ndande, Lycée Cheikh Omar Foutiyou Tall ex. Faidherbe, Lycée Elhadji Yéro Basse de Ourossogui, Lycée Commune 1 de Kédougou, Lycée Bouna Kane, Lycée Coumba Ndofféne Diouf. The map of the study area is shown in Figure 3.1.

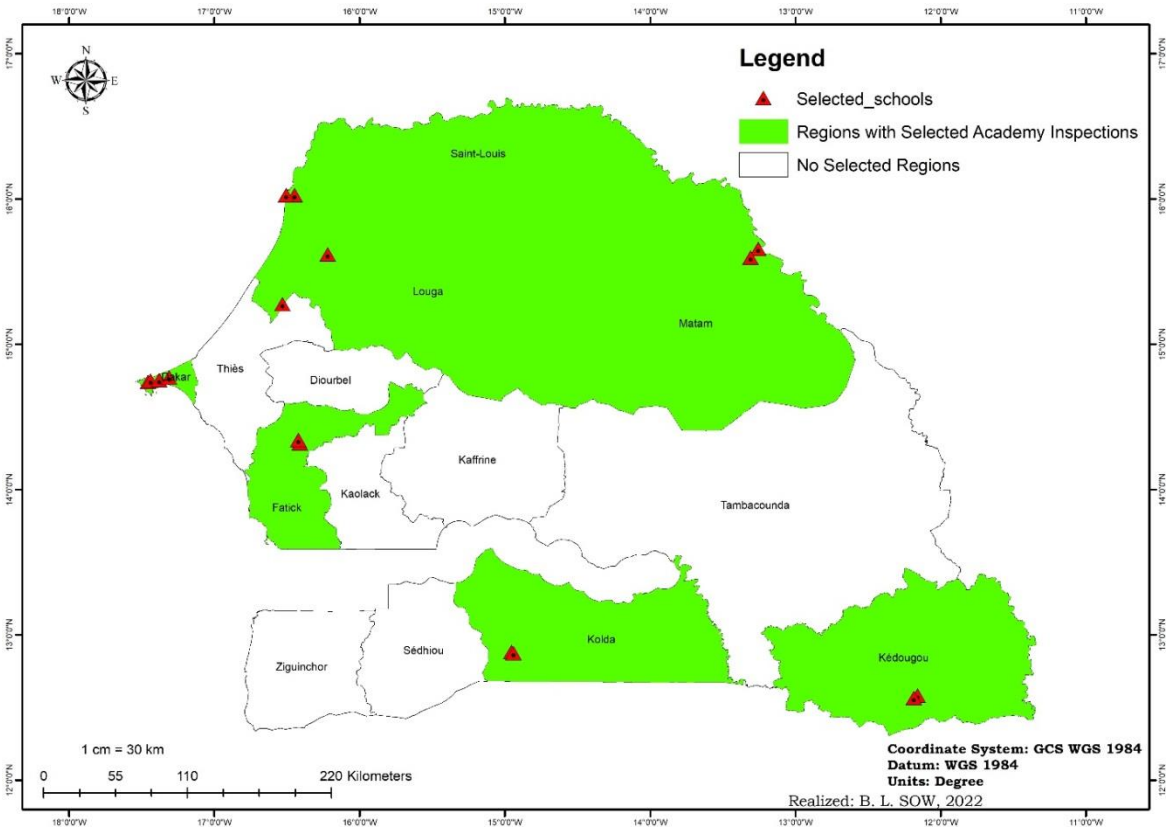

Figure 3.1. Map of the Study Area

NB: The following schools CEM HLM Grand Yoff, Lycée Aminata Sow Fall, CEM Martyrs C de Thiaroye, Lycée de Keur Massar, CEM Modou Awa Balla Mbacké, Lycée de Ndande, CEM de Ngalléle, Lycée Cheikh Omar Foutiyou Tall ex. Faidherbe, CEM Ciré Ba, Lycée Elhadji Yéro Basse de Ourossogui, CEM Maciré Ba, Lycée Commune 1 de Kédougou, CEM Gadapara, Lycée Bouna Kane, CEM 4 de Fatick and Lycée Coumba Ndofféne Diouf, were selected in each of the following Academy Inspections Dakar, Pikine-Guédiawaye, Louga, Saint Louis, Matam, Kédougou, Kolda and Fatick respectively.

Further, at the level of each region of Senegal, it has been created one or more Academy Inspections which are led for each by an Academy inspector. In total, there are sixteen (16) Academy Inspections in the country which are dealing with impetus, coordination, and supervision of all programmes and activities of the education system at the local level. In addition, the Academy Inspection stimulates the development of education and training in the academic district and ensures the efficient management of resources. Thus, within this framework, the Academy Inspection is invested with the mission of piloting, coordination, support, and control of lower and upper secondary schools among others. The selected Academy Inspections for this research also cover 5 out of 7 of the agro-ecological zones of the country which are considered vulnerable to ecological and climatic hazards. Thus, in this context, climate change topic seems to be taught to the learners through local pieces of evidence and examples that can be found in the agro-ecological zones.

3.2 Population of the Study Area

Senegal's formal education system is organized into pre-primary, primary (élémentaire), lower secondary (moyen) which consists of grades 7-10, upper secondary (secondaire) which consists of grades 11-13, and higher education. There were 566,278 lower and upper secondary school students who were enrolled in 690 public secondary schools in 2021 in the selected Academy Inspections for this research (Ministère de l'Education Nationale, 2021). Among of these students 140,884 of them were doing the grades 10 and 13 for the academic year 2020/2021. Also, there were 7,522 geography teachers in 2021 in the selected Academy Inspections. All stakeholders in education regarding the lower and upper secondary schools were considered in this research. Therefore, due to the large

number of learners in grades 10 and 13, the study population for this research was considered to be the total number of learners in each selected class (grade 10 and 13) at each selected school and the geography teachers, principals and headmasters in all selected schools as well. Further, the senior inspectors of geography and senior geography curriculum designers from the Ministry of National Education, and the environmental and information officers from the Ministry of Environment and Sustainable Development were purposely selected for this research. Moreover, geography subject is one of the subjects that are compulsory for all learners in the general secondary education system of Senegal, thus implying that all learners in all grades at Senegalese secondary schools appear to be exposed to geography education, including the aspects of climate change and other environmental related issues.

3.3 Research Design

For this study, a descriptive design was adopted and applied. Thus, Burns and Grove (2003) and Sarantakos (2005) defined descriptive research as a design to depict a picture of a situation as it naturally happens. Indeed, this design can be employed to make a judgment and justify current pictures, and also develop theories. For this research, a descriptive design was used to achieve the study objectives by assessing the concepts of climate change captured in the geography curriculum in Senegal secondary education, determining teachers' understanding and interpretation of climate change concepts, examining students' understanding and knowledge of climate change concepts and identifying the factors that influence the effectiveness of teaching climate change concepts in secondary education geography curriculum in Senegal.

3.4 Sample and Sampling Procedure

As the population is not manageable for this research, sampling was implemented. Thus, the research adopted a multistage sampling technique in constituting a representative sample of respondents. Indeed, using the purposive sampling technique, all the sixteen (16) Academy Inspections of education were considered because the secondary geography curriculum is used throughout the country, thus in all the Academy Inspections. There is also a pressing and urgent need for Senegal to inclusively find solutions to climate change issues that undermine its development, hence the selection of all the Academy Inspections so that to determine what is known and taught about climate change science at Senegalese secondary schools. Further, a simple random sampling technique was then used to select eight (8) Academy Inspections from the sixteen (16) Academy Inspections of Senegal due to limited time and resources. Using the lottery method, the Academy Inspections were labelled on pieces of paper, placed in a box, and shuffled. Thus, for the study, the eight Academy Inspections were randomly selected from the box. Also, from each selected Academy Inspection, one (1) lower secondary school and one (1) upper secondary school were randomly selected using the lottery method of simple random sampling. Therefore, 2 secondary schools were selected from each of the sampled Academy Inspections making a sample of 16 secondary schools, with 8 lower secondary schools and 8 upper secondary schools for this study. Additionally, the students in grades 10 and 13 were purposely selected for this research owing to the fact that the students in grades 10 and 13 had gone through the secondary geography curriculum and were, therefore best suited to test their knowledgeability of issues under study. Moreover, learners in grades 10 and 13 were only considered because they have at least capitalised on knowledge, skills and attitudes aimed

at developing the student profile defined in the objectives of the geography programme for the Senegalese secondary schools.

In addition, from each of the sampled secondary schools (lower and upper secondary), one (1) class of grade 10 concerning the lower secondary schools and one (1) class of grade 13 for the upper secondary schools were randomly selected using the lottery method. Thus, 1 class of grade 10 and 1 class of grade 13 were selected from each of the sampled Academy Inspections making a sample of 16 classes, with 8 classes of grade 10 and 8 classes of grade 13 for this research. From each selected class, simple random sampling was used to select 20 students to form part of the sample of 320 students due to the large number of learners in grades 10 and 13 in the selected schools. Therefore, the multistage sampling technique that was employed for this research has enabled me to select maximum (320) students out of the total number (805) of learners in grades 10 and 13 for the entire study.

From the sampled schools, geography teachers were purposively selected based on their availability. Indeed, teachers selected for the sample constituted those that teach the geography subject at lower and upper secondary schools since the researcher assumed that they possessed the required information about climate change concepts. The sample size for the teachers was arrived at using a formula developed by Yamane (1967) which is widely used. Thus, the following Equation 1 (sample size formula) was used to compute the sample size of teachers for the study. This gave a minimum sample size of 85 out of the population of 108. This encouraged the researcher to select 101 as a sample to ensure that possible errors are taken care of and also due to expectations of uniformity. In all 101 teachers were selected for the entire research.

Equation 1: Sample Size Formula $n = N/1+ N (e)^2$ **…….[1]**

Where: n = required sample size,

N = the population size,

e= the level of precision (0.05)

For this formula, 95% confidence level and P = 0.50 (the population proportion) were assumed since this would provide the maximum sample size.

This sample size formula has been widely used in research (Onuoha et al., 2021; Adam, 2020; Taherdoost, 2017). Also, from the sampled schools, the headmasters and the principals were purposively selected for both the lower secondary schools and upper secondary schools, making up a sample of 16 heads of schools, with 8 headmasters and 8 principals.

Further, key informant interview sessions were held with the individuals responsible for secondary geography education, including environmental and climate change education and the conceptualization of secondary geography curriculum in Senegal. The selected officers know the content in the secondary geography programme, including climate change and other environmental related issues, thus they are in a position to shed more light in a bid to answer the research questions. Indeed, purposive sampling was used to select 3 senior inspectors of geography and 3 senior geography curriculum designers from the Ministry of National Education, and also 3 environmental and information officers from the Ministry of Environment and Sustainable Development. A summary of the sample and sampling techniques is outlined in Table 3.1.

Therefore, the study population was considered as all the students and geography teachers in the selected schools. All students in grades 10 and 13 and geography teachers with the sampling units being students and teachers were considered as the sample frame for the research. Students in grades 10 and 13 and geography teachers were considered as the target respondents for the study.

Table 3.1. Sample Size and Sampling Techniques

Category	Sampling Technique	N	n	Percentage (%)
Academy Inspection	Simple Random	16	**8**	50
Schools	Simple Random	690	**16**	2.31
Students	Purposive/Simple Random	140,884	**320**	0.22
Geography Teachers	Purposive	7,522	**101**	1.34

Key: N- Population, n- Sample size

Source : Ministère de l'Education Nationale, 2021/author, 2022

3.5 Research Data and Sources

The qualitative and quantitative data used in the study were primary and secondary data. The demographic characteristic of students and teachers, their understanding and knowledge of climate change, and the challenges teachers faced in teaching climate change science were the primary data collected for the research. The secondary data collected were the relevant information obtained from published books and publications, newspapers, journals, internet, and reports from the Intergovernmental Panel on Climate Change (IPCC), United Nations Framework Convention on Climate Change (UNFCCC), United Nations Educational, Scientific and Cultural Organisation (UNESCO), Food and

Agriculture Organisation (FAO), National Adaptation Programme of Action (NAPA) of Senegal, National Agency of Statistic and Demography (ANSD) of Senegal, Academy Inspections, Ministry of National Education, Schools among others. Additionally, the academic year 2020-2021 was considered and data from selected schools were collected from February to July 2021.

3.6 Research Instruments

3.6.1 Questionnaire

Questionnaires were used with both closed-ended and open-ended questions that were directly administered by the researcher to the sampled students, geography teachers, principals, and headmasters as well. The questionnaire for students was structured in four sections with section A representing the demographic information of the respondents; section B consisting of questions in line with students' understanding and knowledge about climatic change science. Sections C and D of the questionnaire respectively represent students' experiences and perception of climate change and students' actions towards environmental protection. Also, the teachers' questionnaire consisted of two main sections. Section A of the questionnaire aimed to solicit demographic data about the sampled geography teachers. Section B of the questionnaire aimed at soliciting curriculum information from teachers. Further, the questionnaire for principals and headmasters had two main sections, including section A consisting of questions of personal information, and section B representing the school information. Thus, these questionnaires were used to gather data on respondents' demographic information as well as their understanding, knowledge and interpretations about climate change concepts, and also on the geography

curriculum content addressing climate change topic, and challenges affecting the effectiveness of the teaching about climate change science at Senegalese secondary schools.

3.6.2 Focus Group Discussion

To guide the focus group discussion (FGD) that was held with students, a focus group guide was employed. Information was provided on the consent process, the rationale of the focus group discussion, and some rules for the discussion entailing the focus group. The tool consisted of questions pertaining to students' understanding and knowledge about climate change concepts as well as their actions towards environmental protection. Therefore, the FGD guide was used to gather further explanations on data obtained from the individual student answers through the questionnaire. During the field study, sixteen (16) focus group discussions were held, thus one (1) focus group discussion in each selected school.

3.6.3 Key Informant Interview Guide

To guide the key informant interview session an interview guide was used. The guide consists of a series of open-ended questions aimed at establishing the views of senior inspectors of geography, senior geography curriculum designers, and environmental and information officers on whether the current secondary geography curriculum adequately addresses climate change concepts and as well as environmental education programmes aiming to enhance climate change literacy of learners. The instrument was adopted to interview the key informants in order to deeply understand the teaching and understanding of climate change concepts in secondary education of Senegal through their experiences

and knowledge. The interview guide also aimed at establishing efforts being made by the curriculum development body and the challenges they face in a bid to infuse climate change content into the secondary geography curriculum. Therefore, during the field research, 3 senior inspectors of geography, 3 senior geography curriculum designers, and 3 environmental and information officers were interviewed.

3.6.4 Thematic Areas Content Analysis Template

The template used contains 8 climate change thematic areas identified prior to the research in order to undertake a content analysis in the geography curriculum for secondary education. The thematic areas included scientific concepts and processes, certainties, uncertainties and projections, causes of climate change, adaptation and mitigation measures, consequences/impacts, time-space dynamics, and interests that shape responses to the changing climate. Thus, these climate change thematic areas were adopted from Kariuki (2017) and UNESCO (2013). Further, the template was used against the syllabus of geography subject to establish the areas that were addressed and those that had not been addressed in a bid to answer the first research question of this study. The template is illustrated in Appendix 2.

3.6.5 Pilot- Testing of Instruments

Before conducting a pilot study, the instruments were scrutinized by the supervisors as experts to establish how well they can measure what they were intended to measure, thus ensuring content validity and the appropriateness, relevance, clarity, and suitability for the research, with improvements on the final output. The questionnaires items Cronbach's alpha reliability statistics produced a high coefficient of 0.81 and are regarded as reliable

and valid. Further, a pilot-testing of the research questionnaires was conducted in 2 lower secondary schools and 2 upper secondary schools where the questionnaires have been administered to the headmasters and principals respectively as well as 4 students in grade 10 and 4 students in grade 13 and also 4 geography teachers. The schools were randomly selected as well as the respondents in the Academy Inspection of Rufisque which was also randomly selected. The pilot study was aimed at establishing the validity, accuracy, and reliability of research instruments. The Academy Inspection of Rufisque was randomly selected because all the 16 Academy Inspections of Senegal use the same secondary geography curriculum to teach learners. Therefore, the purpose of the pilot-testing was to know the suitability of the instruments and to reformulate some questions, if necessary, in order to guarantee the validity and reliability of the questionnaires and interview guides.

3.7 Data Collection Procedure

3.7.1 Reconnaissance Survey

A community entry was conducted through a day visit to each selected Academy Inspection and school. The purpose of the visit was to inform the Inspectors of the selected Academy Inspections and the principals and headmasters of the selected schools about the aim of the study and to solicit their permission and support during the data collection process. Further, the visit was to get individuals responsible in the selected schools that the researcher would correspond with for the period of the field research. In addition, it was an occasion for the researcher to make relevant observations about the existing environmental protection activities that are undertaken in the selected schools.

3.7.2 Questionnaire Administration Session

The researcher visited the sampled schools and administered questionnaires to both geography teachers and students and also to the school principals and headmasters as well. Thus, time was allowed for the respondents to fill out the questionnaires before the researcher collected them. Additionally, geography teachers as research assistants helped distribute 20 copies of questionnaires for students in each of the 16 selected schools to provide data used for this study. Also, questionnaires were administered to the available geography teachers in each selected school, therefore 101 responses were obtained from geography teachers. Further, counting of the questionnaires was done to ensure that they had been returned, thus the response rate was 100% for the selected students.

3.7.3 Focus Group Discussion

It has been posited that focus group discussion is a method in which the moderator keeps a small group of people to discuss the research topic (Gresehover et al., 2007). A focus group method of 7 to 10 students was held in each selected school (Plate 1). A total of 16 focus group discussions were held for the entire study, one in each selected school through the use of purposive sampling technique in each selected class. Indeed, specific students were the target in order to ensure the representativeness of the entire school in terms of knowledge and understanding of climate change science, and gender among others. Further, the discussion was chaired by the researcher following the focus group guide; therefore, all the process was recorded. Additionally, the method provided the opportunity to affirm some responses and serve as a cross-check on the answers from the

filled questionnaires. Moreover, it was adopted to provide more detailed explanations on the data that was collected from the questionnaires administration session.

Plate 1. Focus Group Discussion (source: author's photography)

3.7.4 Key Informant Interview

A key informant interview session was held with officers responsible for educating learners on climate change concepts and other environmental issues and also raising populations' awareness about the benefits of environmental protection. Thus, 3 senior inspectors of geography, 3 senior geography curriculum designers, and 3 environmental and information officers were interviewed from the Ministry of National Education and the Ministry of Environment and Sustainable Development respectively. In total, 9 key informant interviews were conducted for the entire study. An in-depth knowledge on the

teaching of climate change science and environmental related issues at secondary school and the experiences about climate change issues possessed by the officers as well as the challenges they face in educating people, particularly, the learners on climate change and other environmental issues were provided during the key informant interview session.

3.7.5 Use of Thematic Areas Content Analysis Template

Using the content analysis thematic area template, the researcher personally reviewed the geography curriculum as well as geography textbooks for both the lower secondary and upper secondary schools and checked the content against the template. Indeed, the researcher would tick on the template according to information that was found in the geography curriculum and the geography textbooks as well.

3.8 Data Analysis Procedure

The quantitative data from the questionnaires was analysed primarily guided by the four (4) research questions of this study with the aid of statistical software STATA 14 and Statistical Package for Social Sciences (SPSS) version 23. The qualitative information obtained through key informant interview and focus group discussion sessions were processed by using narratives in form of discussions and explanations in order to supplement the quantitative data that was obtained from the questionnaires. To analyse teachers, school principals, headmasters, and students' socio demographic characteristics, frequencies, means, modals, standard deviations, maximum, minimum values, and percentages (descriptive statistics) were used during this stage. This process was also used to analyse data on respondents' understanding, knowledge and interpretations of climate change concepts. Also, since the questionnaires capture all key aspects of climate change

concepts like basic meaning, causes, impacts, and solutions, participants' responses reflect their synthesis of conception, interpretation, and perceptions of climate change, which all translate to climate change awareness. Furthermore, an awareness index was also calculated for the sample in order to assess climate change awareness of the sampled teachers and students. This study adopted the calculation technique of climate change awareness used by Gbetibouo and Mills (2012). Thus, climate change awareness was estimated as a composite of three indicators: i) ***conceptual awareness***; ii) ***experiential awareness***, and iii) ***engagement***. Indeed, Gbetibouo and Mills (2012) posited that conceptual awareness is about the individual's knowledge on the human causes of climate change and their impacts, while experiential awareness refers to experiencing and knowing long term changes in climate and their impacts on lives and livelihoods. The last indicator, engagement, is also defined by Gbetibouo and Mills (2012) as the frequency with which an individual talk or hears about the changing climate, but also spreads his/her acquired knowledge on awareness among the community. Further, in order to compute the awareness index for each participant, the answers from the questions in the understanding and awareness section of the questionnaires were assigned a numerical score which was summed up for each respondent. Therefore, the responses to the nine questions were used to compute a climate change awareness index. Indeed, the index was calculated as follows: the scores from the nine questions in the questionnaires for geography teachers, and students were summed up and the minimum and maximum total scores a participant obtained was between 0 and 17 respectively to get an index between 0 and 1, and the total score that a respondent got was then divided by 17. Moreover, climate change awareness scores were normalised to range between 0 – 100% for further analyses by dividing the

scores with the highest possible score (17) and multiplying the quotient by 100 as illustrated in Equation 2 below.

Equation 2: Climate Change Awareness Index Formula

CCAI= AS/MS*100

Where; CCAI refers to Climate Change Awareness Index; AS means Awareness Score

MS refers to Maximum Score

Moreover, associations were done by the use of the Chi-square test in order to examine the relationship between climate change content in the geography curriculum and teachers and students' climate change awareness levels and the significance of climate change content in the curriculum as well. In order to determine whether there is statistical evidence that the associated geography teachers' climate change awareness means are significantly different and for students in grades 10 and 13 as well, the independent sample t-test statistics were employed. Furthermore, the influence of tested variables on geography teachers and students' climate change awareness was assessed for identification and classification of geography teachers and students based on their climate change awareness scores.

In addition, geography teachers and students' climate change awareness are categorized into three levels based on percentage scores – low awareness (0–50%); moderate awareness (51–74%), and high awareness (75% and above). The categorization of the level of awareness of teachers and students which was adopted from Onuoha et al. (2021)

is to enhance further analyses of the data using the multinomial logistic regression model (MLM), as presented in the subsequent section.

Further, a content analysis was done using the variation ratio in order to assess the concepts of climate change captured in the geography curriculum in Senegal secondary education. Indeed, it has been reported that variation ratio is defined as the proportion of cases in a dispersion that is not the mode, and it ranges from 0 to 1 (Linton, 1965). Thus, a zero value implies an absence of any variation, while 1 implies maximum variation. The following formula was used to compute the variation ratio, as shown in Equation 3.

