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Climate Change Literacy among Postgraduate Students of Addis Ababa University, Ethiopia

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Abstract

The primary objective of environmental education is believed to be developing environmental literacy. The environmentally literate person is described as a person who possesses the values, attitudes and skills that enable knowledge to be converted into action. This study was aimed at assessing the level of climate change literacy among graduate students in four programmes at Addis Ababa University, Ethiopia. To this end, a questionnaire was developed and administered to a total of 91 students. An attempt was made to include all the major conceptual and geographical aspects of climate change literacy. Results indicate that the students who participated in the study demonstrated a 'just above average' performance on the whole, but clearly poor performance in some of the key areas related to the science behind climate change, past trends in rainfall and temperature and the impact of climate change on Africa. It is particularly worrisome that many of the students had inadequate or no information about the projected or actual impacts of climate change on poor countries, including those in Africa. Students' awareness about some of the key measures proposed at the global level is also inadequate. It is therefore strongly recommended that follow-up studies be conducted to see the effects of such factors on programme syllabi, teaching approaches used, key sources of information, etc., and on students' climate change literacy.

Background

The Intergovernmental Panel on Climate Change (IPCC) defines climate change as a 'change in the state of the climate that can be identified … by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer' (IPCC, 2007:30). It is also noted that climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. Recent assessment reports of the IPCC conclude (based on observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level) that 'warming of the climate system is unequivocal'. Such declarations from the IPCC and other reputable sources seem to have led to an unprecedented level of concern about climate change over the last two decades.

Though there is no part of the world immune from the impact of climate change, the impact appears to take different forms in different parts of the world. For instance, over the period ranging from 1900 to 2005, precipitation increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia, whereas precipitation declined

in the Sahel, the Mediterranean, southern Africa and parts of southern Asia (IPCC, 2007). In terms of impact and vulnerabilities, there are also sharp differences across regions. Those in the weakest economic position are often the most vulnerable to climate change and are frequently the most susceptible to climate-related damage.

Impact of climate change on Africa

Recent studies confirm that Africa is one of the continents most vulnerable to the impact of climate change because of multiple stresses and low adaptive capacity (IPCC, 2007:65). Nyong (2005) argues that climate change can seriously hamper the realisation of the development goals and aspirations of the continent. A report by the Economic Commission for Africa (ECA) and the African Union Commission (AUC) substantiates that climate change 'is already eroding decades of hard-won development gains' (ECA and AUC, 2010:1). Bauer and Sholtz (2010) thus underscore that any effort to promote sustainable development in sub-Saharan Africa will need to account for the probable impact of global climate change. The following are some of the more specific kinds of impact projected to occur on the African continent:

- By 2020, 75 to 250 million people are projected to be exposed to increased water stress;
- By 2020, yields from rain-fed agriculture could be reduced in some countries by up to 50% thereby adversely affecting food security;
- Towards the end of the twenty-first century, projected sea level rise will affect low-lying coastal areas with the cost of adaptation amounting to at least 5 to 10% of GDP; and
- By 2080, an increase of 5 to 8% of arid and semi-arid land is projected (IPCC, 2007:50).

Impact of climate change in Ethiopia

The recently published 'Ethiopia Environment Outlook' report discloses that climate variability and change are among the pressing issues already affecting the livelihood of most Ethiopians (EPA and UNEP, 2008). Climate-related hazards in the country include drought, floods, heavy rains, strong winds, frost, heat waves, etc. Drought is believed to be the single most important climate-related natural hazard affecting the country (FDRE, 2007). The other climate-related hazard that affects Ethiopia is flooding. Major floods causing loss of life and property occurred in different parts of the country in 1988, 1993, 1994, 1995, 1996 and 2006 (FDRE, 2007). Causes for vulnerability to climate variability and change in Ethiopia include very high dependence on rain-fed agriculture (which is very sensitive to climate variability and change), underdevelopment of water resources, low health-service coverage, high population growth, low economic development levels, low adaptive capacity, inadequate road infrastructure in drought prone areas, weak institutions and a lack of awareness. (FDRE, 2007:5).

Efforts to address climate change

The past two decades saw noteworthy efforts in Ethiopia to address, a least at policy level, issues related to environmental degradation in general and climate change in particular. An important case in point is the effort to mainstream environment and climate change into the recently launched 'Growth and Transformation Plan' (GTP). The GTP is a medium-term strategic framework for the five-year period 2010/11–2014/15. One of the cross-cutting

issues identified in the plan deals with 'environment and climate change' (MoFED, 2010). The document (GTP) duly emphasises that environmental conservation makes a vital contribution to sustainability of development and calls for 'building a carbon neutral and climate resilient economy and enforcement of existing environmental laws' as priority actions (MoFED, 2010:77). The document also underlines that 'the formulation and implementation of a climate change adaptation programme is a dictate of Ethiopia's survival'.

The Role of Education in Combating Climate Change

> People who do not know the ground on which they stand miss one of the elements of good thinking which is the capacity to distinguish between health and disease in natural systems and their relation to health and disease in human ones. (Orr, 1992:86)

The international community adopted the United Nations Framework Convention on Climate Change (UNFCCC or FCCC) at the United Nations Conference on Environment and Development (UNCED) in 1992 in order to combat anthropogenic climate change. To this end, a wide range of mitigation and adaptation measures have been proposed. Article 6 of the UNFCCC deals specifically with education, training and public awareness (United Nations, 1992:10). This Article calls for the development and implementation of educational and public awareness programmes on climate change and its effects; public access to information on climate change and its effects; public participation in addressing climate change and its effects and developing adequate responses; and the training of scientific, technical and managerial personnel.

Ethiopia ratified the UNFCCC in April 1994 (FDRE, 2001). One of the official documents (related to climate change) produced by the Ethiopian government underscores that Ethiopians need to be made aware of the commitments of the country under the convention, the impacts of climate change, adaptation and mitigation options as well as of measures that can be taken at the individual level to combat climate change (FDRE, 2001). The document also lists some of the efforts already made to this end. The Ethiopian Ministry of Education (MoE) has, for instance, made efforts to introduce environmental education into the school curricula at various levels. Topics on climate change have been infused into school subjects like Geography, Agriculture and Biology. Notwithstanding the important steps taken so far, the level of awareness about the environment in general and climate change in particular remains very low among most Ethiopians (FDRE, 2001).

The Problem

The Ethiopian education policy requires higher education at diploma, degree and graduate level 'to be practice oriented, enabling students to become problem solving professional leaders in their fields of study and in overall societal needs' (FDRE, 2004:12). A review of environmental policies in Ethiopia issued over the past two decades also shows that remarkable efforts have been made to address climate change at policy level. The implementation of the various

environment-related policies has, however, been constrained mostly by the gaps between policy and practice and limited stakeholder participation (McKee, 2007). It is also argued that the level of awareness among policy makers, professionals and the general public in Ethiopia about climate change is very low. The same source (FDRE, 2001) discloses that the country's participation in the climate change negotiation process is very weak due to inadequate negotiation and language skills as well as financial constraints. All these issues highlight the need for strengthening climate change literacy at institutions of higher education from which future climate change negotiators and teachers will emerge. The purpose of this study was therefore to assess the actual state of climate change literacy among postgraduate students in selected programmes at Addis Ababa University.

Rationale and Objectives of the Study

The major aim of environmental and sustainability education at university level is to help prospective graduates to not only develop a broad conceptual framework but also to gain specialised knowledge and technical skills which could, in turn, be applied in natural resource management and environmental protection (Belal & Springuel, 1998). Higher education institutions are also expected to contribute towards climate change literacy. In line with such an expectation, some efforts have been made in recent years to assess the extent of climate change literacy among students at higher education institutions (Boyes *et al.* 1995; Dove, 1996; McBean & Hengeveld, 2000; Summers *et al.*, 2000; Cutter & Smith, 2001; Khalid, 2003; Spellman *et al.*, 2003; Papadimitriou, 2004; Pe'er *et al.*, 2007; Cordero, 2008).

Spellman *et al.* (2003) assessed the awareness of higher education students in the United Kingdon about global climate change. Their study indicates that higher education students are well informed on the issues. The writers thus conclude that 'the government, education and media in the United Kingdom have been successful in promoting scientifically and environmentally literate citizens in this age group' (Spellman *et al.*, 2003:218). A study by Summers *et al.* (2000), which assessed primary school teachers' understanding of biodiversity, the carbon cycle, ozone and global warming, indicates that primary teachers had substantial understanding of some aspects of the science underpinning the four environmental topics investigated though 'other key scientific ideas underlying these topics were far less well understood' or absent (Summers *et al.*, 2000:307).