Equation 3: Variation ratio

$$v = 1 - \frac{fm}{N}$$

Where: v- variation ratio,

fm- frequency of the mode,

N- total number of cases

Empirical models

The multinomial logistic regression model

In this study, the multinomial logistic regression model (MLM) used is applied for predicting the possibilities of different potential outcomes when a nominal dependent variable with more than two categories is regressed against specified independent variables. In this particular case, the MLM helped to determine the direction and significance of the influence of each of the explanatory variables on the placement of

geography teachers and students in their respective levels of climate change awareness. The choice of this model in this research is because logistic regression employs maximum likelihood estimation in the determination of the odds (probability) of occurrence of a certain event (Anderson and Rutowski, 2007). It is expected that this model will estimate the likelihood of teachers' and students' membership of the three levels of awareness based on specified independent variables which represent the sociographic characteristics for the geography teachers and students. Indeed, the MLM was adopted to identify the likelihood of teachers' and students' membership of the groups of awareness levels namely low awareness, moderate awareness, and high awareness. Further, previous studies have used the MLM to explain factors that influence the choice of climate change adaptation strategies by using multiple factors as independent variables and a list of preselected climate change adaptation strategies as dependent variables (Onuoha et al., 2021; Onyekuru, 2017; Apata, 2011). Similarly, in this study, the MLM was used to determine variables that influence geography teachers' and students' membership in the three predetermined categories of climate change awareness. Thus, the dependent variable for the regression model is the climate change awareness category with three levels –low awareness, moderate awareness, and high awareness. Therefore, each respondent belongs to one of these three levels of climate change awareness.

Membership to one of these levels of awareness for the geography teacher is tested using gender, age, teacher qualification, geography teacher class, teaching experience, academy inspection and environmental club membership as independent variables. Previous studies have tested the influence of gender, age, and location on the placement of teachers in their respective levels of climate change awareness (Eze, 2019; Anyanwu et al., 2015). For the

students, the independent variables –gender, age, grade level, academy inspection and environmental club membership were regressed against each level of climate change awareness (being the dependent variable) to determine the significance and direction of the influence of each of the independent variables on the placement of students in their respective levels of climate change awareness. Also, the influence of age, gender, location, and class has been tested on the students' membership to one of the associated climate change awareness levels (Onuoha et al., 2021; Eze, 2019). The inclusion of teacher qualification, geography teacher class, teaching experience, student's and teacher's environmental club membership in testing the influencing factors towards climate change awareness index is a core contribution of this study to the body of knowledge, thus conducing insightful results about climate change education in general.

As in binary logistic regression, multinomial logistic regression uses maximum likelihood estimation to determine the probability of categorical membership. Therefore, this type of model allowed to characterizing the probability of a respondent's placement for a particular multinomial discrete choice, conditional on the values of the explanatory variables. Furthermore, the distribution functions that characterize explanatory variables are often nonlinear in the model. Thus, the parameters are used to make predictions about the probability of an event occurring compared with the reference category, once the multinomial regression model is created (Coughenour et al., 2016). Hence, the study sought to know how the identified independent variables influence geography teachers' and students' membership in the three predetermined categories of climate change awareness.

Additionally, the multinomial logistic regression model is a predictive model which is frequently used in predicting probabilities of outcomes of a categorically distributed dependent variable given a set of independent variables (Gao, 2019). As an example, when Y (dependent variable) has n categories, the multinomial regression system contains n logistic models in which each category of Y is treated as a binary variable and X represents the independent variable. In this study, multinomial logistic regression allowed us to compute probabilities of placement of geography teachers and students in their respective levels of climate change awareness, namely low awareness, moderate awareness and high awareness which are considered as 3 categories for the model. In matrix notation, let X be the matrix of the independent variables, β be the coefficients and k be the category, then the following Equations concerning both geography teachers and students were considered in the multinomial logistic regression model as illustrated below.

$$\mathrm{P}(Y = 0 \mid X) = \frac{1}{1+\sum_{k=1}^{3} e^{X\beta_k}}, \mathrm{P}(Y = 1 \mid X) = \frac{e^{X\beta_2}}{1+\sum_{k=1}^{3} e^{X\beta_k}}, \mathrm{P}(Y = 2 \mid X) = \frac{e^{X\beta_3}}{1+\sum_{1}^{3} e^{X\beta_k}}:$$

Equation (4)

Thus, the k-1=2 odds of each category of Y, the probability of categorical membership, with Y=0 as reference category, are given by,

$$\frac{P(Y=1|X)}{P(Y=0|X)} = e^{X\beta_2}, \frac{P(Y=2|X)}{P(Y=0|X)} = e^{X\beta_3} \qquad \textbf{Equation (5)}$$

Therefore, the odds ratios for the predictors should be the exponentiation of the coefficients, which could demonstrate how the risk of the response (dependent) variable

falling in one category compared to falling in the reference category. Indeed, an odds ratio greater than one could be interpreted as the probability of the dependent variable belonging to this category is higher than that belonging to the reference category, and the probability increases as the variable increases (Gao, 2019). Also, Murat Gunduz and Karacan (2017) posited that vice versa, when an odds ratio is less than one, the outcome is more likely to belong to the reference category, and the probability decreases as the variable increases.

Further, after taking natural log of both sides of the above equations, 2 ln odds of Y were obtained, relatively to the reference category,

$$\ln\frac{P(Y=1|X)}{P(Y=0|X)} = X\beta_2,\ \ln\frac{P(Y=2|X)}{P(Y=0|X)} = X\beta_3 \quad \textbf{Equation (6)}$$

Therefore, the logit for each category over the reference category depends on values of explanatory variables. Thus, the multinomial logistic regression model is adjusted with the maximum likelihood method, hence building a multinomial logistic regression model which would help to find associations between each category of climate change awareness and tested independent variables.

Logistic regression model

To identify the factors that influence the teaching of climate change concepts in secondary education geography curriculum in Senegal, a logistic regression model was used in this study, thus helping to determine the factors influencing the effectiveness of teaching about climate change science at Senegalese secondary schools. Logistic regression is a statistical technique that is used to explore the relationship between a

dependent variable and at least one independent variable. Also, it is a model building technique in statistics that is aimed at finding the best fitting and most sensible model to assess the relationship between a response variable and at least one independent variable (Honest, 2013; Al-Ghamdi, 2001). The main objective was to investigate the factors that affect the effectiveness of teaching about climate change concepts at secondary school. In the literature numerous studies have indicated that a number of influencing factors that hinder the teaching of climate change concepts at school such as knowledge gaps and limited learning experiences about climate change for teachers, structural factor and also the patterns of instruction about climate change (Crayne, 2015; Wachholz et al., 2014; Vujovic, 2013; Wise, 2010). Therefore, the ineffectiveness of teaching about climate change concepts at school lead to a limited climate change literacy of learners or into considerable ignorance and misconceptions about the changing climate. Hence, in order to achieve the effectiveness of teaching about climate change concepts at school, advocates of climate change education need to address the following challenges such as teachers' knowledge deficits about climate change science, structural challenges, climate change resources deficits among others (Crayne, 2015; Wise, 2010).

Moreover, Greene (2003) ascertained that the binary logistic model falls in the group of qualitative response models which have the dependent variable as an indicator of a discrete choice. Further, the main advantage of the binary logistic regression model over other models of discrete and limited dependent variables is that it allows the analysis of decisions across two categories, providing the determination of choice probabilities from different categories (Deressa et al., 2009). Additionally, its likelihood function, which is globally concave, makes it easy to compute as a prognostic model. Nevertheless, it has

been argued that the main limitation of binary logistic regression model is the independence of irrelevant alternative properties, which states that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternatives in the available choice selections (Deressa et al., 2009; Al-Ghamdi, 2001). The binary logistic for this study is represented in Equation (7) as shown below.

$$\Pr(y = 1 \mid x') = \frac{\exp(x'\beta)}{1+\exp(x'\beta)} = \mathrm{A}(x'\beta) \qquad \textbf{Equation (7)}$$

Where;

Pr (y =1| x') represents the probability of an event happening, the dependent variable takes a value of 1 given an explanatory variable x'. The x' represents vectors of all the explanatory variables. Also, the coefficient β explains the explanatory power of the independent variable. The dependent variable is the probability of a geography teacher considering effective or ineffective of the teaching about climate change science at Senegalese secondary schools. This dependent variable takes two discrete values which are: 1= effective teaching of climate change concepts or 0= ineffective teaching of climate change concepts.

The model predicts the maximum likelihood of a geography teacher considering teaching of climate change science as effective versus geography teacher considering climate change teaching as ineffective. The coefficient β in the model depicts a relationship of how variations in the independent regressors affect the predicted log of odds of a geography teacher considering teaching of climate change science as effective versus geography teacher considering climate change teaching as ineffective. Thus, this relationship between the dependent and the independent variable can be depicted using the

antilog of the β (exp β) which is the odds ratio. The formula of the odds ratio is shown below.

$$\frac{P_i}{1-P_i} = \frac{1+e^{\Lambda(x'\beta)}}{1+e^{-\Lambda(x'\beta)}} = e^{\Lambda(x'\beta)} \qquad \textbf{Equation (8)}$$

Where Pi is the probability of effective teaching of climate change (Pr (y =1| x')) in equation (7) and 1− Pi is the probability of ineffective teaching of climate change (Pr (y = 0 | x')). Equation (8) represents the odds ratio in favour of effective teaching about climate change science which is the ratio of the probability that a geography teacher considers effective, the teaching of climate change concepts to the probability of not effective of the teaching about climate change. Further, an odds ratio that is greater than 1 implies that a unit increase in the continuous variable or discrete change in the categorical variable in the regressors leads to a decrease in the odds of a geography teacher considering effective the teaching of climate change versus geography teacher considering ineffective the teaching about climate change concepts (Vujovic, 2013).

In summary, to estimate the factors influencing the teaching of climate change concepts in this study, the logistic regression model was employed by using the STATA software version 17.0. Therefore, the logistic model for '*k*' independent variables (*X*1, *X*2, *X*3, …., *Xk*) is given by the following Equation (9).

$$\text{Logit}\, P(x) = \alpha + \sum_{i=1}^{k} \beta_i x_i \qquad \textbf{Equation (9)}$$

Where α denotes a constant and βi denotes the regression coefficient.

Thus, the logistic regression model could be specified for this research as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon \quad \textbf{Equation (10)}$$

Where *Y* denotes whether teaching of climate change is effective or ineffective, X1 denotes frequency of teaching about climate change, X2 denotes knowledge about climate change, X3 denotes teaching and learning experiences for the teacher regarding climate change issues, X4 denotes teaching and learning climate change resources, X5 denotes comprehensive geography curriculum for teaching climate change concepts. These 5 Xi chosen correspond to the 5 independent variables which were hypothesized to influence the effectiveness of teaching about climate change concepts at school based on geography teachers' barriers in teaching climate change science in the study area and literature review as well. Thus, to envisage the probability of the effectiveness of teaching about climate change science in the study area, the logistic regression model uses a number of explanatory variables that are mentioned above. Hence, the description statistics of variables hypothesized to influence the effectiveness of teaching about climate change concepts at secondary school is presented in Table 3.2.

Table 3.2. Independent Variables for Logistic Regression Model

Variable	Mean	Standard Deviation	Minimum	Maximum	A priori expectation on Regression
Frequency Teaching CC (0= not frequent 1= frequent)	0.30	0.459	0	1	+
Knowledge about CC (0= not adequate 1= adequate)	0.81	0.393	0	1	+
Teaching and Learning Experiences (0= none experiences 1= experiences)	0.26	0.439	0	1	+
Teaching and learning CC Resources (0= not available 1= available)	0.12	0.325	0	1	+
Comprehensive Geography Curriculum (0= not comprehensive 1= comprehensive)	0.16	0.367	0	1	+

Key: CC- Climate Change

The explanatory variables for the logistic regression model are statistically described in the Table 3.2 in order to give a general overview of the factors that are expected to influence the effectiveness of teaching about climate change science at lower and upper secondary schools in the study area.

Also, the following Table 3.3 summarizes the methods used and the data analysis approaches applied in this research.

Table 3.3. Methods Used and Data Analysis Approaches Applied in the Study

Research Objectives	Data Collection Methods	Data Analysis Applied in this Study
To assess the concepts of climate change captured in the geography curriculum in Senegal secondary education	Secondary Geography Curriculum; Geography Textbooks for Secondary School	Content Analysis (Climate Change Thematic Areas Content Analysis and Variation ratio calculation adopted from Kariuki, 2017 and UNESCO, 2013
To determine teachers' understanding and interpretation of climate change concepts	Primary Data through Teachers Questionnaires, Key Informant Interviews with Senior Inspectors of Geography and Senior Geography Curriculum Designers	Descriptive Statistic (SPSS) Climate Change Awareness Index calculation (Microsoft Excel) Chi-square test, independent sample test, Multinomial Logistic Regression (SPSS)
To examine students' understanding and knowledge of climate change concepts	Primary Data through Students Questionnaires, Focus Group Discussions, Key Informant Interviews	Descriptive Statistic (SPSS) Climate Change Awareness Index calculation (Microsoft Excel) Chi-square test, independent sample test, Multinomial Logistic Regression Model using SPSS software
To identify the factors that influence the effectiveness of teaching climate change concepts in the secondary education geography curriculum in Senegal	Primary Data through Teachers Questionnaires, Key Informant Interviews, Focus Group Discussions	Binary Logistic Regression Model using STATA

3.9 Ethical Considerations

As an ethical demand, a letter of introduction from my research supervisor was first sent to the Ministry of National Education to have access into all the public lower and upper secondary schools through all the sixteen (16) Academy Inspections in Senegal. Indeed, acting on the letter of introduction that was sent to the Ministry of National Education, the Inspector of each selected Academy Inspection, issued a letter of access to the principals and headmasters of the selected schools through which the researcher was able to gain

access to the schools (Appendix 3). Additionally, a community entry was then conducted to meet the school administration in which the principal or the headmaster informed teachers and school supervisors about the presence and purpose of the researcher as well as seek their support during the data collection procedure. Furthermore, prior arrangements with the geography teachers and school supervisors were made in order to avoid any eventual inconvenience during questionnaire administration.

The research participants were principals and headmasters of schools, geography teachers, students and senior inspectors of geography, senior geography curriculum designers, and environmental and information officers and therefore the researcher obtained their voluntary and consent in participating in the study by first explaining to them the objective and the purpose of the research. Indeed, due to the nature of the study, the researcher supplied to the participants the request for consent form and interview letter (Appendix 4) outlining the aim and objective of the study, the topical issues to be discussed during the research, the confidentiality and anonymity options and the right to withdraw from the research at any point in time with or without justification. Also, the participants made sure if the study had the consent of their Academy Inspection and the Ministry of National Education as some requested to see the permission letter from their Academy Inspection and the Ministry of National Education as well before they participated. The researcher also assured the respondents anonymity will be confidentially and professionally treated, and for only the purpose of the research. Further, the information provided to the researcher by the participants in any form of copies available was protected from unauthorized access and the only persons who had access to them were the researcher and the thesis supervisors.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSIONS

This chapter contains a detailed presentation and discussion of the results of the research. Thus, the presentation of the results is simultaneously done with the discussion. These include demographic characteristics of the respondents, the assessment of the concepts of climate change captured in the geography curriculum in Senegal secondary education, analysis of teachers' understanding and interpretation of climate change concepts. Further, the chapter discusses students' understanding and knowledge of climate change concepts and also the factors that influence the effectiveness of teaching climate change concepts in the secondary education geography curriculum in Senegal. The limitations of the study were also addressed in this section.

4.1 Demographic Characteristics of Respondents

4.1.1 Demographic Characteristics of Geography Teachers

A considerable part of geography teachers (64.4%) were males, while the remaining 35.6% were females in the study area (Table 4.1). The relative domination by male respondents among the geography teachers could be explained by the gender ratio of teachers in lower and upper secondary schools in Senegal which is 30% women and 70% men teachers approximately (Ministère de l'Education Nationale, 2020). This is relatively the

representative of the gender ratio of geography teachers in which it is observed more or less one woman for every 4 men (82% men and 18% women) teaching geography subject in junior and senior secondary schools in Senegal (Ministère de l'Education Nationale, 2018). Therefore, the need to promote female employment in Senegalese secondary education seems essential so that the number of women geography teachers in the system will considerably increase. Further, it has been posited that gender representation in the Senegalese civil service shows gross under representation of women in top management and policy-making positions in general. Therefore, the situation is attributed to the existence of cultural, social and structural barriers to effective female participation in the labour force of the country (ANSD, 2016).

Table 4.1. Gender, Age, Academy Inspection, Qualification, Class, and Teaching Experiences of Geography Teachers

Variables	Description	Frequency	Percentage (%)
Gender	Male	65	64.4
	Female	36	35.6
	Total	101	100.0
Age	between 26 and 30	5	5.0
	between 31 and 35	26	25.7
	between 36 and 40	39	38.6
	between 41 and 45	21	20.8
	above 45	10	9.9
	Total	101	100.0
Academy Inspection	Fatick	13	12.9
	Kolda	14	13.9
	Kédougou	11	10.9
	Matam	11	10.9
	Saint Louis	12	11.9
	Louga	12	11.9
	Pikine-Guédiawaye	15	14.9
	Dakar	13	12.9
	Total	101	100.0
Qualification	Master + CAES	39	38.6
	Bachelor + CAEM	29	28.7
	Baccalauréat + CAE-CEM	33	32.7
	Total	101	100.0
Class	Lower Secondary School	38	37.6
	Upper Secondary School	63	62.4
	Total	101	100.0
Teaching Experience	Less than 5 years	17	16.8
	6-10 years	41	40.6
	11-15 years	30	29.7
	16 years and above	13	12.9
	Total	101	100.0

Key : CAEM means Certificat d'aptitude à l'enseignement moyen,

CAES means Certificat d'aptitude à l'enseignement secondaire,

CAE-CEM means Certificat d'aptitude à l'enseignement dans les collèges d'enseignement moyen.

Table 4.1 also showed that the proportion of geography teachers whose ages ranged between 26–30 years was 5.0%, 31– 35 years was 25.7%, 36–40 years was 38.6%, 41–45 years was 20.8 and over 45 years was 9.9%. The youngest and oldest ages of geography teachers were 26 and 56 years respectively with a mean age of 39 years. The majority

(38.6%) of geography teachers were within the age bracket of 36-40 years old. This means that geography teachers in the study area are relatively young. It could be predicted that geography teachers in the study area would have more interest and incentives in teaching climate change concepts at school since they are relatively young and active to design and implement projects that can protect the environment, thus increasing their students' knowledge about climate change science. Also, geography teachers with their active years in the study area can make a positive contribution to increasing students' climate change awareness, hence they can considerably assist the communities in tackling climate change issues, therefore reducing their vulnerability and increasing their adaptive capacity to the environmental degradation.

The other socio-economic characteristics of the geography teachers are also presented in Table 4.1. It is indicated that the proportion of geography teachers who are in service in the Academy Inspection of Pikine-Guédiawaye was 14.9%, geography teachers in the Academy Inspection of Kolda were 13.9%, those who are in the Academy Inspections of Fatick and Dakar had both the same percentage of 12.9, and 11.9% of the geography teachers in the study area was from Academy Inspection of Saint Louis and also 11.9% was from Louga Academy Inspection and 10.9% was from Academy Inspection of Kédougou and for Matam Academy Inspection the percentage was 10.9. Thus, the occurrence of these frequencies concerning the selected Academy Inspection was entirely left to chance following the availability of geography teachers in each selected school. In terms of qualification, 38.6% of geography teachers in the study area had a Master's degree plus CAES, geography teachers with a Bachelor's degree plus CAEM totaled 28.7%, Baccalauréat plus CAE-CEM holders counted 32.7% (Table 4.1). This is because the minimum requirement for the employment of

teachers in secondary schools in Senegal is a Baccalauréat plus CAE-CEM qualification. Nevertheless, during recruitment of teachers, Master's degree plus CAES and Bachelor's degree plus CAEM are given priority; hence their high numbers in the study area. This is an indication that the qualification of geography teachers in the study area could be seen as an indicator for teachers to effectively address the concepts of climate change in their classes if they have adequate knowledge about the topic. In addition, the majority (62.4%) of the geography teachers were in the upper secondary school while 37.6% were in the lower secondary school in the study area. The results shown in Table 4.1 illustrated that 40.6% of the geography teachers had teaching experience between 6 and 10 years, teaching experience between 11 and 15 years was 29.7%, proposition of geography teachers who had teaching experience 16 years and above was 12.9% and geography teachers with less than 5 years of teaching experience were 16.8%. This means that majority of the geography teachers are experienced in teaching in the study area and this is important in climate change education. Therefore, one should effectively consider geography teachers' experience in designing and implementing climate change education programmes in the research area.

4.1.2 Demographic Characteristics of Students

The majority (55.3%) of students were females and male students represented 44.7% of the selected students (Table 4.2). This is relatively similar to the percentage (53.1%) of female students in both lower and upper secondary schools at the national level in Senegal (Ministère de l'Education Nationale, 2020). This means that female students are in the majority compared to their colleague males in lower and upper secondary schools in Senegal. Thus, this could be due to increased campaigns that have been done in Senegal for girl child schooling (ANSD, 2020).

Table 4.2. Gender, Age, Academy Inspection, and Class of Students

Variables	Description	Frequency	Percentage (%)
Gender	Male	143	44.7
	Female	177	55.3
	Total	320	100.0
Age	below 21	290	90.6
	between 21 and 30	30	9.4
	Total	320	100.0
Academy Inspection	Fatick	40	12.5
	Kolda	40	12.5
	Kédougou	40	12.5
	Matam	40	12.5
	Saint Louis	40	12.5
	Louga	40	12.5
	Pikine-Guédiawaye	40	12.5
	Dakar	40	12.5
	Total	320	100.0
Class	Grade 10	160	50.0
	Grade 13	160	50.0
	Total	320	100.0

Of the 320 students 290 (90.6%) whose ages were below 21, while the remaining 30 (9.4%) were within the age bracket of 21-30 years old (Table 4.2). The youngest and oldest ages of students were 15 and 23 years respectively with the mean age of 18 years. This exhibits the ages range from 12 to 19 years for a learner to be enrolled in the Senegalese secondary schools in general (Ministère de l'Education Nationale, 2020). In addition, for each selected Academy Inspection, 40 (12.5%) students were represented as shown in Table 4.2. Furthermore, it has been illustrated in Table 4.2, 160 (50.0%) students were in grade 10 and 160 (50.0%) were in grade 13.

4.2 Climate Change Content Coverage in the Secondary Geography Curriculum

To know to what extent key areas of climate change are addressed in the current Senegalese secondary school geography curriculum, a thematic area content analysis template was used. Indeed, to ascertain the status of the identified climate change content in

the geography curriculum, variation ratio was computed (vary with identified thematic areas) as shown in Table 4.3.

Table 4.3. Variation Ratio for Secondary Geography Curriculum

Geography Curriculum	Variation Ratio
Lower Secondary School	0.625 (62.5%)
Upper Secondary School	0.812 (81.2%)

Thus, the targeted thematic areas that were sought from the secondary geography curriculum included: scientific concepts and processes; certainties, uncertainties, and projections; causes of climate change; adaptation and mitigation measures; consequences/impacts; time-space dynamics and interests that shape responses to the changing climate.