Cordero's study on climate change education points out significant misconceptions among university students (Cordero, 2008:870). The misconceptions in this case were explained in terms of factors such as the way media portrays global warming and how these topics are covered in K-12 classes (kindergarten to grade 12). Papadimitriou (2004) suggests that misconceptions and misunderstandings about climate change are not limited to students - teachers can have such misunderstandings as well. A study by Khalid confirms that 'pre-service secondary science teachers had a tendency to combine one issue with the other. They showed misconceptions when they tried to interconnect the apparently independent phenomena of the greenhouse effect and ozone depletion in the upper atmosphere' (2003:36).

Many of the studies related to climate change literacy underline the need for identifying

possible misconceptions among students about the causes, consequences and cures of climate change. This is particularly important in teacher training programmes. Unless the misconceptions are rectified while the prospective teachers are still in their training institutions, they 'might pass on false information to or fail to correct the children they eventually teach' (Dove, 1996:99–100). Papadimitriou (2004:300) also argues that prospective teachers should acquire a better and deeper understanding of the subject themselves to be able to teach properly about climate change and not to pass their own misconceptions to pupils. In general, discovering misconceptions held by students before teaching specific courses would enable lecturers 'to avoid students trying to attach new knowledge to existing false ideas' (Dove, 1996:99–100). The aim of the study reported here was assessing the level of climate change literacy among postgraduate students of Addis Ababa University including prospective teachers. The study has the following specific objectives:

- to assess the level of awareness of graduate students about the key aspects of climate change literacy: scientific basis, effects, causes and mitigation and adaptation measures; and
- to examine differences between students from various programmes: Environmental Science, Geography and Environmental Education; and Geography and Environmental Studies.

Methodology

Climate change literacy operationalised

Climate change literacy is understood in this paper as the ability to recognise the basic science underlying climate change; to identify the major causes and effects of climate change; and to distinguish the key measures to mitigate and adapt to the impact of climate change.

Instrument

A questionnaire, prepared on the basis of review of current knowledge related to climate change has been used as a principle tool for gathering data for this study. The questionnaire is composed of 56 statements each having three options: 'correct', 'incorrect' and 'I don't know'. The last option was included to give students the 'freedom' to express doubts about their awareness. The students' responses thus represent the three states 'informed', 'misinformed' and 'uninformed' (Spellman *et al.*, 2003). It is important to note here that four different scales have been developed to measure the four aspects of climate change literacy: basic science (17 statements), effects (19), causes (9) and mitigation and adaptation measures (11). An attempt has also been made to include national, continental and global dimensions of climate change literacy. Box 1 shows sample statements from the four scales developed to measure climate change literacy.

The initial version of the questionnaire was administered to 25 students in a master's programme at Addis Ababa University. The students were first asked to fill out the questionnaire, which was then collected, mixed up and distributed back to the students to correct. Students were advised to correct the responses of their fellow students by assigning '1' to correct responses, '0' to 'don't know' and '-1' to incorrect responses. The correction was done in a regular 'class'

by reading the statements one after another and then deciding whether the given statement is correct or not. This process led to a heated debate in class (on whether some statements were to be accepted as correct or not). The process eventually resulted in the refinement of the wording in a number of statements.

Box 1. Sample statements

Basic science

Statement 15: The greenhouse effect is a phenomenon that keeps the temperature on the earth's surface averaging at 15°C. *(Correct)*

Statement 1: The greenhouse effect is caused by gases that trap rays radiated from the sun. *(Incorrect)*

Effects

Statement 13: The total global sea level rise in the twentieth century amounted to 1.7 metres. *(Incorrect)*

Statement 46: In Ethiopia, the frequency of droughts increased from 'once every ten years' in the 1950s to 'every second to third year' at present. *(Correct)*

Causes

Statement 45: The largest source of human emissions contributing to global climate change is methane. *(Incorrect)*

Statement 5: China is at present the biggest emitter of overall greenhouse gases. *(Correct)*

Mitigation and adaptation measures

Statement 51: Adaptation measures are aimed at exploiting beneficial opportunities that result from climate change. *(Correct)*

Statement 42: There are technological alternatives developed over the last five years that could replace fossil fuels quickly and cheaply. *(Incorrect)*