From Table 4.3, the current geography curriculum for the lower secondary school in Senegal had a variation ratio of 0.625. This means that it possessed only 37.5% of the identified crucial climate change content as per the thematic template. Despite, geography being a compulsory subject for all students from grade 7 to grade 13 in Senegalese secondary schools and also its important role in educating young people about environmental degradation, climate change related topics are not adequately covered in the entire lower secondary school geography syllabus (PURGES, 2020; Thiaré and Cissokho, 2020). Additionally, the interviewed senior geography curriculum designers and senior inspectors of geography agreed that the concepts of climate change were not explicitly addressed in the secondary geography curriculum concerning the lower secondary schools. The subject under the topics in grade 7 (*classe de 6ème*) namely *La Vallée du Senegal*, *La Casamance* indirectly addressed the causes of climate change, also the following topic *Déboisement* et

Reboisement indirectly captured the causes and mitigation strategies to climate change. However, these topics fail to clearly define the concepts of global warming, greenhouse effect, and greenhouse gases, also the term climate variability was not mentioned by the concerned topics. Further, the topics fail to highlight specific human causes and fairly discuss mitigation measures but discuss more of the natural causes and impacts of climate change. Though, they did not address climate change adaptation strategies, certainties, uncertainties, and climate change future projections, interests that shape responses to climate change and the time-space dynamics as well. Moreover, in grade 8 (*classe de 5*ème), the chapter *Les aspects physiques* under the theme *Senegal* fairly defines the notion of climate, and also the topic *Les problèmes d'environnement et de protection de la nature* indirectly addresses the concept of climate change. In addition, the topic *Synthèse* implicitly highlights a few solutions to climate change but it fails to address climate variability, greenhouse effect and the greenhouse gases, climate change future projections, certainties, uncertainties, the interests that shape responses to climate change and the time-space dynamics. Further, geography subject in grade 10 (*classe de 3*ème) under the topics *La Terre, Une Planète du Système Solaire* and *La Terre, Une Planète Menacée* directly address the causes and consequences of climate change and the term greenhouse gas effect. However, climate change mitigation and adaptation measures, certainties, uncertainties, and climate change future projections among others are not captured. Notably though is the fact that the other areas in the template remained largely unaddressed for the geography curriculum regarding the lower secondary schools. The results were in tandem with a study in Kenya by Kariuki (2017) who noted that despite geography being a 'carrier subject' for environmental content and therefore climate change content, the subject possessed only 37% of the identified crucial climate change content in the entire secondary school geography syllabus. Thus, there have

been prior calls for geography curriculum reforms to explicitly include climate change content in the Senegalese education system. Indeed, the Senegalese Association of geography teachers advocates that environmental knowledge enhancement, including climate change issues should be effectively integrated into the secondary school curricula to help learners to better understand this environmental issue, therefore changing their attitudes towards the environment positively (PURGES, 2020; Camara, 2010). Therefore, the infusion of climate change topics for secondary geography education in Senegal is essentially suggested by the senior geography curriculum designers, senior inspectors of geography, and environmental and information officers that were interviewed in this research.

In addition, the current geography curriculum for the upper secondary school in Senegal established the greatest variation of 0.812. This indicated that 81.2% of the identified relevant climate change content as per the thematic template was not covered in the curriculum. This situation is unfortunate since, in the upper secondary school, the learner is prepared to continue his/her studies in higher education where a good understanding of climate change is highly needed, thus combating climate change issues effectively and efficiently. Indeed, the curriculum only addressed some natural causes and consequences of climate change in grade 11 (*classe de Seconde*) through the topics *Les mouvements de la Terre, Les climats de la Terre* but all other thematic areas were not found in the syllabus. Further, in grade 12 (*classe de Première*), the consequences of the changing climate on populations and the rural and urban activities were captured in the chapters *Population et activités en milieu rural* and *Population et activités en milieu urbain* but they did not address the other identified climate change content in the template. Also, the following topic *Senegal* in grade 13 (*classe de Terminale*) indirectly addresses the impacts of climate change on the

water sector and land use but it fails to capture the scientific concepts and processes; certainties, uncertainties, and projections; causes of climate change; adaptation and mitigation measures, time-space dynamics and interests that shape responses to climate change. Additionally, the geography curriculum for the lower and upper secondary schools fails to mention the United Nations bodies such as the United Nations Framework Convention on Climate Change (UNFCCC), the Intergovernmental Panel on Climate Change (IPCC), and the United Nations Environmental Programme (UNEP) among others. Therefore, the senior geography curriculum designers, senior inspectors of geography interviewed for this study alluded that it is primordial for teacher training institutions to adopt proper curriculum and training of pre-service geography teachers in climate change and also the infusion of specific climate change topics in different Senegalese school subjects and non-formal education in order to help learners to effectively understand the concepts of climate change, thus actively participating in the protection of their environment.

Further, the overall variation ratio was computed to establish the status of climate change content in the geography curriculum. Indeed, the geography curriculum for the lower and upper secondary schools had a mean variation ratio of 0.43. Therefore, this implies that approximately 43% of what the study deemed important content in creating climate change awareness was not featured in the geography curriculum but 57% of the content was addressed in varying details in the secondary geography curriculum. Also, the research established that main concepts related to climate change were addressed in the geography curriculum, precisely in the lower secondary school, except for the concept of climate variability. In addition, the main causes of climate change were found to have been directly addressed in the curriculum for the lower secondary school and indirectly regarding the upper

secondary schools. Further, climate change mitigation measures and consequences of climate change were indirectly addressed in the curriculum for the lower and upper secondary schools. Though, climate change adaptation strategies, certainties, uncertainties, and future projections of climate change, time-space dynamics, and interests that shape responses to climate change were not captured in the entire secondary school geography curriculum. The result corroborates the findings of Abraham (2013) and Henry et al. (2012) in which it has been revealed that climate change issues are treated in geography lessons in most secondary schools with few topics focusing on climate and its elements like rainfall, wind and temperature. This indicates that climate change topic seems to be taught to learners in the form of infusion into secondary school curricula in general, therefore leading to ineffective teaching and learning of climate change concepts (Onuoha et al., 2021; Nwosu and Ofili, 2016; Okoli, 2014).

Moreover, a Chi-square test was performed to ascertain whether there was significant climate change content in the current secondary school geography curriculum in Senegal. The results of the test established that the Chi-square value is greater than the significant value, which is $0.626 > 0.429$. This implies that there is no significant climate change content in the current secondary geography curriculum in Senegal. Thus, based on the results, climate change content in the current Senegalese secondary school geography curriculum is inadequate for effective climate change education in schools. Results of the Chi-square test are presented in Table 4.4.

Table 4.4. Chi-Square test for Climate Change Content in the Geography Curriculum

Test	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	0.626	1	0.429
Likelihood Ratio	1.124	1	0.289

Further, the following Table 4.5 revealed that 97 % of the geography teachers claimed that the geography curriculum is not comprehensive in terms of climate change content, thus inappropriate for effective climate change education at Senegalese secondary schools.

Table 4.5. Geography Teachers' Views on Climate Change Content in Geography Curriculum

		Comprehensive Geography Curriculum		
		Yes	No	**Total**
Geography Teachers Awareness of Climate Change	Yes	3	81	84
	No	0	17	17
Total		3	98	101

In addition, Senegalese secondary school geography curriculum does not effectively cover climate change science according to the geography teachers surveyed in the study area. Indeed, there are themes, chapters, and lessons that directly or indirectly address climate change issues in the lower and upper secondary schools. Thus, the surveyed geography teachers reported that the climate change issue is directly captured in grade 10 in the topics:

La Surexploitation des Ressources et ses Conséquences, Les Conséquences Climatiques de l'Exploitation Economique de la Planète where the natural and human causes of climate change and its consequences are explained but climate change adaptation and mitigation strategies and future climate change projections are not deeply addressed in the curriculum. Also, the climate change issues are indirectly addressed in grades 7, 8 in the following topics *Les Régions Géographiques et les Conditions Physiques, Ecosystèmes et la Biodiversité, les Aspects Physiques, le Climat* for the lower secondary school. Further, geography teachers in the study area pinpointed that the curriculum indirectly addresses in grades 11, 12, and 13, the natural causes and impacts of climate change on the populations and their livelihood activities through the following topics *la Planète Terre, Les Régions Naturelles du Globe et leurs Potentialités, l' Atmosphère : Structure et Composition, les Facteurs du Climat , les éléments du Climat , les Eaux Marines, Population et Activités en Milieu Rural* and *Population et Activités en Milieu Urbain, l'étude du Milieu Physique des Differents Espaces étudiés, Le Sénégal* concerning the upper secondary school. Therefore, this indicates that relevant climate change concepts are poorly addressed in the entire secondary school geography curriculum in Senegal as illustrated by the opinion of geography teacher who was surveyed in this study:

The secondary geography curriculum is brief about climate change concepts; hence it would be difficult to teach it based on the teaching and assessment objectives of the curriculum and the time allocated as well.

Furthermore, a majority (97.0%) of the geography teachers in the study area considered that the current secondary school geography curriculum in Senegal is not comprehensive to help learners understand climate change concepts effectively, while 3.0% of the respondents

agreed that the curriculum is comprehensive to help students understand climate change science. This indicates that important climate change content is not captured in the curriculum and this could be detrimental to learners' climate change literacy.

Also, senior geography curriculum designers, senior inspectors of geography, principals and headmasters interviewed in this study expressed that the explicit presentation of climate change concepts in the Senegalese secondary school geography curriculum appears to be limited to effectively increasing climate change literacy of the learners in the lower and upper secondary schools. Hence, more efforts are highly needed towards the secondary school geography curriculum reform in order to explicitly include climate change content, therefore increasing learners' climate change awareness which can lead to effective environmental protection. Further, regarding the status of climate change content in the current secondary school geography curriculum, a senior geography curriculum designer and a senior inspector of geography stated the following respectively:

Senior geography curriculum designer in the Ministry of National Education argued that:

One can say that climate change concepts are not captured well in the secondary geography curriculum and that is why we are in the process of rewriting the curricula (disciplinary and interdisciplinary) through the use of Questions Socialement Vives (QSV) in which the concepts of climate change will be fully taken into account, but we do not have yet the means to do so.

Senior inspector of geography in Dakar Academy Inspection asserted:

I think that climate change science must be explicitly integrated into all curricula from primary to secondary school so that learners understand it effectively and adequately.

Really, the current lower and upper secondary school geography programme has limits regarding sustainable development concepts and therefore climate change concepts.

Globally, climate change concepts were scantly addressed in the current geography curriculum regarding the lower and upper secondary schools in Senegal. At this point, geography teachers' understanding and interpretation of climate change is discussed in the subsequent section.

4.3 Geography Teachers' Understanding and Interpretation of Climate Change

This section of the research explored teachers' understanding and interpretation of climate change concepts. Indeed, awareness of climate change or having heard about the issue, including awareness of the causes, impacts, and solutions are key components of an individual's understanding of climate change concepts.

4.3.1 Awareness of Climate Change Education of Geography Teachers

Geography teachers' awareness of climate change education is presented in Figure 4.1. Out of the 101 respondents, 84 (83.2%) indicated they have heard of climate change education or had an idea of what climate change education is, while 17 (16.8%) indicated they had never heard of climate change education. Anyanwu et al. (2015) reported similar results on geography teachers' awareness of climate change science in the Western Cape Province, South Africa. This indicates that teachers need to be fully literate about climate change science so that they can explain the concepts underlying the causes, impacts, and solutions of climate change as accurately as possible to learners. Moreover, this result indicates that geography teachers in the study area are relatively aware of climate change and climate change education as well. These findings could be explained by the fact that a large part of

the geography teachers in the study area had an academic background in geography which is considered as a school subject that expounds on climate change issues. Further, teachers in the study area could be informed on climate change concepts through their research and professional development activities among others. Also, geography teachers in the study area seem to be able to recognise environmental issues such as climate change and this could be a positive correlation between teachers' awareness of climate change and their students, hence the more teachers' awareness of climate change is, the more their students' is (Dal et al., 2015). However, 16.8% of geography teachers in the study area who indicated that they had never heard of climate change education leave a lot to be desired regarding teachers' training and professional development activities about this environmental issue.

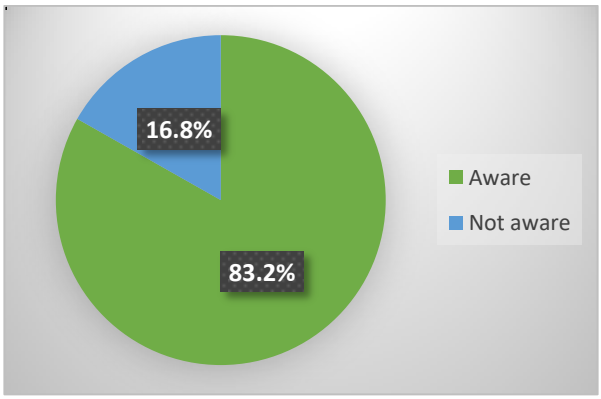

Figure 4.1. Geography Teachers' Awareness of Climate Change Education

To further assess geography teachers' awareness of climate change and climate change education, an awareness index was computed. The average awareness index for geography teachers in the study was 0.6455 (64.55%). Thus, the awareness index for geography teachers in the research area implies that they are aware of climate change and climate change education. Geography teachers' awareness of climate change might provide teachers with

more knowledge about the subject; therefore they can influence students' understanding of climate change issues considerably. It is urgent to emphasize the importance of teachers giving high priority to climate change to assuring a proper understanding of climate change science among their students.

Additionally, to determine how geography teachers in the study area understand climate change education the following open-ended question was asked to them: *What does climate change education mean to you as a geography teacher?* Indeed, 74% of the surveyed geography teachers correctly responded to the question by stating the following:

Geography teacher (Maciré Ba lower secondary school) reported:

It is to teach learners that climate change is a recurring phenomenon that can be caused by several factors (natural and anthropogenic). It can also produce many consequences on several levels, especially economic and social. And it will be too difficult to slow down or stop this phenomenon of climate change, but we can combine our efforts to slow down at least the speed or its deviations. And it should be really everyone's business.

Another geography teacher (Elhadji Yéro Basse upper secondary school) replied:

The phenomenon of climate change impacts us all whether we are aware of it or not, hence, the need to educate the youth and also to make adults aware of these phenomena. Make them understand that it is a phenomenon that is certainly due to a natural process of evolution of our environment but especially to the anthropic action (human action). And if we are not careful, we are going straight to a catastrophe in which man has more to lose.

Moreover, to ascertain whether there exists a no significant relationship between climate change content in the geography curriculum and climate change education awareness among geography teachers, the research performed a Chi-square test; thus the results of the test are presented in Table 4.6.

Table 4.6. Chi-square test for Geography Teachers' Awareness

Test	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	83.651	86	0.552
Likelihood Ratio	24.236	86	1.000

According to Table 4.6, the Chi-square value is greater than the significant value. That is 83.651>0.552 (N=101). Therefore, this indicates that there is no statistically significant relationship between climate change content in the geography curriculum and climate change education awareness of geography teachers in the study area. This indicates that the current geography curriculum does not significantly take into account geography teachers in terms of teaching and learning climate change science at school. This means that geography teachers in the study seem to teach climate change concepts to their students through their academic backgrounds and experiences. Also, a lack of explicit presence of climate change in a curriculum could lead to limited attention to the topic of climate change (Ronald et al., 2017). Additionally, the findings of this study are in conformity with that of Kariuki (2017) in which it has been averted that there was no significant relationship between implementation of the secondary school curriculum and climate change awareness by teachers in Kenya. The climate change content lies at the background of other topics and requires expertise of the geography teachers to retrieve it,

thus teaching about climate change depends on capacity and interest of individual teachers in the study area. Therefore, it is urgent to teach climate change science within the classroom setting by well-equipped teachers using appropriate pedagogical strategies that can prompt efficient climate actions from learners.

4.3.2 Geography Teachers' Understanding of Climate Change Concepts

This section outlined the findings relating to geography teachers' understanding of climate change concepts, including the causes of climate change, climate change impacts and remedial actions. To establish geography teachers' understanding of issues of climate change, Likert-type questions relating to their perceptions about the realities of climate change were administered to them and the results are as shown in Table 4.7.

Table 4.7. Geography Teachers' Perceptions about the Realities of Climate Change

Perceptions about the realities of climate change	SA	A	D	SD	CT
Climate change is really happening	44.6	53.5	0.0	0.0	2.0
The climate has changed for the past five years and more	24.8	35.6	8.9	2.0	28.7
Climate change is a result of human activities	37.6	54.5	2.0	3.0	3.0

Note: SA=Strongly Agree, A=Agree, D= Disagree, SD= Strongly Disagree, CT= Cannot tell. All scores are in percentage. N=101.

Table 4.7 outlines the perceptions of geography teachers about the realities of climate change. From the table, most geography teachers expressed their perceptions about the realities of climate change. For instance, 44.6% of the respondents said that they strongly

agreed that climate change is really happening and 53.5% agreed that the changing climate is real, while 24.8% strongly agreed that the climate has changed for the past five years and more and 35.6% of them agreed the climate has been changing for the past five years and more. In addition, 28.7% of the surveyed geography teachers said that they cannot tell that the climate has changed for the past five years and more, implying that they could have limited information about climate change issues due to a possible absence of climate change content during their training. Also, majority (54.5%) of the geography teachers agreed that climate change is a result of human activities and 37.6% strongly agreed that the changing climate is a result of human activities. Thus, to explore more geography teachers' understanding of the causes and consequences of climate change and its remedial actions the following open-ended question was asked to them: *How do you understand climate change?*

All geography teachers were familiar with the term climate change but the majority (79%) scantly mentioned a few causes of climate change without explaining the scientific processes behind this environmental issue. Indeed, they reported that the changing climate is due to the modification of Earth's climate by both natural causes (volcanic eruptions) and human activities such as overexploitation of natural resources, industry development, pollution and degradation of forests. However, the surveyed teachers briefly mentioned the term greenhouse gas without properly explaining the role of the greenhouse gas effect in the atmosphere's composition and function. In addition, some teachers in their responses reported very misleading information on the cause of global warming; they mentioned that global warming is caused by the destruction of the ozone layer leading to direct penetration of the sun's rays (ultraviolet UV) hence increasing temperatures on Earth's surface. This can be observed in the extracts below:

Climate change is primarily linked to the exploitation of natural resources, especially energy resources. With the latter, their exploitation leads to air pollution with greenhouse gases that destroy the ozone layer. This destruction heats up the earth which has as a consequence the increase in temperature, sea-level rise with the melting of the ice, the rainfall changes, especially in the tropical zones (Geography teacher, Martyrs C de Thiaroye lower secondary school).

Another incorrect explanation of causes of climate change:

It is a problem that threatens life on earth. Climate change is mainly anthropogenic due to various forms of pollution (domestic, transport and especially industrial). Its effects range from floods, droughts to bush fires and others, and all this is induced by the progressive reduction of the ozone layer (Geography teacher, Cheikh Omar Foutiyou Tall upper secondary school).

Further, all geography teachers mentioned the main consequences of climate change such as rainfall increase or decrease, floods, droughts, acid rain, ocean levels rise, deterioration of sanitary conditions, temperature increase, recurrent cyclones, and melting glaciers and also they argued these mentioned impacts endanger human life and unbalance ecosystems. Also, they claimed urgent solutions to this environmental issue nevertheless, a large part of them failed to properly explain the suggested solutions to climate change issues; they did not give any details about the measures that need to be taken to protect the environment. The terms climate change adaptation and mitigation have not been highlighted by geography teachers in their responses.

Geography teachers in the study area fairly understand the consequences of climate change on lives and livelihoods of the populations but they seem to have limited knowledge and understanding about the scientific processes of the causes of climate change and also they scantly have a good understanding of solutions to climate change namely adaptation and mitigation strategies and as well as the United Nations bodies dealing with climate change issues among others. This result could be due to the fact that the study of climate change science formed no part or a small part of the course at university for geography teachers and as well as their lack of personal development activities regarding environmental issues. Therefore, the findings of this research are supported by PURGES (2020) in which it has been argued that as much as some geography teachers at Senegalese secondary schools are able to tackle all the themes of the programme in its globality, many others have serious limitations related in particular to the themes of physical geography, including climate change science. Additionally, climate change solutions require among other things, teachers who are fully literate about climate change science, so that they can explain the concepts underlying the causes, impacts, and solutions of climate change as accurately as possible to learners (Raymond et al., 2015).

Furthermore, the majority (58.4%) of the surveyed geography teachers as shown in Table 4.8 below affirmed that the study of climate change education formed no part of their course at the university, 37.6% designated that the study of climate change formed a small part of their course at the university, while 4.0% reported that the study of climate change science formed a large part of their course at the university. This implies that geography teachers need to be well trained on climate change science and climate change education

so that they can be considerable drivers of climate change awareness at school and community as well.

Table 4.8. Geography Teachers Study of Climate Change at University

How much do you know and understand climate change education as a geography teacher?	Frequency	Percentage
Study of climate change education formed no part of the course at the university	59	58.4
Study of climate change education formed a small part of the course at the university	38	37.6
Study of climate change education formed a large part of the course at the university	4	4.0

Moreover, 26.7% of the geography teachers affirmed that they are very confident in teaching climate change concepts and 51.5% reported that they are fairly confident in teaching climate change science, while 21.8% agreed that they are not confident in teaching climate change. This shows that more efforts should be done towards teacher training and professional development programmes in climate change education in order to make geography teachers in Senegalese secondary schools fully literate about climate change science, so that they can explain the concepts underlying the causes, impacts and solutions of climate change as accurately as possible to students.

Also, a large part (76.2%) of geography teachers in the study area affirmed that they integrate climate change topics in their lessons, while 23.8% do not address the issues of climate change in their courses. This suggests that teachers who are not aware of climate change education in the study area are likely to increase societal misconceptions and apathy towards climate change issues among their students. In other words, the aspects of

climate change are poorly taught within the geography curriculum at Senegalese secondary schools, thus implying ineffective teaching about climate change concepts at schools in Senegal. Further, the limited presence of climate change content in Senegalese secondary geography school curriculum could lead to limited attention to the topic of climate change. Additionally, with their considerable teaching experience (83.2% had teaching experience between 6 and 16 years and above), geography teachers in the research area could be assisted through professional development programmes and support interventions in teacher knowledge and understanding of climate change concepts, so as to enhance climate change education in schools. Therefore, it is essential to better train geography teachers in the study area on climate change education and also assist them to effectively teach their students about the aspects of climate change, including its environmental, social and economic dimensions.

When teachers were asked about the scientific teaching methods that are normally used in their geography lessons, almost all the teachers mentioned the use of the skills-based approach method combined with the active method. Also, geography teachers in the study area asserted that the active method puts the learner at the centre of the teaching-learning action. Thus, through discovery, the learner is led to discover the knowledge by himself/herself and to acquire the experience and skills. With well trained teachers on climate change education, the use of these mentioned methods coupled with the use of pictures, videos, field trips and discussion could be seen as the best way when working with climate change education in schools in the study area.