Participants

Participants of the study included graduate students (these are students working towards their master's degree) in three colleges of the Addis Ababa University, namely the College of Natural Sciences, the College of Social Sciences and Humanities and the College of Education and Behavioural Studies. A total of 91 students took part from four different programmes: Environmental Science (regular), Geography and Environmental Education (regular), Geography and Environmental Education (extension) and Geography and Environmental Studies (regular). These particular programmes were selected because of their overt interest in environmental issues in general and climate change in particular. The Geography and Environmental Studies Department (former Department of Geography) is one of the oldest departments at Addis Ababa University, whereas the other three programmes are among those programmes that have been initiated more recently, partly because of the growing interest in environmental issues both globally and locally. The great majority of the participants (92.3%) were male students.

Data gathering and analysis

The questionnaire was administered during regular lecture sessions by the writer or (in the case of the Environmental Science Programme) another professor. Participants were instructed to choose one of the three options: 'correct', 'incorrect' and 'I don't know'. Quantitative data analysis was undertaken using the SPSS software. ANOVA was run to check the significance of the mean difference between the various groups. The reliability of the four scales that make up the questionnaire was checked using the WINMIRA 2001 programme. Accordingly, the ANOVA reliability for the first scale (basic science) was 0.66; 0.72 for the second scale (effects); 0.49 for the third scale (causes); and 0.55 for the fourth scale (mitigation and adaptation measures).

Findings

Overall performance

The overall performance of the students has been summarised in Table 1. The figures in the table indicate that the students demonstrated climate change literacy that can be rated as 'just above average', with 31 correct responses on average out of 56 statements (54.7%). The highest score was 43 out of 56 (76.8%) and the lowest 15 (26.8%). Interestingly, both the highest and lowest scores come from the same programme: Geography and Environmental Education (extension). It is also important to note that 39.3% of the statements received less than 50% correct responses. On average, 14.3% of the statements received less than 25% correct responses.

Table 1. Key performance indicators

Indicator	Value
No. of statements	56
Minimum correct score (out of 56)	15
Maximum correct score (out of 56)	43
Mean	30.65
No. of statements with more than 75% correct responses	16 *(28.6%)*
No. of statements with 50-75% correct responses	18 *(32.1%)*
No. of statements with 25-49% correct responses	14 *(25.0%)*
No. of statements with less than 25% correct responses	8 *(14.3%)*

Performance by programme

Table 2 provides more specific information about performance by programme. Accordingly, participants from Geography and Environmental Education (regular) achieved the highest average score, whereas those from the Geography and Environmental Education (extension) programme scored the lowest. The former are students who are currently being trained to teach Geography in high schools and colleges or universities. The group with the lowest average score is composed of relatively older participants, most of whom are currently teaching Geography in high schools in Addis Ababa. The results thus reveal that those who are actually teaching

Geography in high schools performed far worse than those who are not. This is perhaps due to the difference in the curriculum at the bachelor's level. The recent Geography curriculum has more courses related to contemporary global environmental issues than previous curricula (Dalelo, 2010). It could also be due to the paucity of information on climate change at school level. McBean and Hengeveld suggest that 'most educators within elementary and secondary schools have limited access to peer-reviewed scientific literature or current science assessment reports' (2000:19–200).

Table 2. Performance by groups

Groups	No. of participants	Mean (out of 56)	SD	Min.	Max.
Environmental Science (ES)	16	32.3 *(57.7%)*	5.053	22	41
Geography and Environmental Education Regular (GEEd.R)	25	34.6 *(61.8%)*	3.215	28	40
Geography and Environmental Education Extension (GEEd.E)	23	26.7 *(47.7%)*	7.475	15	43
Geography and Environmental Studies (GEES)	27	29.4 *(52.5%)*	5.064	20	40
Total	91	30.7 *(54.8%)*	6.114	15	43

In most cases, the differences between the groups are found to be statistically significant at 0.05 level. Accordingly, students of the Environmental Science programme performed significantly better than those of Geography and Environmental Education (extension), and students of Geography and Environmental Education (regular) performed significantly better than those of Geography and Environmental Education (extension) and Geography and Environmental Studies.

Table 3 reveals an interesting pattern of performance across the different programmes against the four aspects of climate change (CC) literacy.