At this point, responses on what teaching resources geography teachers in the study area used in geography were elicited. Indeed, teachers reported that teaching materials,

including teachers' resource guides in geography in lower secondary school (*guide pédagogique, guide d'usage en géographie*), books for the lower secondary school (*Géographie de la Troisième, Boissy* ; *Géographie Classe de Troisième, Jean Dieye*, 2015 ; *Géographie Troisième, le Monde* ; *Atlas Afrique* ; ouvrage *Espace Vécu* ; *livret de l'élève de la troisième*), books for the upper secondary school (*Atlas Monde* ; *Encarta* ; *Ramses* ; *Géographie Collection Hatier* ; le livre *Jeune Afrique*, 2007), some university courses in geography ; maps ; texts; internet links ; photos ; videos among others. The review of these mentioned manuals and books revealed that climate change content was scantly addressed and also surveyed teachers reported that they have challenges to properly deliver their courses such as the lack of educational resources namely textbooks, audio-visual resources related to secondary geography education. Further, the majority (65.3%) of the surveyed teachers claimed that the geography books that they use address climate change concepts in a certain way, while 34.7% reported that climate change science is not addressed in the geography books that they use. This indicates that climate change science is not adequately captured in geography books that teachers use in the study area, therefore establishing that limited attention that is given to the importance of climate change education as a tool for addressing and mitigating climate change in Senegal (Diop, 2019). Moreover, in attempt to promoting climate change education in schools, 45.5% of geography teachers in the study area affirmed that there is an environmental club in their schools, while 54.5% reported that they have not an environmental club. Among schools having an environmental club, only 22.8% of geography teachers affirmed that they are members of their school environmental clubs, therefore revealing a lack of engagement and limited interest and attention of geography teachers in the study area to environmental issues and climate change within their schools

and communities, despite 88.1% of them agreed that school environmental clubs are important in promoting climate change education in schools. Importantly, Nicholls (2016) pinpointed that it is not enough for people to know about climate change in order to be engaged; they also need to care about it, be motivated and able to take actions that combat climate change. Additionally, Dlamini (2019) opined that the presence of Eco or Environmental Clubs in schools helps the learners to acquire an education that seeks to balance human and economic well-being with cultural traditions and respect for the Earth's natural resources.

In addition, from the teacher questionnaires, the responses from a large part of (85.10%) geography teachers suggested that the time they have for teaching geography it is not enough to enable them to cover the geography syllabus and emphasize on climate change issues. The Majority (73.3%) of the geography teachers indicated that they are allocated 120 minutes per week for geography, while 23.8% have 160 minutes to teach geography. These findings imply the limited possibility for geography teachers in the study area to guide, inspire and empower students towards environmental protection with the already crowded geography curriculum (PURGES, 2020). This could contribute to the existing students' indifference and little impetus for behavioral change for the environmental protection. Although, the majority (98.0%) of geography teachers agreed that the use of practical approaches to the teaching and learning of geography has a role in enhancing climate change education but 47.5% of them rarely used fieldwork in the teaching and learning of geography, while 48.5% did not use at all fieldwork in teaching geography, thus leading to decreasing environmentally-friendly behavior of learners. The findings of this study are in line with the study of Diop (2019) who argued that secondary school

geography teachers in Dakar district, Senegal do not plan any activity aimed at implementing a change in behavior for better management of the environment in schools and communities as well.

Moreover, surveyed geography teachers were asked that do they think that climate change science should be taught as a separate subject. Respondents selected from closed answer yes or no. Thus, the majority (57.4%) felt that climate change science should not be taught as a separate subject rather it could be effectively integrated into the school curricula and taught through using appropriate pedagogical strategies that can prompt efficient climate actions from learners. While 42.6 % agreed that climate change science should be taught as a separate subject in schools, therefore, implying that the climate change issue is seen as a big danger for humanity, justifying that climate change science should be taught as a separate subject at all levels of formal education and non-formal education so that to eliminate people's indifference and little impetus for behavioral change for the good of the environment (Onuoha et al., 2021; Bulkeley, 2000). The following section discussed the comparison of climate change awareness between geography teachers at lower secondary school and those at upper secondary school so that to determine who better understand the concepts of climate change.

4.3.3 Climate Change Awareness Comparison among Geography Teachers

Preliminary analyses of the data showed that all the selected geography teachers at lower secondary had 50% and above as climate change awareness score compared to the geography teachers at upper secondary who have 8 respondents who had less than 50% as climate change awareness score. This implies that although the geography teachers at

upper secondary had the highest score (86.76%), they are likely less aware of climate change and climate change education as well. The mean awareness score (66.18%) for geography teachers at lower secondary school is relatively greater than the one scored (61.86%) by their counterparts at upper secondary school.

Further analysis using independent sample t-test statistics indicates the mean climate change awareness score obtained by the geography teachers at lower secondary school is statistically and significantly different than the one obtained by their counterparts of the upper secondary school, as illustrated in Table 4.9. Thus, from the table, the p-value (sig. (2-tailed)) which is 0.031 is less than 0.05 (5%), implying that the means awareness of climate change of these two groups (geography teachers at lower secondary and geography teachers at upper secondary) are statistically and significantly different.

Table 4.9. Mean Climate Change Awareness Scores of Geography Teachers

Variable	Category	N	Mean	t	df	Sig. (2-tailed)
Awareness score	Geography teacher at lower secondary school	38	66.18	2.186	99	0.031**
	Geography teacher at upper secondary school	63	61.86	2.378		

***p* significant at <0.05; N=101

This result suggests that geography teachers in the study area at lower secondary schools are statistically and significantly more aware of climate change and climate change education than their counterparts at the upper secondary schools. This could be

linked to the fact that the geography curriculum concerning the upper secondary school in Senegal does not explicitly contain concepts of climate change, thus leading to a lack of attention of teachers towards environmental issues, including climate change concepts in their lessons. Consequently, this could increase misconceptions and apathy towards climate change issues from senior secondary school students who will bear the brunt of the impacts of this environmental issue. These findings corroborate those of Vujovic (2013) who found some gaps in geography teachers' understanding of climate processes as well as their limited understanding of the meaning of climate change in Gauteng Province, South Africa. Therefore, it is important that geography teachers have adequate information about the science of climate change so that they can present concepts as precisely and logically as possible to learners because geography offers the greatest opportunity for understanding climate change concepts based on its emphasis on place, spatial processes, spatial distribution, society and environment (Anyanwu et al., 2015; UNESCO, 2012).

Additionally, it is considered necessary to assess the influence of demographic and geographical variables on geography teachers' climate change awareness. Indeed, teachers' gender, age, academy inspection, teachers' qualifications, and teaching experience were included for identification and classification. These variables turned out to have an influence on climate change awareness with female teachers, teachers who are between 41 and 45 years old, teachers who have Baccalauréat plus CAE-CEM as qualification, teachers who have between 11 and 15 years as teaching experience, and geography teachers in Matam Academy Inspection having statistically and significantly higher mean climate change awareness scores than their counterparts (Table 4.10). Indeed,

this relative high climate change awareness level for female geography teachers in the study area could be due to the fact that women are more vulnerable to the effects of climate change than men and also, they are more dependent for their livelihood on natural resources that are negatively affected by the changing climate (World Bank, 2020; ANSD, 2016), thus making them to give more attention to climate change information and increase their impetus towards environmental protection. Also, the broader interactions of most female geography teachers with the environment are therefore likely to have contributed in higher climate change awareness than male geography teachers in the study area. It is essential to organize capacity building or professional development programmes for in-service teachers and appropriate teacher training for pre-service geography teachers in order to level off climate change awareness variations among geography teachers respective of their gender in Senegalese secondary schools.

Further, young geography teachers are believed to be more exposed to climate change education at their tertiary education than the older generation (above 45 years old) who had the lowest mean awareness score (54.56%) in the study area. In other words, geography teachers who are above 45 years old in the study area appeared to be not exposed to climate change education at the university level or teachers' training centre, due to the fact that this concept has been poorly addressed for a long time. These findings are similar to that of Dlamini (2019) who found that young geography teachers are more aware and confident in teaching climate change science in their geography lessons in Swaziland. Also, it has been posited that young adult teachers are likely to better understand climate change concepts than their colleagues who graduated at least a decade ago from university or college level (Mower, 2012). Thus, it is important to expose

geography teachers to climate change education at the university level so that they can have a clear understanding of climate change concepts and teach the topic to their students effectively. In addition, in the study area, geography teachers with Baccalauréat plus CAE-CEM as qualification are more aware of climate change concepts (60.14%) because they relatively teach the topic in the lower secondary schools where the concepts of climate change are although scantly addressed in the curriculum compared to geography teachers in the upper secondary schools where climate change science was not captured, therefore leading to teachers' indifference for climate change education in the senior secondary schools. This indicates that more efforts are urgently needed to improve the knowledge and understanding of climate change concepts of geography teachers, especially those in the upper secondary schools in Senegal to enhance climate change literacy of learners, thus helping them to protect their environment.

Furthermore, geography teachers who have between 1 and 15 years of teaching experience scored high climate change awareness (63.97%) compared to their counterparts with teaching experience 16 years and above made up 57.56% as awareness score. These findings relatively asserted that young geography teachers in the study area are more aware of climate change and climate change education than the old generation despite their considerable teaching experience. Also, the young teachers have been partially trained on climate change concepts, while the old teachers did not have courses on climate change science at the university or training centre. Therefore, this implies that building capacity in climate change education of in-service geography teachers in Senegalese secondary schools is considered to be important and urgent in moving towards environmental protection and sustainable development gaols. Moreover, geography

teachers in Matam Academy Inspection had the highest (66.20%) climate change awareness score than geography teachers in the other selected Academy Inspections. This could be due to the severity of climate change impacts in this part of the country where teachers could locally experience these adverse impacts of climate change, thus enhancing their understanding of this environmental issue. Thus, local pieces of evidence of climate change impacts on lives and livelihoods of the populations could play an important role in the comprehension of the climate change phenomenon by people. In other words, the personal development activities of teachers on climate change concepts linked to their local environment could considerably contribute to the increase of their knowledge and understanding of climate change (Crayne, 2015).

Table 4.10. Results of the Influence of Demographic and Geographical Variables Tested on Geography Teachers' Climate Change Awareness

Variable	Category	N	Mean Awareness Score (%)	df	Sig.	Remarks
Gender	Male	65	58.90	99	0.019**	Female>Male
	Female	36	63.57			
Age	Group {18-25}	0		4	0.027**	Group {41-45}> to other Age Groups
	Group {26-30}	5	52.19			
	Group {31-35}	26	57.81			
	Group {36-40}	39	61.56			
	Group {41-45}	21	63.0			
	Group {Above 45}	10	54.56			
Teacher Qualification	Master + CAES	39	54.03	2	0.005***	Baccalauréat + CAE-CEM > Bachelor + CAEM. Baccalauréat + CAE-CEM > Master + CAES
	Bachelor + CAEM	29	59.41			
	Baccalauréat + CAE-CEM	33	60.14			
Teaching Experience	Less than 5 years	17	61.67	3	0.055*	Teachers with 11-15 years Teach. Exp.> other Teachers
	6-10 years	41	64.35			
	11-15 years	30	65.90			
	16 years and above	13	57.56			
Academy Inspection	Fatick	13	60.12	7	0.009***	Matam> other Academy Inspections
	Kolda	14	60.36			
	Kédougou	11	61.36			
	Matam	11	66.20			
	Saint Louis	12	54.34			
	Louga	12	60.76			
	Pikine-Guediawaye	15	53.11			
	Dakar	13	56.56			

*Significance level at 10%; **Significance level at 5%; ***Significance level at 1%.

In sum, it is essential to consider the academic background and social characteristics of geography teachers in designing and implementing school climate change education programmes so that this pressing environmental issue will be well understood by teachers and properly delivered in schools. The multinomial logistic regression model (MLM) helping to identify the likelihood of geography teachers being categorized into one of the three predetermined groups of climate change awareness is discussed in the subsequent section.

4.3.4 Parameter Estimates of the Multinomial Logistic Model of Climate Change Awareness Groups of Geography Teachers

Initially, geography teachers' climate change awareness is categorized into three levels based on percentage scores – Low awareness (0–50%); Moderate awareness (51–74%) and High awareness (75% and above). Therefore, there are 78.2% of geography teachers that are being categorized under Moderate awareness group, 11.9% under High awareness group, while 9.9% being categorized as possessing Low climate change awareness. The categorization of the level of awareness is to enhance further analyses of the data using the multinomial logistic regression model (MLM). The MLM was adopted to identify the likelihood of geography teachers' membership of the groups of awareness level ("Low awareness," "Moderate awareness" and "High awareness"). The results of the MLM Model are as follows in Table 4.11.

Table 4.11. Parameter Estimates of the Multinomial Logit Model of Awareness Group Membership of Geography Teachers

	Moderate Awareness Group			High Awareness Group		
Variable	Coefficient	Odds Ratio-Exp(B)	*p*	Coefficient	Odds Ratio-Exp(B)	*p*
Gender	0.690	1.459	0.000***	1.861	3.429	0.123
Age	-0.909	1.124	0.000***	-2.018	8.076	0.996
Qualification	0.114	1.121	0.094*	1.076	3.934	0.543
GeoTeaClass	1.544	3.595	0.049	2.867	8.922	0.013**
AcdemyInspect	-1.816	3.163	1.000	0.301	1.351	0.000***
TeachingExper	-1.749	3.874	0.140	-2.261	8.104	0.000***
MemberofEClu	-2.225	8.108	0.122	-1.508	3.730	0.040**

Reference category: Low Awareness Group

Model Fitting Likelihood Ratio: X^2= 49.702**
Goodness-of-fit: 83.589 (Pearson); 77.125 (Deviance)
Overall Classification percentage: 80.2%

*, ** and *** indicate statistically significant values at 10%, 5% and 1%, respectively.

The multinomial logistic regression showed the best fitness of the model at 5% significant level (Model Fitting Likelihood Ratio: X^2=49.702, p= 0.040<0.05). The model had adjusted a Pseudo R- Square of 0.525 (Nagelkerke), signifying that about 52.50% of the variation in teachers' membership in the three predetermined categories of climate change awareness is appropriately predicted by the explanatory variables as illustrated in Table 4.11. In addition, the Pearson (83.589) and the Deviance (77.125) statistics test, p=1.000>0.05, indicate that the test is not statistically significant, thus the fitted model is correct. Also, for the predictions of the model, the performance shows an overall rate of correct classification of 80.2%.

All independent variables tested (i.e., geography teacher's gender, age, qualification, geography teacher class, academy inspection, teaching experiences and environmental club membership had positive effects on the dependent variable (climate change awareness score) as shown by positive odds ratio results in all tested variables. Thus, this implies there is an increasing probability of geography teachers being categorized under Moderate awareness group and High awareness of climate change based on their gender, age, qualification, class, academy inspection, teaching experiences and environmental club membership than being classified under Low awareness of climate change. While gender, age and geography teacher qualification significantly increased the probability of teachers being categorized as possessing moderate climate change awareness, academy inspection, geography teacher class, teaching experiences and environmental club membership occurred as significant variables in categorizing teachers into high awareness group. These findings are dissimilar from that of Eze (2019), who reported no significant effects of teacher's gender, school location, academic discipline, grade level and educational

qualification on their climate change awareness and willingness to engage in pro-environmental behaviour in Nsukka Local Government Area of Enugu State, Nigeria. However, the results of this study corroborate with the findings of Onuoha et al. (2021); Vujovic (2013) and Owolabi et al. (2012) who found that gender, location, age, class, subject status, sources of information on climate change, and teachers' attitudes towards climate change as determinants of high school students and teachers' climate change awareness in Nigeria, Ghana, and South Africa respectively. Thus, geography curriculum developers should consider influencing factors to climate change awareness as well the aspects of the goal of education in relation to the environment. Hence, related content that directly applies to the achievement of environmental friendliness should be infused across the secondary school geography curriculum, therefore improving teachers' environmental and climate change awareness and knowledge in the study area. Although the variations of geography teachers' scores based on tested variables exist, a large part of surveyed geography teachers presented a mean climate change awareness score of equal to or high than 51%. This indicates that most geography teachers tested had at least a moderate level of climate change awareness, irrespective of their gender, age, qualification, class, academy inspection, teaching experiences, and environmental club membership.

Furthermore, gender was statistically significant at 1% and this indicates that female geography teachers are more likely to be placed among the moderate awareness group than the low awareness category, while the male geography teachers are more likely to be categorized into low awareness group. The findings are consistent with the findings of Ochieng (2014) in which it has been revealed that female teachers recorded a higher climate change awareness score than male teachers in Kenya. Therefore, it seems that

female geography teachers in the study area are more exposed to climate change information than male teachers, implying that capacity building on climate change among geography teachers in secondary schools is highly needed in the study area to ensure that climate change concepts are understood irrespective to the teacher's gender and properly delivered to learners. Additionally, age was statistically significant at 1%, implying that the middle-aged geography teachers are more likely to be categorized under the moderate awareness group than the low awareness category. Inversely, the elder geography teachers seem to be in the low awareness group, especially, the teachers who are above 45 years old with the lowest climate change awareness mean score (54.56%) in the study area. Based on the findings of this study, it is essential to continue education interventions that will enable geography teachers, especially the old teachers to develop deeper scientific knowledge and understanding of climate change, such that they will be able to promote the development of climate change literacy in Senegalese secondary schools. The results of this research are in line with the findings of Ochieng (2014) who revealed that the level of climate change awareness of teachers increases with increase in age from younger to older age groups, but this was only true up to age 45 years above which increase in age did not produce any influence on teachers' level of climate change awareness in Kenya. This indicates that youthful and older geography teachers seem to be less aware of climate change compared to middle aged geography teachers in the study area, thus implying to level off climate change awareness variations among geography teachers. For geography teacher qualification, the test was statistically significant at 10%, indicating that geography teachers with Baccalauréat plus CAE-CEM are likely to be categorized into the moderate awareness group than the low awareness category compared to their counterparts who have Master's degree plus CAES and Bachelor's degree plus CAEM.

This result could be due to the fact that geography teachers with Baccalauréat plus CAE-CEM in the study area are more exposed to climate change information through the content of climate change in the geography curriculum for the lower secondary schools, therefore motivating them to be interested to climate change concepts. This means that geography teachers with Master's degree plus CAES and Bachelor's degree plus CAEM as qualifications mostly teach in the upper secondary schools where the geography curriculum did not explicitly capture climate change content, thus leading to limited attention and understanding of teachers about climate change science. Therefore, geography teachers in the upper secondary schools in the study area need to enhance their climate change literacy in order to thoroughly teach the topic to their learners who highly need to be well prepared to embark on sustainable development activities which are considerably linked to climate change. Globally, it is urgent to train secondary geography teachers in Senegal on climate change so that they can have adequate information about the science of climate change and present concepts as precisely and logically as possible to students.

Also, geography teacher class was statistically significant at 5%, showing that geography teachers at lower secondary schools are more likely to be placed among the high awareness group than the low awareness category. In other words, they are more likely to be in the high awareness group of climate change than their colleagues in the upper secondary schools, thus indicating that geography teachers in the senior secondary schools possessed limited knowledge of climate change science with the limited contribution of the geography curriculum about climate change education in the senior secondary schools. This result is in agreement with that of the findings of Diop (2019)

who pinpointed the main concern for the geography teachers in senior secondary schools in Dakar, Senegal is to articulate the causes and consequences of climate change with its repercussions on the surrounding environment of the learners. Thus, for climate change education in Senegal to best serve its purpose, which is to support climate-friendly behaviour and activities, it is suggested to establish the training of in-service and pre-service geography teachers in the upper secondary schools on climate change science.

Further, Academy Inspection was statistically significant at 1%, showing that the location (Academy Inspection) of the school seems to influence geography teachers to be categorized in the high awareness group than the low awareness category. In this study, it has been revealed that geography teachers in Matam Academy Inspection are more aware of climate change with the highest mean awareness score (66.20%) than their counterparts in the other Academy Inspections. These findings could be explained by the fact that geography teachers in Matam Academy Inspection have more experienced the consequences of climate change and environmental related issues in this northern semi-arid part of the country than their colleagues in the other regions of Senegal, thus helping to enhance their understanding of climate change. Also, the closer connection with the natural environment, and first-hand experiences with impacts of climate change such as increasing temperature, dwindling crop yields, fluctuating rainfall among other impacts, could explain their moderate or high climate change awareness. The result is similar to the findings of Ochieng (2014) who reported that school location influenced the level of awareness of climate change of teachers, therefore showing that teachers from schools located in the urban area are more aware of climate change compared to their counterparts from schools located in the peri-urban area in Kenya. However, the result is not in

agreement with previous findings (Eze, 2019) in which it has been posited that there is no statistically significant difference in mean scores of both awareness of climate change and willingness to engage in pro-environmental behaviour of students in Nigeria based on location. It is essential to pay particular attention to increasing geography teachers' awareness of climate change in the study area, thus contributing to avoid information-deficiency even ignorance on the topic of climate change as teachers stand a good chance of knowledge-sharing with their students during class activities.

Moreover, teaching experience was statistically significant at 1%, implying that with increasing teaching experience, the probability of geography teachers to belong to the high awareness group increases but from 16 years and above of teaching experience, geography teachers are likely to be categorized as possessing low climate change awareness than being grouped under high awareness category. This means that being old teachers with considerable experience in teaching in the study area seems to be not enough to have clear understanding of climate change science. In other words, young teachers in the study area are likely to be more exposed and well informed about climate change than their elders who maybe did not have change to be thoroughly trained on climate change concepts. Also, there is a possibility that young geography teachers with teaching experience less than 16 years acquire climate change information from alternative sources aside from the school curriculum, which is reflected in their moderate and high levels of climate change awareness. These findings are similar from that of Ronald et al. (2017), who reported low climate change awareness of geography teachers in Uganda due to their limited teaching of climate change which is exerted by their limited experience and knowledge about the topic. Hence, teachers who are well exposed to information on climate change will find

themselves making connections of their environmental subject-content to relevant issues in the environment, such as climate change (Onuoha et al., 2021). Therefore, based on this result, it is highly needed for in-service and pre-service geography teachers, especially the elders, in Senegalese secondary schools to be trained on climate change science through seminars and workshops (both in-person and on-line) in order to ensure a high climate change literacy in schools.

Member of school environmental club was statistically significant at 5, indicating that geography teachers who are members of environmental clubs in their schools are more likely to be categorized under high awareness group than the low awareness category. Therefore, the possibility as inferred from our findings is that school environmental club has an important role to play in improving teachers and students' climate change literacy, thus contributing to climate change mitigation actions in schools and communities as well. Indeed, geography teachers in the study area who are members of school environmental clubs showed more understanding of environmental issues, hence possessing moderate and high climate change awareness scores than their counterparts who are not involved in any climate actions or school environmental club. Therefore, geography teachers who are members of school environmental clubs are exposed to in-depth discussion of topic of climate change and environmental related problems, which could improve their climate change understanding. This result is dissimilar from that of Akrofi et al. (2019) who pinpointed that the relationship between climate and environment-related student clubs in some African universities and their knowledge and awareness of climate change was not statistically significant. Thus, various climate and environment-related student clubs

should tailor their activities in the direction of awareness increase and implementation of climate change adaptation and mitigation initiatives in schools and communities.

Overall, the likelihood of geography teachers' information-deficiency in understanding climate change concepts could be overturned by the organisation of capacity building or professional development programmes on climate change for in-service teachers and appropriate teacher training for pre-service geography teachers in secondary schools in Senegal. Hence, factors influencing geography teachers' climate change awareness in the study area should to be taken into account in capacity building or professional development programmes on climate change and environmental related problems for teachers in order to achieve a strong climate change literacy, which is expected to lead to climate actions in schools. Additionally, development of appropriate methods and materials as the foremost step in education for improved climate change awareness is relevant for all geography teachers in secondary schools. Thus, the role of the teacher is pivotal in improving students' climate change awareness and shaping their environmental behavior positively. In the subsequent section, students' understanding and knowledge of climate change concepts is discussed.

4.4 Students' Understanding and Knowledge of Climate Change Concepts

In this section, students' awareness of climate change, factors influencing their awareness level and the comparison of climate change awareness among students are outlined.

4.4.1 Climate Change Awareness of Students

To establish what does climate change mean to students a closed-ended question was asked to them and the findings revealed that most (90.9%) of the selected students affirmed that they have heard of climate change or have an idea of what climate change is, while 5.3% indicated that they had never heard of climate change before and 3.8% reported that they do not remember their encounter with the construct as shown in Table 4.12. This result shows that students in the study area are relatively aware of climate change. The findings could be due to the limited students' exposition to the sources of climate change information in the study area. These findings imply that climate change mitigation and adaptation will require knowledgeable actors, including school students who can hold the relevant skills, values and dispositions to enable informed decision making and appropriate actions to protect the environment. Though, the percentage (9.1%) of those students that had never heard of climate change before or do not remember their encounter with the construct, leaves a lot to be desired. Also, the findings of this study are in line with the results of Diop (2019) who pinpointed that secondary school students in Dakar district, Senegal had limited knowledge on climate change science and they are scantly aware of climate change consequences on lives and livelihoods of the populations.

Table 4.12. Students Climate Change Awareness

Have you ever heard of climate change?	Frequency	Percentage
Yes	291	90.9
No	17	5.3
Don't remember	12	3.8

N=320

Moreover, an awareness index was computed in order to further assess students' awareness of climate change. Thus, the average awareness index for students in the study area was 0.5343 (53.43%). This indicates that students in the study area are relatively aware of climate change concepts, therefore suggesting that adequate teaching methods and the use of techniques are needed to educate students about what climate is, its impacts, and as importantly about the contribution of each individual as part of efforts to handle this environmental problem considerably. Also, it is essential to emphasize on teachers' training on climate change science and environmental related problems, so as to effectively enhance climate change education in schools in the study area. In addition, the direct teaching of the topic of climate change by geography teachers seems to be needed in lower and upper secondary schools in Senegal through relevant methods and strategies helping to enhance students' climate change literacy. However, these findings are dissimilar from that of Falaye and Okwilagwe (2016) who found that geography students in Ibadan, southwestern of Nigeria, significantly achieved high scores in climate change knowledge and practices.

Also, to ascertain how students in the study area understand climate change concepts the following open-ended question was asked to them: *How do you understand climate change?* A few of the surveyed students correctly answered the question, while 58% of students hold misconceptions about climate change processes as illustrated by the following:

Student (HLM Grand Yoff lower secondary school, grade 10) stated:

Climate change is caused by the destruction of the ozone layer which causes a lot of heat.

Another student (Coumba Ndofféne Diouf upper secondary school, grade 13) reported:

I understand climate change in two ways: the rainy season and the dry season.

In addition, there is a considerable number of students who have poor climate change literacy and also some of them ignore climate change concepts by stating the following:

Climate change is when the climate changes. That is to say, if it was hot, it becomes cold or the opposite is how I understand climate change (Student, CEM 4 de Fatick lower secondary school, grade 10).

Another answer showing ignorance about climate change topic:

Climate change is something that cannot be missed in life because it is made by God (Student, Aminata Sow Fall upper secondary school, grade 13).

Furthermore, to establish how students understand the causes of climate change the following open-ended question was asked to them: *What are the main causes of climate change?* A low percentage of students had adequate knowledge about the causes of climate change, while a large part possessed limited knowledge of climate change causes or held misconceptions of climate change processes as shown below:

The main causes of climate change can be water pollution, plastic waste, and smoke from factories and cars. This air pollution destroys the ozone layer and this is what

causes climate change (Student, HLM Grand Yoff lower secondary school, grade 10).

Smoke from factories mixes with the air and destroys the ozone layer leading to global warming (Student, Coumba Ndofféne Diouf upper secondary school, grade 13).

Additionally, a considerable part of the surveyed students has no knowledge or understanding of climate change processes and this can be seen in the following extracts:

The main causes of climate change are heat and cold. If the heat is released, it is hot and if the coolness is released, it is cold (Student, Gadapara lower secondary school, grade 10).

The main causes of climate change are the succession of the rainy season and the dry season (Student, Ndande upper secondary school, grade 13).

Also, to find out how students understand the consequences of climate change, the following open-ended question was asked to them: *What impacts of climate change do you know?* The result revealed that a scant part of students has adequate knowledge and understanding of climate change impacts, while the majority of them had limited knowledge and understanding of climate change consequences on lives and livelihoods of people as shown in the following extracts below:

Student, CEM 4 de Fatick lower secondary school (grade 10) replied:

The major impact of climate change is the air pollution we experience.

Another student (Aminata Sow Fall upper secondary school, grade 13) reported:

> *The impacts of climate change are environmental and economic.*

There is also a considerable number of the surveyed students who have no knowledge or understanding of climate change impacts and this can be seen in the following:

> *The impacts of climate change are the variations of the day which can be high or low variations* (Student, Modou Awa Balla Mbacké lower secondary school, grade 10).

> *The impacts of climate change are deforestation, and overgrazing* (Student, Ndande upper secondary school, grade 13).

Moreover, to establish how students understand the strategies that have been used to tackle climate change issues, the subsequent question was asked to them: *What are the strategies one can use to tackle climate change issues?* A scant number of students have adequate knowledge and understanding of the strategies that have been used to tackle climate change, while a considerable part of students has no knowledge and understanding of climate change solutions as illustrated in the following:

> *Strategies to fight climate change is that we shall stay fit* (Student, CEM 4 de Fatick lower secondary school, grade 10).

> *There are no strategies to fight against climate change because it is a natural phenomenon* (Student, Coumba Ndofféne Diouf upper secondary school, grade 13).

Also, a few of them possessed limited knowledge and understanding of climate change remedies as shown below:

Student, HLM Grand Yoff lower secondary school (grade 10) reported: *Avoid dumping chemicals into the sea.*

Student, Aminata Sow Fall upper secondary school (grade 13) replied: *To fight against climate change, we should limit gas plants.*

Overall, the students in the study area scantly understand the causes, consequences and solutions of climate change. Additionally, this relative low climate change awareness of students was captured during the Focus Group Discussion sessions that were held in all the selected schools for this study. Thus, important efforts are needed so that to enhance climate change literacy of learners in Senegalese secondary schools.

Furthermore, to find out how the students perceive and experience climate change in the study area the following open-ended question was asked to them: *Do you personally think or feel there has been a change in climate?* The results revealed that a large majority of students (88.8%) thought or felt there has been a change in climate, while 11.2% did not think or feel there has been a change in climate. In addition, a considerable number of students who thought or felt there has been a change in climate, claimed that they have experienced temperature increase, rainfall decrease, short or irregular rainy season, recurrent flooding, increasing droughts areas, coastal erosion and increase of weather-related diseases like malaria among others.

To establish students' understanding of issues of climate change, Likert-type questions relating to their perceptions about the realities of climate change were administered to them and the findings are as illustrated in Table 4.13.

Table 4.13. Students' Perceptions about the Realities of Climate Change

Perceptions about the realities of climate change	SA	A	D	SD	CT
Climate change is really happening	46.6	40.9	3.1	2.5	6.9
The climate has changed for the past five years and more	11.3	21.9	16.9	16.9	33.0
Climate change is a result of human activities	39.4	34.7	8.4	5.6	11.9

Note: SA=Strongly Agree, A=Agree, D= Disagree, SD= Strongly Disagree, CT= Cannot tell. All scores are in percentage. N=320.

Table 4.13 shows the perceptions of students about the realities of climate change. From the table, most students expressed their perceptions about the realities of climate change. For instance, 46.6% of the respondents said that they strongly agreed that climate change is really happening and 40.9% agreed that the changing climate is real, while 21.9% agreed that the climate has changed for the past five years and more and 16.9% of them strongly disagreed that the climate has been changing for the past five years and more. In addition, 33.0% of the surveyed students said that they cannot tell that the climate has changed for the past five years and more, implying that they could have limited information about climate change issues due to the scant presence of climate change

content in the geography curriculum at Senegalese secondary school. Also, a considerable number (39.4%) of the students strongly agreed that climate change is a result of human activities and 34.7% agreed that the changing climate is a result of human activities, while 11.9% cannot tell that the changing climate is a result of human activities and also 8.4% disagreed that climate change is a result of human activities. These results indicate that there are students in the study area who seem to be climate sceptics or have no knowledge of climate change science; therefore suggesting teaching the aspects of climate change at Senegalese secondary schools effectively.

Moreover, the majority (82.2%) of surveyed students reported that climate change is something that is affecting or going to affect them through weather borne diseases, increase temperature, increase droughts and flooding, while 17,8% replied that climate change is something that is not affecting or going to affect them. These findings reveal a considerable part of students holds limited or no knowledge of climate change and its future projections as well, thus contributing to students' indifference towards environmental protection.

Also, students' major sources of knowledge about climate change and environmental issues were explored. The results revealed that a considerable part of the students received climate change knowledge from diverse sources with 26.1% received climate change knowledge from school via courses, whilst 17.9% and 17.3% are informed about climate change through media and internet respectively (Table 4.14). The findings also indicated that 12.08% of the students received climate change information from environmental clubs, whilst 12.0% from friends and family. In addition, 7.8% of the students are informed about climate change through publications and academic journals, while 6.2%

through government agencies. These findings imply that school play a primordial role in educating learners about climate change issues and this could be coupled with the use of other relevant sources of climate change information for students in the study area such as media, internet, environmental clubs, friends and family in order to place students as most environmentally literate, equipped with surpassing spatial insights and corresponding skills for the protection of the environment.

Table 4.14. Students' Source of Climatic Change Knowledge

Major sources of climate change knowledge	Frequency	Percent
School via courses	83	26.1
Environmental clubs	42	12.8
Government agencies	20	6.2
Publications/academic journals	24	7.8
Media	58	17.9
Friends/ family	38	12.0
Internet	55	17.3

N=320.

Furthermore, 25.9% of the students reported that academic knowledge has most influenced their state of mind about climate change and environmental issues, while 23.4% and 20.0% said that observations and media respectively have most influenced their state of mind about climate change issues. Also, 15.0% of the surveyed students in the study area indicated that their experiences have most influenced their state of mind about the changing climate, whilst 9.4% and 6.3% reported that their religious beliefs and political affiliation have most influenced their state of mind about climate change issues. This means that academic knowledge, observations, experiences of students in the study

area and the media broadcasting could be considered as important ways in raising awareness and educating the young people on climate change through courses, field trip and group discussion among learners.

Additionally, 57.8% of students in the study area indicated that there is an environmental club in their schools, while 42.2% reported that they have not an environmental club. Among schools having an environmental club, only 19.1% of students affirmed that they are members of their school environmental clubs, thus revealing a lack of engagement and limited interest and attention of students in the study area to climate change issues within their schools and communities, despite 74.7% of them agreed that school environmental clubs are important in promoting climate change education in schools. A scant number of students claimed that there are activities that have been done by their school environmental clubs in the study area such as tree planting, sensitization about environmental issues and eco-citizen practices, school cleaning, organizing forums, debates, and theatres on environmental issues, recycling of plastic waste, and installation of dustbins in schools. However, these mentioned activities appear to be limited or not properly monitored in schools because researcher's observations in all selected schools revealed considerable environmentally unfriendly behaviour and actions, including plastic bags and cups, tissues and other papers in classrooms and schools, and absence of dustbins and trees in schools among others. Therefore, this exhibits the limited content of climate change and other environmental related issues in the secondary geography curriculum and its ineffective teaching and education towards environmental protection. Moreover, the interviewed environmental and information officers from the Ministry of Environment posited that there is limited collaboration between them and the Ministry of National

Education in terms of environmental education and raising awareness about climate change issues in schools, therefore contributing to limited attention of leaners in Senegal towards the protection of their environment. The findings are in agreement with of the results of Thiaré and Cissokho, 2020; Sambou, 2011 and Berthelot, 2008 in which it has been pinpointed that students' environmental protection behaviour and climate actions are scant, thus showing the ineffective and inefficient teaching of the aspects of climate change and other environmental related issues in Senegalese schools.

Table 4.15 indicates students' assimilation of climate change issues. From the table, most students expressed their assimilation of climate change. For instance, 43.0% of the students said that they strongly agreed that the issue of climate change is very important to them, while 39.7% agreed that climate change is very important to them. Also, 38.4% indicated that they are strongly ready to do something or anything to stop climate change, whilst 40.6% are ready to do something or anything to stop climate change. However, 21% of the students reported that they disagreed or cannot tell that they are ready to do something or anything to stop climate change. This indicates that there are students in the study area who seem to have little impetus or apathy towards the environment and also may have no knowledge of climate change. Further, 42.2% of the surveyed students strongly agreed that climate change should be taken serious by Senegalese, while 26.9% agreed that the issues of climate change should be taken serious in Senegal. Nevertheless, 30.9% of the students indicated that climate change should not be taken serious by Senegalese or they cannot tell that the Senegalese should seriously take the issues of climate change in their daily lives. Therefore, this means that the issues of climate change in Senegal appear to be less important for some students in the study area compared to the

others daily issues such as unemployment and poverty among others. Thus, intensification of climate change education beyond the most common causes and effects is highly recommended among the learners in order to create actors who are well equipped and engaged in protecting the environment.

Table 4.15. Students' Assimilation of Climate Change Issues

Assimilation of climate change	SA	A	D	SD	CT
The issue of climate change is very important to me	43.0	39.7	8.8	2.2	6.3
I am ready to do something or anything to stop climate change	38.4	40.6	5.6	5.1	10.3
I think climate change should not be taken serious by Senegalese	5.9	7.2	26.9	42.2	17.8

Note: SA=Strongly Agree, A=Agree, D= Disagree, SD= Strongly Disagree, CT= Cannot tell. All scores are in percentage. N=320.

In addition, 37.2% of the students indicated that individuals should be responsible to protect the environment, while 27.2% reported that national government should be the one responsible to protect the environment. Also, 17.2% said that the international organisations should be responsible to protect the environment, while 11.3% indicated that businesses and industries should be the one responsible to protect the environment. These results imply that the issues of climate change should be combated by everybody, including national governments, individuals, international organisations, businesses,

industries, civil society, non- governmental organisations (NGOs) and religious bodies so that the environment will be protected and sustained for humans and the natural systems. Furthermore, during the Focus Group Discussion sessions that were held in each selected school in the study area, the surveyed students exhibited scant knowledge and understanding of climate change causes, impacts, and mitigation and adaptation strategies.

In sum, the students in the study area have limited understanding of climate change science. These findings corroborate with that of Gautam et al. (2021) who revealed that half of the secondary level students have inadequate level of awareness of climate change in Biratnagar, Nepal. However, the results are dissimilar from that of Onuoha et al. (2021) in which it has been shown that the students in Ibadan, southwestern of Nigeria had significant level of climate change knowledge. Therefore, this relative low awareness of climate change concepts of students could have a negative implication for the attainment of the sustainable development goals (SGDs) in the country for the long term.

Moreover, to establish whether there exists a no significant relationship between climate change content in the geography curriculum and climate change awareness of students, a Chi-square test was performed and the results of the test are presented in Table 4.16.

Table 4.16. Chi-square test for Students' Awareness of Climate Change

Test	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	49.503	56	0.718
Likelihood Ratio	59.391	56	0.353

The findings established that the Chi-square value is greater than the significant value. That is 49.503>0.718 (N=320) as shown in Table 4.16. Thus, this shows that there is no

significant relationship between climate change content in the geography curriculum and students' awareness of climate change. This means that the current secondary geography curriculum does not significantly address climate change and consequently a limitation attention is given to climate change science in the curriculum, implying that majority of the students in the study area seem to acquire knowledge of climate change from other secondary school subjects, internet and media among others. In addition, this lack of explicit presence of climate change in the geography curriculum could lead to apathy of learners towards climate change issues and environmental protection. The results of the study are in accordance with the findings of Kariuki (2017) in which it has been reported that there was no significant relationship between implementation of the secondary school curriculum and climate change awareness by students in Kenya. Thus, it is essential to effectively integrate relevant climate change content in the geography curriculum at Senegalese secondary schools so as to help learners to be well prepared in combating climate change at local, national and global scale. The subsequent section discussed the comparison of climate change awareness between students in grade 10 and those in grade 13 so that to determine who better understand the concepts of climate change.

4.4.2 Climate Change Awareness Comparison among Students

Preliminary analyses of the data revealed that 75 students in grade 10 had less than 50% as climate change awareness score, while 61 students in grade 13 scored less than 50% on the climate change awareness index. This indicates that students in grade 13 are likely more aware of climate change concepts (highest score= 88.23%) than their counterparts in grade 10. Further, the mean awareness score (52.91%) concerning students in grade 10 is relatively lower than the one of their counterparts in grade 13 which was 55.87%.

Additionally, analysis using independent sample t-test statistics indicates the mean climate change awareness score obtained by the students in grade 10 is statistically and significantly different than the one scored by their counterparts in grade 13, as shown in Table 4.17. Therefore, from the table, the p-value (sig. (2-tailed)) which is 0.036 is less than 0.05 (5%), meaning that the means awareness of climate change of these two groups (students in grade 10 and students in grade 13) are significantly and statistically different.

Table 4.17. Mean Climate Change Awareness Scores of Students

Variable	Category	N	Mean	t	df	Sig. (2-tailed)
Awareness score	Students in grade 10	160	52.91	2.356	318	0.036**
	Students in grade 13	160	55.87	2.106		

***p* significant at <0.05; N=320

These findings report that students in grade 10 are statistically and significantly less aware of climate change concepts than their counterparts in grade 13 in the study area. This could be due to the fact that students in grade 13 are more exposed to climate change information sources and also might have more attention towards climate change issues than their counterparts in grade 10 although, the geography curriculum for the upper secondary school does not explicitly address climate change science. As a consequence, this relative low climate change awareness of students in the study area could increase misconceptions and apathy towards climate change issues in schools and communities as well. The results are similar to that of Ronald et al. (2017) who revealed low climate change awareness in Uganda secondary schools. However, these findings are dissimilar from that of Onuoha et al. (2021) who reported moderate or high climate change

awareness of students in Nigeria. Therefore, it is essential to effectively and efficiently teach climate change science to young people who will bear the brunt of the impacts of this changing climate.

Also, it is important to assess the influence of demographic and geographical variables on students' climate change awareness. Student's age, gender and academy inspection were included for identification and classification of surveyed students. These variables turned out to have an influence on climate change awareness with female students, students who are between 21 and 30 years old and students in Pikine-Guédiawaye Academy Inspection having statistically and significantly higher mean climate change awareness scores than their counterparts in the study area (Table 4.18). This slight high climate change awareness level for female students in the study area could be explained by the fact that females have broader interactions with the environment through water harvesting, firewood gathering and agricultural activities among others than male students, thus contributing in enhancing their climate change awareness. The result of this study is similar to that of Pandve and Raut (2011) who showed that female students had higher awareness than male students. However, the findings are not in line with the results of Eze (2019) in which female students had less climate change awareness scores that male students in Nigeria. Therefore, students' level of climate change awareness could be influenced by their relationship with the environment. It is essential to pay particular attention to increasing students' awareness of climate change in Senegalese secondary schools, especially male students, so that they can benefit from the goals of climate change education in their schools and communities.

Moreover, students in Pikine-Guédiawaye Academy Inspection had the highest (61.31%) climate change awareness score than students in the other selected Academy Inspections. This could be due to the important sources of climate change information that students in Pikine-Guédiawaye Academy Inspection are exposed to, thus this might contribute to give them more attention towards climate change issues. The findings are in accordance with the results of Owolabi et al. (2012) who recorded that school location could be a factor influencing knowledge of climate change science. It is important that students are in continuous exposure to climate change education through their local environment so as to help them to have an adequate understanding of climate change at hand, therefore leading to take actions to protect the environment. Further, students who aged between 21 and 30 years old exhibit slight climate change awareness score (55.37%) than their counterparts who are below 21 years old. This result could be explained by the fact that students who aged between 21 and 30 years old likely have capitalised on climate change knowledge throughout their schooling compared to their junior colleagues who might have limited knowledge and experiences about climate change issues. The result of this study is at variance with the findings of Owolabi et al. (2012), indicating younger students (below 15 years) are more aware of climate change than older students but their results were not statistically significant. Thus, age is a critical predictor of individual's familiarity with climate change issues (Ochieng, 2014). It is crucial to improve students' awareness of climate change in Senegalese secondary schools so as to increase climate literacy and pro-environmental behaviour of leaners.

Table 4.18. Results of the Influence of Demographic and Geographical Variables Tested on Students' Climate Change Awareness

Variable	Category	N	Mean Awareness Score (%)	df	Sig.	Remarks
Gender	Male	143	50.60	318	0.005***	Female>Male
	Female	177	56.02			
Age	Below 21	290	54.86	2	0.062*	Between 21 and 30> Below 21
	Between 21 and 30	30	55.37			
Student Grade Level	Grade 10	160	52.91	2	0.002***	Grade 13> Grade 10
	Grade 13	160	55.87			
Academy Inspection	Fatick	40	50.86	7	0.001***	Pikine-Guediawaye > other Academy Inspections
	Kolda	40	53.77			
	Kédougou	40	52.66			
	Matam	40	58.60			
	Saint Louis	40	56.94			
	Louga	40	54.03			
	Pikine-Guediawaye	40	61.31			
	Dakar	40	51.85			

*Significance level at 10%; **Significance level at 5%; ***Significance level at 1%.

Overall, it is essential to take into account demographic and geographical characteristics of students in designing and implementing school climate change education curricula in order to effectively train and educate young people on climate change and its associated issues. In the following section, the multinomial logistic regression model (MLM) helping to identify the likelihood of students being grouped into one of the three predetermined categories of climate change awareness is addressed.