Table 3. Percentages of correct responses by programme and category

	Category			
Programme	**CC: Basic science**	**CC: Effects**	**CC: Causes**	**CC: Measures**
EnS	**53.2***	49.5	**51.1**	**61.8**
GEEd.R	46.7	**62.1**	43.3	**64.5**
GEEd.E	35.3	43.2	41.1	43.6
GEES	44.1	**53.7**	48.9	**57.3**

* Figures in bold show mean values greater than 50%.

Students of the Environmental Science Programme achieved a mean score of more than 50% in three of the four aspects of CC literacy. On the contrary, students of Geography and Environmental Education (extension) failed to score more than 50% in any of the four aspects. In relation to this, Boyes *et al.* (1995:143) report that students with an arts-based background were less sure of some of the issues surrounding a major environmental problem compared to their counterparts with a science-based background. Participants from the GEEd.R and GEES programmes scored above 50% in two of the four aspects of CC literacy as defined in this paper.

Level of difficulty of the various aspects of climate change literacy

Table 4 also provides important hints as to the relative ease or difficulty of the specific categories of CC literacy. Accordingly, categories 1 and 3, scientific basis and causes, seem to be relatively more difficult for the participants (only one of the four groups being able to score more than 50%). On the other hand, the fourth category, measures, is found to be relatively easier, with three of the four groups scoring above 50%. This is perhaps due to the impact of the Ethiopian public media (TV and newspapers), which tend to emphasise effects of climate change and actions that must be taken. At this juncture, it is important to note that the present study did not gather information on students' sources of information.

Table 4 shows that the difference between the groups is significant at 0.05 level for all categories of CC literacy except category 3 (causes). All the groups performed quite poorly in this category. Only the Environmental Science programme achieved above average performance.

Table 4. Significance of difference between programmes against the four categories

Categories	Difference	Sum of squares	Df*	Mean square	F	Sig.
1. CC: Scientific basis	Between groups	94.429	3	31.476	6.054	*.001*
	Within groups	452.318	87	5.199		
	Total	546.747	90			
2. CC: Effects	Between groups	160.520	3	53.507	6.722	*.000*
	Within groups	692.469	87	7.959		
	Total	852.989	90			
3. CC: Causes	Between groups	10.367	3	3.456	2.429	.071
	Within groups	123.743	87	1.422		
	Total	134.110	90			
4. CC: Measures	Between groups	73.534	3	24.511	12.498	*.000*
	Within groups	170.620	87	1.961		
	Total	244.154	90			

* Degree of freedom

Statement Analysis

The science behind climate change

Understanding of and participation in discussions and debates pertaining to climate change require precise knowledge about certain essential concepts. This study assessed the level of understanding about five such concepts: weather, climate, El Nino/La Nina and the greenhouse effect. The participants of the study demonstrated a good understanding about the meanings of weather (s53) and climate (s1) (with 83.5% and 90.1% correct responses respectively). The definition of El Nino (s30) seemed, however, to be more difficult. It received correct responses from less than half of the respondents (45.1%); and almost an equal percentage of the students (44%) had no idea at all (Table 5). Though El Nino and La Nina are not caused by climate change, global warming is believed to change the way they behave (s27). This statement received correct responses from only 34.1% of the students.

The natural greenhouse effect (or the heat trapping property of the atmosphere) keeps the annual average surface air temperature of the earth at about 15ºC thereby making it liveable for organisms including humans (FDRE, 2001). Without this natural phenomenon the earth's annual average temperature would be minus 18ºC. This fact (s15) was known to a mere 16.5% of the respondents. A similar statement – (s2): 'Although the greenhouse gases are present in the atmosphere at only small concentrations, they warm the surface by 33˚C' – got correct responses from only one fifth of the students (Table 5).

The role of water vapour as the most prevalent greenhouse gas (s50) is known to only one third of the respondents whereas close to one third (31.9%) wrongly endorsed the statement 'The greenhouse effect is caused by gases that trap rays radiated from the sun' (s7). On the other hand, both the use of chlorofluorocarbons (s9) and their contribution to the creation of an ozone 'hole' (s29) seem to be well understood by the participants (87.9% and 93.4% responded correctly). The latter statement received one of the highest frequencies of correct responses hinting that students who participated in this study had a higher degree of awareness about ozone depletion than global warming (Table 5).