4.4.3 Parameter Estimates of the Multinomial Logistic Model of Climate Change Awareness Group of Students

Initially, students' climate change awareness is categorized into three levels based on percentage scores – Low awareness (0–50%); Moderate awareness (51–74%) and High awareness (75% and above). Thus, there are 48.76% of students that are being categorized under Moderate awareness group, 8.12% under High awareness group, while 43.12% being categorized as possessing Low climate change awareness. This categorization of the level of awareness is to enhance further analyses of the data through the use of the multinomial logistic regression model (MLM). The MLM was adopted to identify the likelihood of students' membership of the groups of climate change awareness ("Low awareness," "Moderate awareness" and "High awareness"). The results of the MLM Model are illustrated in Table 4.19.

The multinomial logistic regression indicated the best fitness of the model at 5% significant level (Model Fitting Likelihood Ratio: X^2=45.359, p= 0.021<0.05). The model had adjusted a Pseudo R- Square of 0.697 (Nagelkerke), meaning that about 69.7% of the variation in students' membership in the three predetermined categories of climate change awareness is appropriately predicted by the explanatory variables as shown in Table 4.19. Furthermore, the Pearson (79.323) and the Deviance (71.926) statistics test, p=0.163>0.05, show that the test is not statistically significant; therefore the model is fit. In addition, for the predictions of the model, the performance indicates an overall rate of correct classification of 87.49%.

Table 4.19. Parameter Estimates of the Multinomial Logit Model of Awareness Group Membership of Students

	Moderate Awareness Group			High Awareness Group		
Variable	Coefficient	Odds Ratio-Exp(B)	*p*	Coefficient	Odds Ratio-Exp(B)	*p*
Gender	0.830	1.023	0.000***	2.061	3.112	0.236
Age	0.689	1.403	0.000***	-1.862	4.604	0.736
StuGradlevel	1.352	2.614	0.354	-2.167	2.846	0.001***
AcdemyInspect	-2.168	1.665	1.000	0.679	1.866	0.000***
MemberofEClu	1.291	3.842	0.208	1.141	3.738	0.000***

Reference category: Low Awareness Group

Model Fitting Likelihood Ratio: X^2= 45.359**
Goodness-of-fit: 79.323 (Pearson); 71.926 (Deviance)
Overall Classification percentage: 87.49%

*** indicates statistically significant values at 1%.

All explanatory variables tested – student's gender, age, student grade level, academy inspection and environmental club membership had positive effects on the dependent variable (climate change awareness score) as illustrated by positive odds ratio findings in all tested variables. Therefore, this means there is an increasing probability of students being categorized under Moderate awareness group and High awareness of climate change based on their gender, age, grade level, environmental club membership and academy inspection than being classified under Low awareness of climate change. While gender and age of students significantly increased the probability of students being categorized as possessing moderate climate change awareness score, academy inspection, environmental club membership and student grade level occurred as significant variables in categorizing students into high awareness group. The results of this study are at variance with the findings of Adejoke et al. (2014) and Falaye and Okwilagwe (2016) who suggested that

there is no significant difference in students' awareness and attitudes towards climate change on the basis of gender.

Nevertheless, the findings are in line with that of Onuoha et al. (2021) and Owolabi et al. (2012) who opined that gender, location, age, class, sources of information on climate change and subject status of students as determinants of their climate change awareness level. Thus, these influencing factors to students' climate change awareness should be taken into account for effective climate change education in schools. Related content that directly applies to the achievement of pro-environmental behaviour of students should be infused across the secondary school geography curriculum, thus enhancing students' climate change literacy for the protection of the environment. Despite the variations of awareness scores of students based on tested variables exist; a relative majority (56.88%) of students possessed a mean climate change awareness score of equal to or high than 51%. This means that a slight majority of students tested had at least a moderate level of climate change awareness, irrespective of their age, gender, grade level, environmental club membership and academy inspection.

Furthermore, gender of student was statistically significant at 1% and this means that male students are more likely to be placed among the moderate awareness group than the low awareness category, while female students are more likely to be categorized into high awareness group. Additionally, female students in the study area seem to have broader interactions with their environment, thus helping them to be more aware of climate change than their male counterparts. This result is in agreement with that of Ochieng (2014) in which it has been reported that female teachers recorded a higher climate change awareness score than male teachers in Kenya. This calls for an increased interest towards

dissemination of climate change information among the male gender to improve climate change literacy in schools.

Also, age was statistically significant at 1%, indicating that the young students are more likely to be categorized under the moderate awareness group than the low awareness category. Further, the middle-aged students seem to be in the moderate or high awareness groups, especially, the students who are between 21 and 30 years old with the highest score (55.37%) of climate change awareness. Thus, it is essential to continue sharing climate change knowledge with all students in relatable terms and with local examples so as to likely close up knowledge gaps and reduce information-deficiency about climate change issues, therefore leading to improve students' climate literacy. The findings of this study are dissimilar from that of Onuoha et al. (2021) who found student age did not statistically and significantly influence climate change awareness.

Further, student grade level was statistically significant at 1%, showing that students in grade 13 are more likely to be placed among the high awareness group than the low awareness category. This indicates that students in grade 10 in the study area are more likely to be in the low awareness group due to probably their limited exposure to climate change information. Adejoke et al. (2014) and Diop (2019) similarly suggested statistically significant environmental awareness and attitude scores among students of different grades. It is crucial to develop appropriate methods and materials in order to improve climate change awareness of students in all grade levels in Senegalese secondary schools.

Member of school environmental club was statistically significant at 1%, meaning that students who are members of environmental clubs in their schools are more likely to be categorized under high awareness group than the low awareness category. Thus, in order to improve students' climate literacy and help them to acquire skills and pro-environmental behaviour, it is important for students to be actively engaged in their school environmental clubs. Also, the findings of the research revealed that students who are members of school environmental clubs showed a better understanding of climate change issues, hence possessing high or moderate climate change awareness scores than their counterparts who are not involved in any school environmental club or climate actions. Indeed, students who are members of school environmental clubs are exposed to in-depth discussion of topic about climate change and other environmental related issues which could improve their climate literacy. Akrofi et al. (2019) dissimilarly argued that the relationship between climate and environment-related student clubs in some African universities and their awareness and knowledge of climate change was not statistically significant. Therefore, it is essential that various climate and environment-related student clubs tailor their activities in the direction of awareness and implementation of climate change adaptation and mitigation initiatives in schools and communities for the protection of the environment.

In addition, Academy Inspection was statistically significant at 1%, suggesting that the location (Academy Inspection) of the school seems to influence students to be categorized in the high awareness group than the low awareness groups. In this research, it has been recorded that students in Pikine-Guediawaye Academy Inspection are more aware of climate change with the highest mean awareness score (61.31%) than their counterparts in

the other selected Academy Inspections. This explains that students in Pikine-Guediawaye Academy Inspection seem to be more exposed to climate change information or have more experiences about climate change issues within their environment than their counterparts in the other Academy Inspections. This result is not in agreement with the findings of Eze (2019) which reported that there is no statistically significant difference in mean scores of both awareness of climate change and willingness to engage in pro-environmental behaviour of students in Nigeria based on their location. Thus, climate change education for Senegalese secondary schools should incorporate into the school curricula the relevant climate change issues and environmental related problems that have locally and nationally been experienced by the populations so as to efficiently and effectively enhance climate literacy and pro-environmental behaviour of learners.

It is essential that factors influencing students' climate change awareness in the study area should be considered in capacity building or professional development programmes on climate change and other environmental related problems so that to achieve a strong climate change literacy, which is expected to lead to climate actions in schools. Thus, relevant methods and materials for climate change education in Senegalese secondary schools are needed in order to effectively improve students' climate literacy and their actions towards environmental protection. In the subsequent section, factors influencing the effectiveness of teaching climate change concepts in the secondary education geography curriculum are addressed.

4.5 Factors Influencing the Effectiveness of Teaching Climate Change Concepts in the Secondary Education Geography Curriculum

The logistic regression model showed the best fitness of the model at 1% significant level (LR chi2 (5) = 54.77; Prob > chi2 = 0.0000). The model had adjusted R^2 of 0.7112, signifying that about 71.12% of the variation in the effectiveness of teaching about climate change science in the study area is appropriately predicted by the explanatory variables (Table 4.20).

Table 4.20. Results of Logistic Regression Model on Factors Influencing the Effectiveness of Teaching about Climate Change Science at Secondary Schools

Number of obs = 101

LR chi2 (5) = 54.77

Prob > chi2 = 0.0000

Pseudo R^2 = 0.7112

Log likelihood = -38.40153

[95% C.I]

Variable	**Odds Ratio**	**Std. error**	**z**	***p*-value**
Frequency	15.33762	10.10574	4.14	0.000***
Knowledge	6.15369	6.643119	1.68	0.092*
Experience	7.068904	4.642172	2.98	0.003***
Resources	6.01107	6.099714	1.24	0.087*
Geocurriculu	6.121466	4.64444	2.39	0.017**
_cons	0.0176175	0.0193873	3.67	0.000

*Significance level at 10%; **Significance level at 5%; ***Significance level at 1%.

Post estimation of logistic regression model

On the predictions of the model, the performance shows overall rate of correct classification of 81.19% with 89.23% specificity and 66.67% sensitivity as illustrated in Table (4.21).

Table 4.21. Classification Table and Summary Statistics

	True	
Classified	D	
	~D	Total
+	24	31
-	7	
Total	12	
	58	70
Classified + if predicted Pr (D) >= 0.5		
True D defined as Effective != 0		
Sensitivity	Pr (+| D)	66.67%
Specificity	Pr (-|~D)	89.23%
Positive predictive value	Pr (D| +)	77.42%
Negative predictive value	Pr (~D| -)	82.86%
False + rate for true ~D	Pr (+|~D)	10.77%
False - rate for true D	Pr (-| D)	33.33%
False + rate for classified +	Pr (~D| +)	22.58%
False - rate for classified -	Pr (D| -)	17.14%
Correctly classified		
81.19%		

Additionally, the Homsmer-Lemeshow test is used for the goodness fit of the model. This test is an important parameter test that assumes that there is no difference between the observed and the predicted result. Thus, Homsmer-Lemeshow test of the model (Prob > chi2 = 0.7860) failed to reject the null hypothesis. This explains that the expected and

observed cell frequencies are generally in good agreement and the model in question is a good fit.

Further, for the model to make 100% correct predictions, it would make about 10% wrong predictions as shown by the Receiver Operating Characteristics (ROC) curve (Figure 4.2).

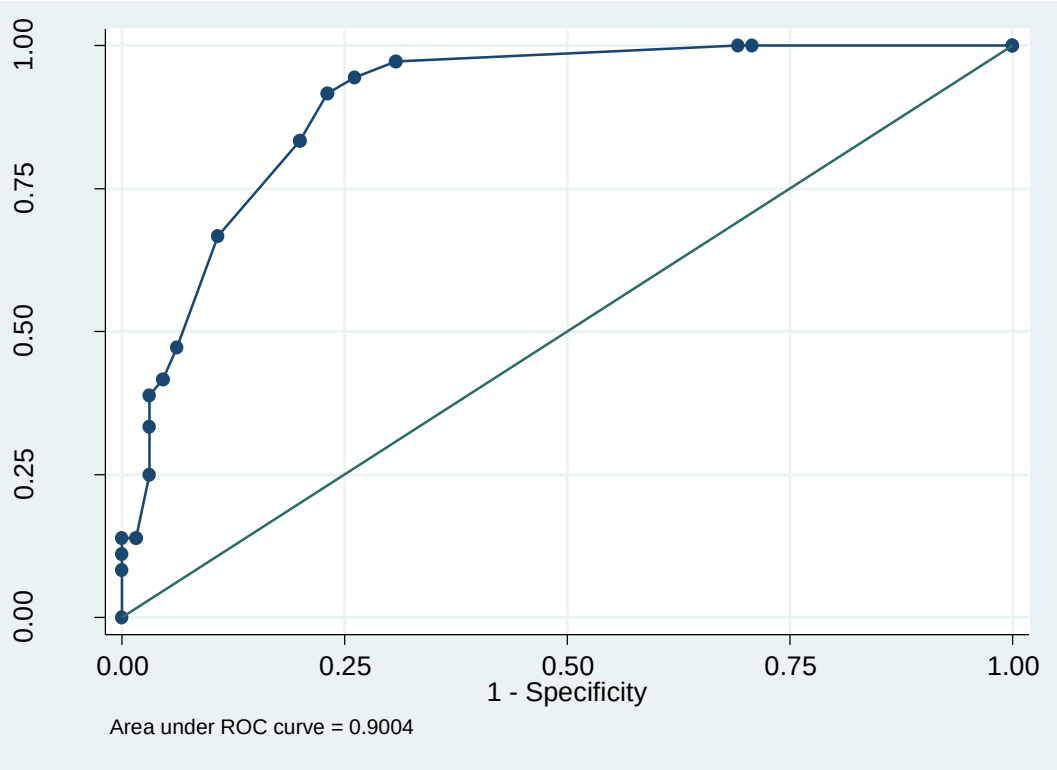

Figure 4.2. Receiver Operating Characteristics (ROC) Curve

Moreover, an excellent predictive power was obtained as illustrated by the area under the curve which is 0.9004 as shown in Figure 4.2. This predictive power is coupled with the optimum cutoff probability of about 0.48 (48%) which separates geography teachers considering teaching of climate change science as effective versus geography teachers considering climate change teaching as ineffective (Figure 4.3). These results indicate that

the effectiveness of climate change teaching is correctly predicted by the independent variables in the model.

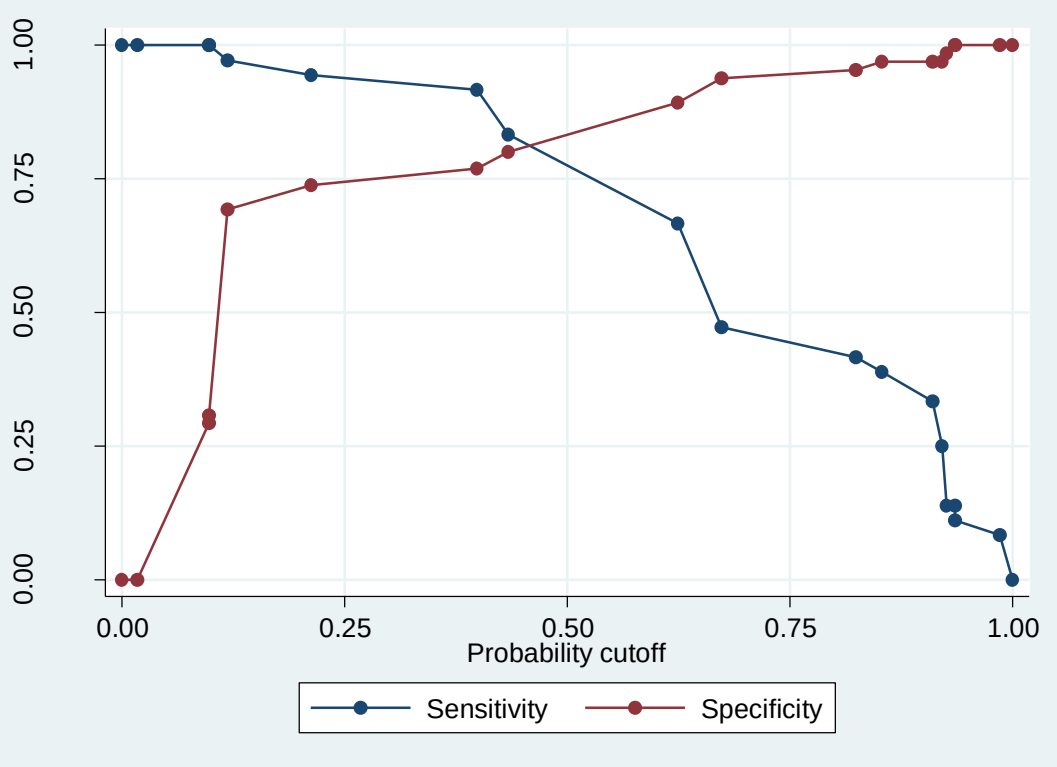

Figure 4.3. Probability Cut-off Graph

As expected, the findings from the logistic regression model reveal that frequency of teaching about climate change, teacher's experience about climate change issues were significant factors at 1% significant level, whilst comprehensive geography curriculum for teaching about climate change concepts was significant factor at 5%. Also, knowledge about climate change, and teaching and learning climate change resources were significant at 10%. Thus, all the tested independent variables were significant in influencing the effectiveness of teaching of the aspects of climate change in the study area (Table 4.20).

Frequency of teaching about climate change was statistically significant at 1% and positively influenced the effectiveness of climate change teaching at school. This indicates that as the frequency of teaching about climate change at school increases, both the teacher and students are more likely to be highly climate change literate, therefore leading to increase their interest to protect the environment. This result is in line with findings (Ennes et al., 2021; Wise, 2010) which asserted that adequate and frequent teaching about climate change at school help to building climate literacy among current and future generations. Further, frequency of teaching about climate change variable in the model has an odd ratio of 15.33762, meaning that frequent teaching about climate change at a given level is 15.33762 times more likely to increase the effectiveness of the teaching than absence of or limited teaching about climate change topic at school. This follows the hypothesis of the study which stated that the frequency of teaching about climate change is positively expected to influence the effectiveness of climate change teaching in schools. Therefore, organisation of capacity building or professional development programmes on climate change for in-service teachers and appropriate teacher training for pre-service teachers could help to effectively improve climate change literacy at school.

Teacher's experience about climate change issues was statistically significant at 1% and positively influenced the effectiveness of climate change teaching at school. This indicates that the more a teacher is experienced in climate change issues, the more likely he or she can explain the concepts underlying the causes, impacts and solutions of climate change as accurately as possible to students. This follows the a-priori expectation which shows that teacher's experience positively influence the effectiveness of teaching about climate change. This result is in agreement with previous findings (Onuoha et al., 2021; Shealy et

al., 2021; Siegner, 2018) in which it has been expressed that well-equipped teachers in climate change issues positively influence learners' understanding of climate change concepts.

Comprehensive geography curriculum for teaching about climate change was statistically significant at 5% and positively influenced the teaching of climate change concepts. This shows that more the secondary geography curriculum is comprehensive towards climate change education, more likely the teaching about climate change at school tends to be effective. Also, an odd ratio of 6.121466 was shown in the model for the comprehensive geography curriculum variable, explaining that relevant and comprehensive content of climate change in the geography curriculum at a given level is 6.121466 times more likely to facilitate effective teaching about climate change than absence of or limited climate change content in the geography curriculum. The findings are consistent with the results of Ronald et al. (2017); Anyanwu (2015) and Crayne (2015) in which it has been pinpointed that comprehensive content of climate change in the secondary geography curriculum incites discussions on climate change within the classroom, thus increasing climate literacy at school. This follows the hypothesis of the research which stated that comprehensive geography curriculum towards climate change education at secondary school is positively expected to influence the effectiveness of the teaching about climate change science.

Knowledge of climate change is positive and significantly (at 10% level) related to the effectiveness of climate change teaching at school. This means that with increasing of teacher's knowledge of climate change, the probability of an effective teaching about climate change concepts at school increases. In addition, knowledge of climate change

variable has an odd ratio of 6.15369, implying that teacher's knowledge of climate change at a given level is 6.15369 times more likely to increase climate change literacy of students than teacher who has no knowledge or limited knowledge of climate change. The result is similar to that of Vukelić et al. (2022); Seroussi et al. (2019) and Miléř et al. (2012) who suggested that teacher's knowledge of climate change could enhance climate change education in schools.

Teaching and learning climate change resources had a positive influence on the effectiveness of climate change teaching in schools and was statistically significant at 10%. This implies the probability of an effective teaching about climate change is greater for school where teaching and learning climate change resources are available compared to school with no climate change teaching and learning materials. The findings are in line with results (Kariuki, 2017; Vujovic, 2013; Wise, 2010) which affirmed that the success of climate change education is largely dependent on the resources through which learners acquire knowledge of climate change, namely textbooks and teachers.

In addition, senior inspectors of geography and senior geography curriculum designers interviewed in this research asserted that the teaching about climate change concepts at Senegalese secondary schools can be considered as ineffective due to the hindering factors such as limited climate change content in the secondary geography curriculum, absence of climate change teaching and learning materials, limited knowledge about climate change science of teachers in the lower and upper secondary schools. This can be illustrated in the extracts below from the interviews in this study:

Climate change concepts are not captured well in the secondary geography curriculum and it seems that some teachers in the secondary schools do not understand well the concepts of climate change (Senior inspector of geography in Saint Louis Academy Inspection).

*I think that climate change science should be explicitly integrated into all curricula at secondary school so that learners understand it adequately. Really, the current lower and upper secondary school geography programme has limits regarding the teaching and learning of the aspects of climate change (*Senior geography curriculum designer in the Ministry of National Education).

Thus, these impeding factors towards effective climate change teaching at school need to be taken into consideration in the designing and the implementation of climate change education programmes in Senegal.

4.6 Problems encountered in the Field

The approach of this research has some limitations. Indeed, considering issues pertaining to time, coverage and resource limitations, it was not possible to perform an exhaustive study on the understanding and teaching of climate change concepts in the secondary education geography curriculum for the whole of Senegalese lower and upper secondary schools. Also, some information bias could result from the translation since all the participants' responses were written in French and translated into English language by the researcher for the purpose of the data analysis.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The dissertation dealt with studying understanding and teaching climate change concepts in geography curriculum at secondary schools in Senegal. The chapter summarizes the major findings of the study based on the research objectives; research questions, theory, and reviewed literature. Further, it attempts to integrate and synthesize the major findings, and then provides conclusion, recommendations and contribution to knowledge, and also proposes issues requiring further studies.

5.1 Summary

The main goal of the study was to investigate into the teachers' and learners' understanding of climate change concepts in the secondary education from the geography curriculum in Senegal. The objectives of the research are clearly stated in Chapter 1 of the dissertation. Thus, the first objective was to assess the concepts of climate change captured in the geography curriculum in Senegal secondary education. In the second objective, geography teachers' understanding and interpretation of climate change concepts was determined. The third objective was to examine students' understanding and knowledge of climate change concepts. In the last objective, the factors that influence the effectiveness of teaching climate change concepts in secondary geography education in Senegal were identified.

The reviewed literature on climatic change concepts, climate change education, teachers' and students' understanding of climate change was done in order to achieve the stated objectives of the research. It focused on the concept of climate change and climate variability, climate change education, understanding of climate change concepts, including knowledge, awareness, risk perceptions, beliefs, engagement, and responses about climate change, and teaching and learning methods in climate change, curriculum concept and the importance of geography education in understanding climate change. Then the study analysed in depth the identified barriers in teaching climate change science in school curriculum, content of climate change education, the relevance of pedagogic content knowledge in climate change education and educational policies on climate change as well. Additionally, literature was reviewed on the theoretical framework of the research which comprises the Activity Theory by Engeström in 1987. The literature was finally reviewed on the empirical models employed in the research.

The descriptive design was adopted and all students in grade 10 and 13, geography teachers, principals and headmasters in each selected schools were the study population for this research. Through purposive and simple random sampling procedures three hundred and twenty (320) students, one hundred and one (101) geography teachers were selected from sixteen (16) secondary schools in eight (8) Academy Inspections for this research. Moreover, purposive sampling was used to select three (3) senior inspectors of geography and three (3) senior geography curriculum designers from the Ministry of National Education, and also three (3) environmental and information officers from the Ministry of Environment and Sustainable Development.

The key instruments of the study consisted questionnaires, thematic area content analysis template and interview guides; and the questionnaires were first pilot tested in order to establish their reliability and validity before their use for data collection for this research. To analyse the data the statistical packages SPSS version 23 and STATA 14 were used for the study. Results of the study were presented in a form of both inferential and descriptive statistics such as percentages, standard deviations, means, awareness index, and summations, minimum, maximum and Chi-square and independent sample t-tests. Additionally, figures, charts and tables were used to summarize the findings of the study. A logistic regression model and multinomial logistic regression model were also employed for the study.

5.2 Major Findings

The major findings for the study included:

1. For the first objective, 57% of climate change content was relatively addressed in the secondary geography curriculum. Thus, the current Senegal's secondary school geography curriculum is inadequate for effective climate change education in schools as ascertained in the Chi-square test result (0.626 > 0.429) and reported by surveyed geography teachers, geography curriculum designers, senior inspectors of geography, and principals and headmasters interviewed for this study. Indeed, the current geography curriculum for the lower secondary school in Senegal possessed only 37.5% of the identified crucial climate change content as per the thematic template, while 81.2% of the identified relevant climate change content as per the thematic template was not covered in the geography curriculum for the upper secondary school in Senegal.

2. On the second objective, the average climate change awareness index for geography teachers was 0.6455 (64.55%). Also, the Chi-square test (83.651>0.552) revealed that there is no significant relationship between climate change content in the geography curriculum and climate change awareness of geography teachers in the study area. Further, geography teachers at lower secondary school are statistically and significantly more aware of climate change and climate change education than their counterparts at the upper secondary school, as shown in the independent sample t-test (0.031<0.05) result. In addition, while gender, age and geography teacher qualification significantly increased the probability of teachers being categorized as possessing moderate climate change awareness, academy inspection, geography teacher class, teaching experiences and environmental club membership occurred as significant variables in categorizing teachers into high awareness group, as illustrated in the multinomial logistic regression model (MLM) findings. Therefore, factors influencing geography teachers' climate change awareness in the study area should be taken into account in capacity building or professional development programmes on climate change and related environment problems for teachers in order to achieve a strong climate change literacy, which is expected to lead to climate actions in schools and communities as well.

3. The third objective was to examine students' understanding and knowledge of climate change concepts. The average climate change awareness index for students was 0.5343 (53.43%), indicating that students in the study area are scantly aware of climate change concepts. Further, the Chi-square test (49.503>0.718) established that there is no significant relationship between climate change content in the geography curriculum and students' awareness of climate change. Moreover, the independent sample t-test

(0.036<0.05) suggested that students in grade 10 are statistically and significantly less aware of climate change concepts than their counterparts in grade 13. Also, the multinomial logistic regression model (MLM) results revealed that gender and age of students significantly increased the probability of students being categorized as possessing low climate change awareness score, while academy inspection, environmental club membership and student grade level occurred as significant variables in categorizing students into high awareness group. Thus, these influencing factors to students' climate change awareness should be taken into account for effective climate change education in schools.

4. A logistic regression model was estimated in order to identify the factors that influence the effectiveness of teaching climate change concepts in secondary geography education in Senegal. From the binary logistic model in Chapter 4 empirical results revealed that frequency of teaching about climate change, teacher's experience about climate change issues, comprehensive geography curriculum for teaching about climate change concepts, knowledge about climate change, and teaching and learning climate change resources were factors that significantly and positively influence the effectiveness of teaching climate change concepts in the study area. Additionally, senior inspectors of geography and senior geography curriculum designers interviewed in this study asserted that teaching about climate change concepts at Senegalese secondary schools can be considered as ineffective due to the hindering factors such as limited climate change content in the secondary geography curriculum, absence of climate change teaching and learning materials, limited knowledge about climate change science of teachers in the lower and upper secondary schools.

5.3 Conclusion

Climate change has been designated as one of the persisting challenges that Senegal faces at the moment. Climate change content was relatively covered (57%) in the geography curriculum at Senegalese secondary schools and seems to be inadequate for effective climate change education in schools. Globally, climate change concepts were scantly addressed in the current geography curriculum regarding the lower and upper secondary schools in Senegal. Teaching the aspects of climate change in schools is considered as means of empowering students for meaningful contributions toward the attainment of the sustainable development goals (SGDs) in the long term.

Geography teachers in the study area are relatively aware of climate change with 64.55% as their average climate change awareness index. Also, geography teachers at lower secondary schools are statistically and significantly more aware of climate change and climate change education than their counterparts at the upper secondary schools. While students had average climate change awareness index of 53.43%, thus indicating a relative low climate change awareness of students in the study area where students in grade 10 are statistically and significantly less aware of climate change concepts than their counterparts in grade 13. Therefore, climate change awareness ought to be adequately present to stimulate appropriate adaptation and mitigation measures. Further, the study pinpointed that a considerable number of geography teachers and their students in the study area held misleading information on the causes of climate change and misconceptions about the consequences of climate change as well as climate change adaptation and mitigation strategies.

Additionally, there exists a no significant relationship between climate change content in the geography curriculum and climate change education awareness among geography teachers and their students as revealed in the Chi-square test analysis.

Independent variables tested such as gender, age and geography teacher qualification significantly increased the probability of teachers being categorized as possessing moderate climate change awareness, while academy inspection, geography teacher class, teaching experiences and environmental club membership occurred as significant variables in categorizing teachers into high awareness group. For students, the explanatory variables tested – gender and age of students significantly increased the probability of students being categorized as possessing low climate change awareness score, whilst academy inspection, environmental club membership and student grade level occurred as significant variables in categorizing students into high climate change awareness group. It is essential that factors influencing geography teachers' and students' climate change awareness in the study area should be considered in capacity building or professional development programmes on climate change and related environment issues so that to achieve a strong climate change literacy, which is expected to lead to climate actions in schools and communities.

The logistic regression model indicates that frequency of teaching about climate change, teacher's experience about climate change issues, comprehensive geography curriculum for teaching about climate change concepts, knowledge about climate change, and teaching and learning climate change resources were significant factors in influencing the effectiveness of teaching climate change concepts in the study area. Therefore, these impeding factors towards effective climate change education at school need to be

essentially considered in the implementation of climate change education programmes and projects in Senegalese schools.

5.4 Recommendations

The recommendations included here are presented as suggestions on how initiatives on climate change education at lower and upper secondary schools in Senegal could be more effective and efficient. Recommendations also emphasize the various stakeholders involved in climate change education in Senegalese secondary schools and how the country should organize their role to increase the effectiveness and efficiency of climate change education in schools and communities.

The study recommends that climate change content should be explicitly included in the geography curriculum for the lower and upper Senegalese secondary schools so as to effectively increase teachers' and learners' climate change literacy. Thus, it is recommended that the current geography curriculum should be reviewed and outcomes pertaining to climate change education be integrated into all the geography topics from junior to senior secondary level and across all grades.

Further, Government should provide adequate teaching and learning materials about the aspects of climate change in order to help teachers to properly deliver their courses related to climate change within the secondary geography education, in particular, and the other secondary school subjects in general. In addition, the General Inspection of Education together with the National Curriculum Commissions should organize workshops for all subjects in the country on climate change education, thus enabling subject panels to develop their teaching materials which will fully address climate change science.

The research also recommends that more efforts should be made towards teacher training and professional development programmes on climate change education in order to make in-service and pre-service geography teachers in Senegalese secondary schools fully literate about climate change science, so that they can explain the concepts underlying the causes, impacts and solutions of climate change as accurately as possible to students.

Furthermore, it is recommended that geography teachers should be encouraged to seek partnerships with their colleagues in the science field in their schools in order to gain greater insight into pure science-related climate change concepts, therefore leading to the ultimate quality of climate change education in Senegal.

It is also recommended that the positive factors affecting the effectiveness of teaching climate change concepts such as frequency of teaching about climate change, teacher's experience about climate change issues, comprehensive geography curriculum for teaching about climate change concepts, knowledge about climate change, and teaching and learning resources about climate change science, need essentially to be taken into consideration in the designing and implementation of climate change education programmes for the Senegalese secondary schools.

Also, the research recommends that it is essential to consider the academic background and social characteristics of geography teachers – gender of the teacher, age, location (academy inspection), teacher's qualifications, and teaching experience for the designing and implementing of school climate change education programmes so that this pressing environmental issue will be well understood by teachers and properly delivered in schools.

Furthermore, it is recommended that student's age, location (academy inspection) and gender need to be considerably taken into account in the implementation of climate change education projects and programmes for the secondary schools in Senegal.

In the study area, school plays a primordial role in educating learners about climate change issues, thus the research recommends that this could be coupled with the use of other relevant sources of climate change knowledge for students such as media, internet, environmental clubs, friends, family, government agencies and publications/academic journals in order to place students as most environmentally literate, equipped with surpassing spatial insights and corresponding skills for the protection of the environment. Upper and lower secondary schools in the country should establish environmental peer educators among the learners so as to promote awareness of climate change among students.

Also, it is recommended that the skills-based approach method commonly used by teachers in the lower and upper secondary schools could be combined with the use of pictures, videos, field trips, and discussion on climate change issues at local, national and global level in order to enhance climate change literacy of learners effectively.

Moreover, the study recommends that establishment of environmental clubs in all Senegalese secondary schools and full engagement and active participation of teachers, headmasters, principals and students of all grade levels so as to promoting climate change education, therefore inciting pro-environmental activities in schools and communities.

Further, it is recommended that climate change education should be infused into school subjects' curricula and at all levels of formal education in Senegal as suggested by senior

geography curriculum designers, senior inspectors of geography, principals and headmasters interviewed in this study so that to engage everybody in environmentally-friendly behavior in conserving the environment for increased safety and beauty in the long term.

Additionally, non-government organisations together with other educators should design climate change education projects which can be implemented at community level in order to reach all members of the society for the benefit of the country.

Overall, recommendations and implications of this research for the Ministry of National Education, policy makers, stakeholders and communities are discussed subsequently.

5.4.1 Recommendation to the Department of Education

The National Commission of Geography and History together with the General Inspection of Education in the Ministry of National Education in conjunction with non-government organisations should develop education and awareness materials on climate change and sustainable development for schools and the public as well. This will enable the establishment of a mechanism for information sharing and networking focusing on the role of Government and non-government organisations in climate change education and awareness programmes, thus creating opportunities for the youth to learn more about climate change science.

The Government of Senegal through the Ministry of National Education should embark on an empowerment exercise to equip all citizens of the country about climate change and environmental education. In other words, it should be the priority of the Senegalese Government to provide training on climate change and other environmental related issues

for teachers, learners, environmental representatives and members of the public in the entire country.

5.4.2 Recommendations to Policy Developers

The government ministries should integrate climate change education into all sectorial policies and strategies, such as Education Policy, Environment Policy, Agriculture Policy, and Energy Policy among others, therefore providing opportunities for training on climate change and environmental education for media and other professionals involved in combatting climate change issues.

Policy makers should empower community leaders, mentors and educators to share their knowledge, experience and values with different target audiences about climate change education so as to ensure comprehensive climate change education is integrated into the school curriculum.

All policy makers in Senegal should be sensitized about the importance of addressing climate change education in schools and communities.

5.4.3 Recommendation to Stakeholders

The research recommends that the Government of Senegal, together with non-government actors, should collectively strive in promoting public awareness on climate change and environmental education. Further, the media, including television, print and radio should be pioneers in staging events and campaigns geared to promote climate change and environmental education. Also, the Ministry of National Education and the Ministry of Environment, Sustainable Development and Ecological Transition have

valuable responsibility in leading all stakeholders for climate change and environmental education initiatives.

Furthermore, stakeholders (government agencies, community groups, private sector, youth and non-governmental organisations) involvement in decision making regarding climate change education, training and awareness at national and district level should be considerably promoted. Additionally, media officers should be trained and educated regarding how to develop interesting and locally-relevant stories about climate change and environmental education.

5.4.4 Recommendations to Communities

The Ministry of National Education, Ministry of Environment, Sustainable Development and Ecological Transition and non-governmental organisations should be encouraged to carry out projects and programmes about climate change in all the communities in Senegal. Therefore, it is recommended that teaching about climate change should aim at providing all community members with the appropriate decision making skills and problem-solving, inducing positive environmental attitudes, helping everyone in the community understand climate change science effectively and efficiently.

5.5 Contribution to Knowledge

Based on the findings and the conclusions drawn from this research, the following contribution to knowledge is presented:

1. The inclusion of teacher qualification, geography teacher class, teaching experience, student's and teacher's environmental club membership in testing

the influencing factors of climate change awareness level is a core contribution of this study to the body of knowledge.

2. Establishing the determinant factors influencing the effectiveness of climate change teaching at secondary schools is also a contribution to the literature on climate change education.
3. The scope of this research provides a relevant overview about understanding and teaching of the aspects of climate change at Senegalese secondary schools. This could be considered as essential contribution to the documentation about understanding and teaching climate change at Senegalese schools, and is expected to guide further work in this field, intensifying the dialogue on how to better educate students about climate change and its associated problems.

5.6 Suggestions for Further Studies

From the study it is suggested that further research to be conducted including:

1. This research investigated eight (8) Academy Inspections only. A wider sample that includes teachers, students, headmasters and principals from the other eight (8) Academy Inspections within Senegal would provide a richer understanding of teachers and learners about climate change aspects in the secondary education from the geography curriculum and the variations over different geographical regions.

2. It is essential to conduct a comparative research of understanding and teaching about climate change concepts in different geographical regions which are

considered in the geography curriculum at secondary schools in order to provide more robust and comprehensive understanding of climate change in Senegalese schools.

3. Also, research is needed to explore how professional development and training programmes may best be placed to help teachers in developing a solid understanding of climate change and climate change education and how to best engage and support teachers in thinking about this pressing environmental issue.

4. The following direction for future research is needed to understand the extent to which teachers' misconceptions and limited knowledge about climate change are included in their teaching practice and how these effect learner's knowledge and engagement towards environmental protection.

5. Further, study might investigate the sub group of geography teachers who had never heard of climate change education and also the sub group of students who had never heard of climate change before or do not remember their encounter with the construct so as to provide insightful findings about the implications of climate change on lives and livelihoods of the populations of Senegal.

Finally, more research is needed to deeply explore the contributions of all subjects' curricula to climate change literacy in Senegalese secondary schools and the tertiary level as well so that to acquire valuable bases for future curricula changes within the sustainable development goals pathway.

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Appendices

Appendix 1

Geography Curriculum (Lower Secondary School)

General objectives

The teaching of geography aims to help students understand the environment in which they live, in order to be able to integrate into it and transform it as needed. It ultimately aims to develop the ability of the student to "know how to think about space" as said by Yves Lacoste. This objective is at the same time an objective of knowing (knowledge), of expertise (aptitude), of know-how and know-how to become (attitude and state of mind).

I. General objectives of the first level (class of grade 6 - class of grade 5)

1- Knowledge objectives:

At the end of the first level of lower secondary education, the learner must:

- know the basic language of geography;
- know specific notions of geography from the study of its "close environment";
- apply the notions acquired in broader contexts ranging from the local scale to national and regional scales.

2- Know-how objectives:

The student should know:

- to observe;
- to represent the observed phenomena;
- to compare the phenomena of a given space to other different spaces;
- to discriminate between geographical realities (physical, human, economic, etc.).

3- Skills objectives:

The student must:

- know how to show critical thinking and judgment in order to be able to relativize the geographical dimensions of phenomena and spaces;
- know how to anticipate (foresee) the evolution of phenomena and geographical areas;
- have a sense of proportion in their dealings with their environment;
- be aware of the precariousness of the spatial balance.

II. General objectives of the second level (class of grade 4 - class of grade 3)

1- Knowledge objectives:

At the end of the second level of lower secondary education, the learner must:

- know specific notions of geography from the study of his or her continent and other regional spaces of the world;

- get to know other spaces, other geographical environments.

2- Know-how objectives:

The student should know:

- to analyze the components of a geographical space (search for components, characteristics, interactions, causality...);

-to compare modes of representation of geographical reality (designing and interpret a map, a graph, a topographic section, a statistical table, etc.);

-to manipulate geographical knowledge tools (know how to read a photograph aerial, knowing how to read a slide, knowing how to handle a tutorial, knowing how to manage a database, knowing how to use measuring instruments such as the thermometer, the barometer, etc.).

3- Skills objectives:

The student must:

- know how to relativize the potentialities of the environment (compared to the needs of the populations, relative to other environments);

- know how to show imagination for an optimal and rational use of community resources;

- become aware of the complementarity and solidarity between spaces and environments different;

- know how to show respect and tolerance towards other environments, other spaces.

Geography Curriculum (Upper Secondary School)

General objectives

1. Knowledge objectives:
   At the end of upper secondary education, the student must:
   - know the processes of geographical knowledge in their outline: method inductive, hypothetico-deductive method;
   - master the main products of these processes (fundamental concepts, key notions, basic qualitative and quantitative data);
   - know the geographical phenomena at different scales (general, zonal, regional and local) and their main articulations.
2. Cognitive know-how objectives
   At the end of the second cycle, the student must:
   - know how to build a geographical reasoning by induction and/or deduction on the programme content database;
   - apply geographical principles, laws and theories to various phenomena;
   - analyze knowledge or a geographical situation to highlight all the various components ;
   - know how to look for connections between phenomena and situations;
   - know how to establish correlations;
   - know how to draw summaries;
   - know how to relativize geographical realities by placing them in their contexts general, zonal, regional and local;
   -know how to hold a geographical "discourse" using the appropriate language (concepts, notions, data, etc. relevant to contexts and things).
3. Practical know-how objectives
   At the end of secondary education, the student must:
   - know how to observe reality or its representation;
   - know how to describe reality or its representation;
   - know how to derive (from these representations and descriptions) relevant hypotheses;
   - know how to concretize their analysis with diagrams, sketches, graphs, etc.;
   - know how to draw graphic and cartographic summaries, etc.
4. Objectives of know-how and know-how to become
   At the end of secondary education, the student must:
   - have a sense of space and its balance;
   - have a critical sense and relativity of judgment in relation to environments and geographical phenomena;
   - know how to become a future agent of development;
   - be aware of planetary interdependence in terms of Sustainable development;
   -know how to relativize geographical knowledge to open up to other disciplinary knowledge
   - become aware of the scientific totality.

Appendix 2

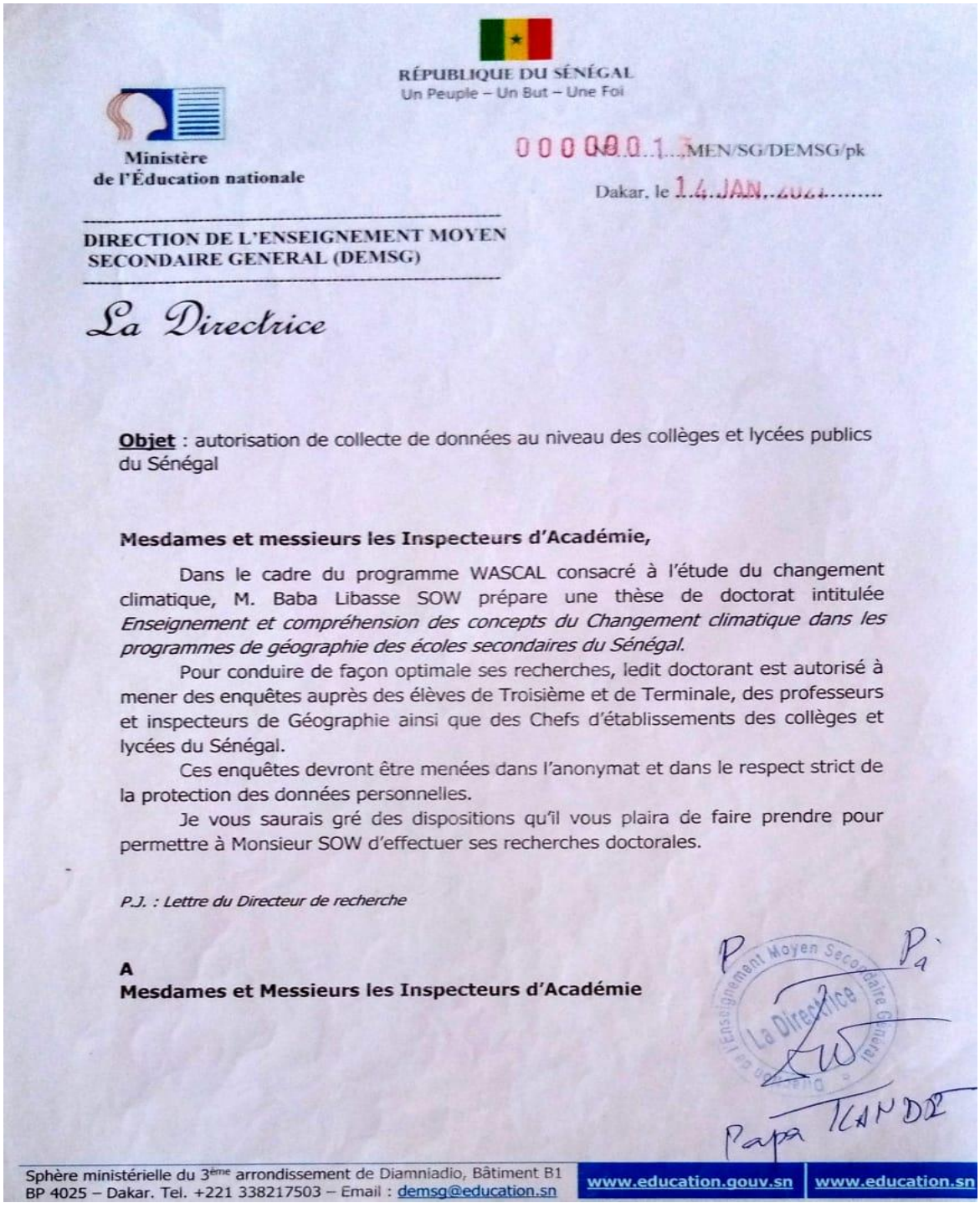
Thematic Areas Content Analysis Template

Subject…….	**FEATURED**	
THEMATIC AREA	**YES**	**NO**
Scientific Concepts and Processes		
Climate change		
Climate variability		
Global warming		
Greenhouse gases (GHGs)		
Greenhouse effect (GHE)		
TOTAL SCORE (5)		
Causes of Climate Change		
Widespread use of land		
Large scale deforestation		
Increased fossil fuel use		
Increased livestock farming		
Natural causes		
TOTAL SCORE (5)		
Certainties, Uncertainties and Projections		
Is climate change a myth?		
Is it a reality?		
What are the future projections?		
TOTAL SCORE (3)		
Consequences/Impacts		
Extreme weather events		
Depletion of natural resources		
Increased rural-urban migration		
Depletion of household assets		
Increased pests and diseases		
TOTAL SCORE (5)		

Adaptation and Mitigation Measures		
Reduce energy consumption		
Use of renewable forms of energy		
Design and use greener technologies		
Changes in consumption patterns		
Mitigate bio-diversity loss		
Drought resistant farming		
Introduction of new technologies		
TOTAL SCORE (7)		
Interests that Shape Responses to Climate Change		
Business interests		
Consumer interests		
Farmer's interests		
Political interests		
Future generations' interests		
TOTAL SCORE (5)		
Time-space Dynamics		
Delayed consequences of GHEs		
Security & development options in future		
TOTAL SCORE(2)		

Appendix 3

Research Authorization from the Ministry of National Education



RÉPUBLIQUE DU SÉNÉGAL
Un Peuple – Un But – Une Foi

Ministère
de l'Éducation nationale

0000001 MEN/SG/DEMSG/pk

Dakar, le 14 JAN 2021

DIRECTION DE L'ENSEIGNEMENT MOYEN SECONDAIRE GENERAL (DEMSG)

La Directrice

Objet : autorisation de collecte de données au niveau des collèges et lycées publics du Sénégal

Mesdames et messieurs les Inspecteurs d'Académie,

Dans le cadre du programme WASCAL consacré à l'étude du changement climatique, M. Baba Libasse SOW prépare une thèse de doctorat intitulée *Enseignement et compréhension des concepts du Changement climatique dans les programmes de géographie des écoles secondaires du Sénégal.*

Pour conduire de façon optimale ses recherches, ledit doctorant est autorisé à mener des enquêtes auprès des élèves de Troisième et de Terminale, des professeurs et inspecteurs de Géographie ainsi que des Chefs d'établissements des collèges et lycées du Sénégal.

Ces enquêtes devront être menées dans l'anonymat et dans le respect strict de la protection des données personnelles.

Je vous saurais gré des dispositions qu'il vous plaira de faire prendre pour permettre à Monsieur SOW d'effectuer ses recherches doctorales.

P.J. : Lettre du Directeur de recherche

A
Mesdames et Messieurs les Inspecteurs d'Académie

Papa IANDE

Sphère ministérielle du 3ème arrondissement de Diamniadio, Bâtiment B1
BP 4025 – Dakar. Tel. +221 338217503 – Email : demsg@education.sn
www.education.gouv.sn | www.education.sn

Research Authorization from the Academy Inspections (Saint-Louis Academy Inspection)

REPUBLIQUE DU SENEGAL
Un Peuple – Un But – Une Foi

Ministère
de l'Éducation nationale

Inspection d'Académie de Saint-Louis

N°001032 IASL/SG/SEPA/oc
Saint-Louis, le 14 JUIN 2021

L'Inspectrice d'Académie,

Objet : Autorisation de collecte de données au niveau du Lycée Cheikh Oumar Foutiyou Tall (IEF Saint-Louis Commune).

Madame Le Proviseur,

Dans la cadre du programme WASCAL consacré à l'étude du changement climatique, Monsieur Baba Libasse SOW prépare une thèse de doctorat intitulée : « *Enseignement et compréhension des concepts du changement climatique dans les programmes de Géographie des écoles secondaires du Sénégal* ».

Pour conduire de façon optimale ses recherches, ledit doctorant est autorisé à mener des enquêtes auprès des élèves de Terminale, des professeurs et inspecteurs de Géographie ainsi que du chef de l'établissement.

Ces enquêtes devront être menées dans l'anonymat et dans le respect strict de la protection des données personnelles.

Je vous saurais gré de prendre toutes les dispositions utiles et nécessaires afin de lui permettre de mener à bien ses recherches.

A

Madame le Proviseur du Lycée Cheikh Oumar Foutiyou Tall (IEF SLC).

L'Inspectrice d'Académie

INSPECTION D'ACADEMIE DE SAINT-LOUIS – L'INSPECTEUR D'ACADEMIE

Adama Diagne SY

Appendix 4

RESEARCH TOPIC:

Understanding and Teaching Climate Change Concepts in Geography Curriculum at Secondary Schools in Senegal

QUESTIONNAIRE (for Geography Teachers)

Good morning, my name is Baba Libasse SOW. I'm a PhD student with the University of The Gambia under WASCAL scholarship programme. I'm conducting a research on this topic *"Understanding and Teaching Climate Change Concepts in Geography Curriculum at Secondary Schools in Senegal"*. Please help me by answering a few questions on this topic. Your answers will help us understand what learners already know about climate change education, as well as what kind of information they would like to learn and how they would like to learn about it. You do not have to answer these questions if you don't want to. You can also stop answering at any time. If you decide to stop, no one will be angry or upset with you. There is no right or wrong answer. You should not write your name down; I just want to get your thoughts. The information you provide will be used for the purpose of this research only and all information acquired from you will remain confidential. Please provide us with information as honestly, accurately and completely as you can. Thank you for your time and participation.

Region/School:	
Questionnaire #:	
Respondent code :	

INSTRUCTIONS:

- Tick marks in space provided for closed-ended questions and write your response on the space provided for open ended questions.
- This survey is an individual questionnaire to be addressed to each Geography teacher sampled.

Part A: Personal Information

Gender: Male [ ] Female [ ]

Age:

a) [ ] 18-25
b) [ ] 26-30
c) [ ] 31-35
d) [ ] 36-40
e) [ ] 41-45
f) [ ] Above 45

Qualification:

a) [ ] Master + CAES
b) [ ] Bachelor + CAEM
c) [ ] Baccalauréat + CAE-CEM
d) [ ] Other, specify……

Geography teacher:

A. [ ] At Lower Secondary School
B. [ ] At Upper Secondary School

Part B: Curriculum Information

1. As a Geography teacher are you aware of climate change education?
   A. [ ] Yes
   B. [ ] No
2. How do you understand climate change?

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3. Please indicate the extent to which you agree or disagree with the following.
   Note: SA=Strongly Agree, A=Agree, D= Disagree, SD= Strongly Disagree, CT= Cannot tell

Perceptions about the realities of climate change	**SA**	**A**	**D**	**SD**	**CT**
Climate change is really happening					
The climate has changed for the past five years and more					
Climate change is as a result of human activities					

4. Which themes in the curriculum do you think cover climate change issues?

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5. How many minutes do you have for teaching Geography per class per week?
   A. [ ] 120 minutes
   B. [ ] 160 minutes
   C. [ ] 200 minutes
   D. [ ] 240 minutes
   E. [ ] 280 minutes

6. The time you have for teaching Geography, is it enough to enable to cover the Syllabus and emphasis on climate change issues.
   A. [ ] Yes
   B. [ ] No

7. What are your views on teaching matters related to climate change within the school geography curriculum?

	Very confident in teaching CCE	Fairly confident in teaching CCE	Not confident in teaching CCE
Lower Secondary level			
Upper Secondary level			

8. How much do you know and understand Climate Change Education as a Geography teacher?

Teaching experience in years	1. Study of CCE formed no part of the course at University	2.Study of CCE formed a small part of the course at University	3. Study of CCE formed a large part of the course at University
Less than 5 years			
6-10 years			
11-15 years			
Above 16 years			

9. How much do you sometimes use of fieldwork in the teaching and learning of Geography?

	Used in every theme	Rarely used in teaching	Not used at all
Lower Secondary level			
Upper Secondary level			

10. Do you think the use of practical approaches to the teaching and learning of geography has a role in enhancing CCE?

	1. using practical approaches does help to enhance CCE	2. using practical approaches does not help to enhance CCE
Lower Secondary level		
Upper Secondary level		

11. Please indicate the extent to which you agree or disagree with the following sentence: School Environmental Clubs are the most important in Promoting Climate Change Education.

Note: SA=Strongly Agree, A=Agree, D= Disagree, SD= Strongly Disagree, CT= Cannot tell

SA	**A**	**D**	**SD**	**CT**

12. Does the school have an environmental club?

A. [ ] Yes
B. [ ] No

13. Are you a member of the club?

A. [ ] Yes
B. [ ] No

14. Could you list the major activities of the School Environmental Club?

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15. Do you think Climate Change science should be taught as a separate subject?

A. [ ] Yes
B. [ ] No

16. In your lessons, do you integrate climate change science?

A. [ ] Yes
B. [ ] No

17. Which scientific teaching methods do you normally use in your Geography lessons?

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18. What are your teaching resources being used in Geography?

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19. The books you use in Geography do they address climate change science?

A. [ ] Yes
B. [ ] No

20. Do you think the Geography curriculum at secondary education is comprehensive to help learners understand climate change?

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End of the questionnaire

Thank you very much for your time and participation

RESEARCH TOPIC:

Understanding and Teaching Climate Change Concepts in Geography Curriculum at Secondary Schools in Senegal

QUESTIONNAIRE (For Students)

Good morning, my name is Baba Libasse SOW. I'm a PhD student with the University of The Gambia under WASCAL scholarship programme. I'm conducting a research on this topic *"Understanding and Teaching Climate Change Concepts in Geography Curriculum at Secondary Schools in Senegal"*. Please help me by answering a few questions on this topic. Your answers will help us understand what learners already know about climate change education, as well as what kind of information they would like to learn and how they would like to learn about it. You do not have to answer these questions if you don't want to. You can also stop answering at any time. If you decide to stop, no one will be angry or upset with you. There is no right or wrong answer. You should not write your name down; I just want to get your thoughts. The information you provide will be used for the purpose of this research only and all information acquired from you will remain confidential. Please provide us with information as honestly, accurately and completely as you can. Thank you for your time and participation.

Region/School:	
Questionnaire #:	
Respondent code :	

INSTRUCTIONS:

- Tick marks in space provided for closed-ended questions and write your response on the space provided for open ended questions.
- This survey is an individual questionnaire to be addressed to each sampled student at grade 10 or 13.

SECTION A: Demographic Data

1. Gender: Male [ ] Female [ ]
2. Age:
   a) [ ] Below 21
   b) [ ] 21-30
   c) [ ] Above
3. Level:
   [ ] Grade 10
   [ ] Grade 13

SECTION B: Understanding and Knowledge about Climate Change Science

4. Have you ever heard of climate change?

   a) [ ] Yes
   b) [ ] No
   c) [ ] Don't remember

5. How do you understand climate change?

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6. What are the main causes of climate change?

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7. How those causes mentioned in 6 above do contribute to climate change?

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8. What impacts of climate change do you know?

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9. What are the strategies one can use to tackle climate change issues?

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SECTION C: Perception and Experiences of Climate Change

10. Do you personally think or feel there has been a change in climate?

    A. [ ] Yes
    B. [ ] No

11. Please give reason(s) to your response in question 10 above? Give example if possible.

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12. Please indicate the extent to which you agree or disagree with the following.
    Note: SA=Strongly Agree, A=Agree, D= Disagree, SD= Strongly Disagree, CT= Cannot tell

Perceptions about the realities of climate change	**SA**	**A**	**D**	**SD**	**CT**
Climate change is really happening					
The climate has changed for the past five years and more					
Climate change is as a result of human activities					

13. Do you think climate change is something that is affecting or going to affect you?

    A. [ ] Yes
    B. [ ] No

14. Give reason(s) to your answer in question 13.

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15. Please indicate the extent at which you agree or disagree with the following.
Note: SA=Strongly Agree, A=Agree, D= Disagree, SD= Strongly Disagree, CT= Cannot tell

Assimilation of climate change	**SA**	**A**	**D**	**SD**	**CT**
The issue of climate change is very important to me					
I am ready to do something or anything to stop climate change.					
I think climate change should not be taken serious by Senegalese					

SECTION D: Students' Actions towards Environmental Protection

16. What have you been doing or intends to do to help protect the environment?

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17. Please give reason(s) for your response in question 16 above

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18. Who should be responsible to protect the environment? Please rank them in order of importance. (please tick only one)

    a) [ ] Religious bodies
    b) [ ] Businesses/Industries
    c) [ ] Individuals
    d) [ ] Non-Governmental Organisations (NGOs)
    e) [ ] National Government
    f) [ ] International Organisations
    g) [ ] Others (please specify)……

19. Please indicate how much you agree or disagree with the following statements.

Personal Actions	True	False	Cannot Tell
I have been conserving energy and water due to climate change			
I like walking or cycling because of climate change			

20. Please indicate the extent to which you agree or disagree with the following sentence: School Environmental Clubs are the most important in Promoting Climate Change Education.
    Note: SA=Strongly Agree, A=Agree, D= Disagree, SD= Strongly Disagree, CT= Cannot tell

SA	**A**	**D**	**SD**	**CT**

21. Does the school have an environmental club?
    A. [ ] Yes
    B. [ ] No

22. Are you a member of the club?

    A. [ ] Yes

B. [ ] No

23. Could you list the major activities of the School Environmental Club?

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24. What have been the major sources of your knowledge about climate change and environmental issues?

a) [ ] School via courses
b) [ ] Environmental clubs
c) [ ] Government agencies
d) [ ] Publications/academic journals
e) [ ] Media
f) [ ] Friends/ family
g) [ ] Internet
h) [ ] Other (please specify)

25. Would you be prepared to change your behaviour to reduce your contribution to climate change and protect the environment in any of the following ways? Please tick the choice that most closely reflects your opinion.

a) [ ] Use public transport
b) [ ] Buy food with less packaging
c) [ ] Protect animals and plants as much as possible
d) [ ] Switch off lights
e) [ ] Turn appliances off at the plug when not in use
f) [ ] Use more environmentally friendly chemical products
g) [ ] Use water sparingly
h) [ ] Recycle as much as possible
i) [ ] Reuse bottles and containers
j) [ ] Replace broken appliances with more energy-efficient ones

26. How significant are the impacts of climate change and environmental issues in your district or region?

Impacts of Climate Change and Environmental Issues	**Large Positive Impacts**	**Mild Positive Impacts**	**Not Positive or Negative**	**Mild Negative Impacts**	**Great Negative Impacts**	**Don't Know**
a. Mean temperature rises						
b. Increase windiness						

c. Increase in severity of extreme weather events						
d. Increase in total precipitation						
e. Increases in large floods						
f. Increase in Drought periods						
g. Shorter Growing season						
h. Atmospheric, Soil and Water Pollutions						

27. Which of these has most influenced your state of mind about climate change and environmental issues? (Please tick only one)
    a) [ ] Media
    b) [ ] Religious believes
    c) [ ] Observations
    d) [ ] Experiences
    e) [ ] Political affiliation
    f) [ ] Academic Knowledge
    g) [ ] Any other (please specify)…….

28. Why protecting the environment is important to you and others as well?
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End of the questionnaire

Thank you very much for your time and participation

RESEARCH TOPIC:

Understanding and Teaching Climate Change Concepts in Geography Curriculum at Secondary Schools in Senegal

FOCUS GROUP DISCUSSION GUIDE (For Students)

Good morning, my name is Baba Libasse SOW. I'm a PhD student with the University of The Gambia under WASCAL scholarship programme. I'm conducting a research on this topic *"Understanding and Teaching Climate Change Concepts in Geography Curriculum at Secondary Schools in Senegal"*. Please help me by answering a few questions on this topic. Your answers will help us understand what learners already know about climate change education, as well as what kind of information they would like to learn and how they would like to learn about it. You do not have to answer these questions if you don't want to. You can also stop answering at any time. If you decide to stop, no one will be angry or upset with you. There is no right or wrong answer. You should not write your name down; I just want to get your thoughts. The information you provide will be used for the purpose of this research only and all information acquired from you will remain confidential. Please provide us with information as honestly, accurately and completely as you can. Thank you for your time and participation.

Group details:

Number of students:

Date:

Time:

Focus Group Questions

1. What do you understand about the concept of climate change?
   Can you tell me more about this concept?
2. What comes into your mind when you hear the word global warming?
3. Do you think Senegal is experiencing climate change?
4. Can you give an example of a cause of climate change?
5. How will climate change affect the livelihoods of Senegalese?
6. What is your understanding of climate change education?
7. As learners, which topics do you think are more relevant to climate change education?
8. As students in this school do you have an environmental club? If yes, what are major activities of the club?

9. With the understanding and knowledge, you gain in Geography about the importance of climate change education, do you participate and share information with members of you family, community among others?

10. What are the major environmental problems faced by your community?

11. What strategies can you apply in attempt to minimize these problems?

End of the Focus Group Discussion

Thank you very much for your time and participation

RESEARCH TOPIC:

Understanding and Teaching Climate Change Concepts in Geography Curriculum at Secondary Schools in Senegal

INTERVIEW GUIDE (Senior Inspector of Geography)

Good morning, my name is Baba Libasse SOW. I'm a PhD student with the University of The Gambia under WASCAL scholarship programme. I'm conducting a research on this topic *"Understanding and Teaching Climate Change Concepts in Geography Curriculum at Secondary Schools in Senegal"*. Please help me by answering a few questions on this topic. Your answers will help us understand what learners already know about climate change education, as well as what kind of information they would like to learn and how they would like to learn about it. The information you provide will be used for the purpose of this research only and all information acquired from you will remain confidential. Please provide us with information as honestly, accurately and completely as you can. Thank you for your time and participation.

Region:	
Respondent code:	

Date:

Name of institution:

Position held in the institution:

Main responsibilities of the officer:

Supportive information

1. How long have you been Inspector of Geography?
2. How do you understand climate change education?
3. Does the Geography Syllabus address climate change education across the themes at grade 10 and 13?
4. Which specific themes cover climate change education in Geography?
5. Are the Geography teachers at secondary schools in the country compelled by the syllabus to integrate climate change education in their teaching?
6. Considering the number of topics that geography teachers are expected to teach, do you think climate change education should be offered as a separate subject or integrated into the existing Geography syllabus?

7. With climate change education as the main concern for reorienting curriculum in the world, do you have any plans to restructure the current Geography syllabus to integrate climate change education?

8. Are the prescribed geography textbooks at secondary schools address climate change education?

9. Have you ever had a workshop for Geography teachers at secondary schools on climate change education?

10. What aspect (content) of climate change do you train the Geography teachers on and why?

11. How often do you carry out these training programme/activities?

12. In your opinion do you think your training efforts are helping Geography teachers to understand better the science of climate change and deliver it to the learners effectively (Please explain with evidence and examples).

13. Do you consider climate change education as an important concept that should always be incorporated in Geography lessons?

14. If yes, why?

15. What are the challenges that you face in helping Geography teachers and learners to understand better climate change concepts?

16. Please, do you have anything to say?

End of the interview

Thank you very much for your time and participation

RESEARCH TOPIC:

Understanding and Teaching Climate Change Concepts in Geography Curriculum at Secondary Schools in Senegal

INTERVIEW GUIDE (Geography Curriculum Designer)

Good morning, my name is Baba Libasse SOW. I'm a PhD student with the University of The Gambia under WASCAL scholarship programme. I'm conducting a research on this topic *"Understanding and Teaching Climate Change Concepts in Geography Curriculum at Secondary Schools in Senegal"*. Please help me by answering a few questions on this topic. Your answers will help us understand what learners already know about climate change education, as well as what kind of information they would like to learn and how they would like to learn about it. The information you provide will be used for the purpose of this research only and all information acquired from you will remain confidential. Please provide us with information as honestly, accurately and completely as you can. Thank you for your time and participation.

Date:

Name of institution:

Position held in the institution:

Main responsibilities of the officer:

Supportive information

1. How long have you been Geography Curriculum Designer?

2. How do you understand climate change education?

3. Does the Geography curriculum address climate change education across the themes at grade 10 and 13?

4. Which specific themes cover climate change education in Geography curriculum at secondary schools?

5. Are the Geography teachers at secondary schools in the country compelled by the syllabus to integrate climate change education in their teaching?

6. Considering the number of topics that geography teachers are expected to teach, do you think climate change education should be offered as a separate subject or integrated into the existing Geography syllabus?

7. With climate change education as the main concern for reorienting curriculum in the world, do you have any plans to restructure the current Geography syllabus to integrate climate change education?

8. Are the prescribed geography textbooks at secondary school address climate change education?

9. Have you ever had a workshop for Geography teachers at secondary schools on climate change education?

10. What aspect (content) of climate change do you consider in integrating climate change education in the secondary Geography curriculum and why?

11. In your opinion do you think your efforts are helping Geography teachers to understand better the science of climate change and deliver it to the learners effectively
(Please explain with evidence and examples).

12. Do you consider climate change education as an important concept that should always be incorporated in Geography lessons?

13. If yes, why?

14. What are the challenges that you face in designing the Geography curriculum which could hinder a better understanding about climate change concepts of teachers and learners?

15. What are the future plans does your institution have to ensure that every young has some form of climate change education?

16. Which subject do you think is ideal for the implementation of climate change education in the country?

17. Please, do you have anything to say?

End of the interview

Thank you very much for your time and participation

RESEARCH TOPIC:

Understanding and Teaching Climate Change Concepts in Geography Curriculum at Secondary Schools in Senegal

INTERVIEW GUIDE (Environmental Information Officer)

Good morning, my name is Baba Libasse SOW. I'm a PhD student with the University of The Gambia under WASCAL scholarship programme. I'm conducting a research on this topic *"Understanding and Teaching Climate Change Concepts in Geography Curriculum at Secondary Schools in Senegal"*. Please help me by answering a few questions on this topic. Your answers will help us understand what learners already know about climate change education, as well as what kind of information they would like to learn and how they would like to learn about it. The information you provide will be used for the purpose of this research only and all information acquired from you will remain confidential. Please provide us with information as honestly, accurately and completely as you can. Thank you for your time and participation.

Date:

Name of institution:

Position held in the institution:

Main responsibilities of the officer:

Supportive information

1. How long have you been Environmental Information Officer?
2. How do you understand climate change education?
3. Your institution is responsible for the formulation of environmental policies, of which sustainable development is one of the major issues that need to be observed by all sectors, do you have any policy on climate change education?
4. If yes, who are the major stakeholders in formulation of the climate change education policy?
5. What are the objectives of your institution?
6. What is the major role of the institution in the implementation of climate change education in the country?
7. Are you able to reach out to schools for environmental activities?
8. If yes, what are the major activities you do in the schools?
9. How best can schools integrate climate change education in their curriculum?

10. What are the strategies that the institution has put in place to ensure that climate change education is integrated into the school curriculum and future plans of the institution to ensure that every learner has an effective understanding of climate change science?

11. What is your source of climate change information?

12. Have you ever had a meeting or workshop with teachers in schools in attempt to sensitize them about the importance of integrating climate change education as a means to minimize environmental problems?

13. What aspect (content) of climate change do you emphasize in climate change education activities and why?

14. How often do you carry out these training programme/activities?

15. In your opinion do you think your training efforts are helping the schools to understand better the science of climate change effectively? (Please explain with evidence and examples).

16. What are the challenges that you face in educating, training people about climate change concepts and environmental issues?

17. Please, do you have anything to say?

End of the interview

Thank you very much for your time and participation