A little more than 60% of the participants were aware of the fact that oceans are 'the largest active carbon "sink" on earth' (s32). Similarly, the statement related to the amount of CO_2 absorbed by an average tree (s35) got correct responses from 54.0% of the participants. Some studies indicate that accumulation of CO_2 in the lower atmosphere can stimulate plant growth thereby increasing yield for some crops. Such an advantage of accumulated CO_2 (s56) is known to 35.2% of the students.

Renewable sources of energy are often presented as effective alternatives to fossil fuels. It is also known that most renewable sources generate energy only intermittently: when the sun is shining or the wind is blowing. More than half of the students (57.2%) were not aware of this feature of renewable sources of energy (s55). The other feature of renewable energy sources is their low power density (s28). Only one third of the respondents got this correct (Table 5). The uncertainties characterising the CC science (s19) is recognised by 58.2% of the participants. Current studies indicate that predicting the localised effects of climate change is far more challenging than predicting global effects (s25). This fact was recognised by 70.3% of the respondents.

Table 5. Performance in statements related to category 1: Scientific basis

Code*	Issues addressed in the statements	Correct (%)	wrong (%)	'Don't know' (%)
s29	Formation of ozone 'hole'	93.4	5.5	1.1
s1	Climate: definition	90.1	7.7	2.2
s9	CFCs: definition	87.9	7.7	4.4
s53	Weather: definition	83.5	14.3	2.2
s25	Difficulty related to predicting localised effects of CC	70.3	26.4	3.3
s7	Explaining the greenhouse effect	65.9	31.9	2.2
s32	Oceans as the largest carbon sink on earth	61.5	11.0	27.5
s19	Uncertainties related to the impact of CC	58.2	40.7	1.1
s35	Role of trees as carbon sink	54.0	5.5	39.6
s30	El-Nino: definition	45.1	11.0	44.0
s55	Characteristic features of renewable energies (being intermittent)	44.0	42.9	13.2
s56	Role of CO2 in increasing crop yield	35.2	37.4	27.5
s27	Relation between global warming and El Nino/La Nina	34.1	30.8	35.2
s50	Water vapour as the most prevalent greenhouse gas	33.0	60.4	6.6
s28	Characteristic features of renewable energies (low power density)	33.0	41.8	25.3
s2	Capacity of GHGs to warm the earth's surface	19.8	37.4	42.9
s15	Role of greenhouse effect (maintaining average global temperature)	16.5	56.0	27.5

* The code refers to the serial number assigned to each statement in the original questionnaire

The effects of climate change

Participants of this study demonstrated a very low awareness about the pattern of change in temperature and rainfall across the world over the last century. More than two thirds (70.4%) either wrongly thought that in the twentieth century, 'precipitation decreased significantly in parts of the Americas, northern Europe and northern and central Asia' (s4) or had no idea (Table 6). The proportion of respondents who gave wrong answers or had no idea went down to 51.7% with regard to the pattern of rainfall in areas closer to Africa (s38). In Ethiopia, there has been a warming trend in the annual minimum temperature over the past 55 years. On the other hand, the trend analysis of annual rainfall shows that rainfall remained more or less constant when averaged over the whole country. Interestingly, more than two thirds of the respondents (68.1%) wrongly thought that 'In Ethiopia, rainfall declined significantly when averaged for the whole country over the last fifty years' (s24). With regard to patterns of temperature in Ethiopia over the past 50 years (s3), the proportion of correct response improved to 74.7% (Table 6).

Table 6. Performance in statements related to category 2: Effects

Code	Issues addressed in the statements	Correct (%)	Wrong (%)	'Don't know' (%)
s43	Effects of CC on crops' growing season	84.6	13.2	2.2
s41	Effects of CC on progress towards sustainable development	83.5	13.2	3.3
s12	Differentiated effects of CC (warming vis-à-vis cooling)	80.2	17.6	2.2
s6	Species' extinction as effect of CC	76.9	15.4	7.7
s3	20th century trends in temperature in Ethiopia	74.7	6.6	18.7
s46	Frequency of drought occurrence in Ethiopia	70.3	13.2	16.5
s40	Probability of anthropogenic warming to continue	68.1	19.8	12.1
s36	Effect of CC on distribution of malaria	64.8	23.1	12.5
s44	Magnitude of water scarcity in Africa	61.5	7.7	30.8
s31	Magnitude of shrinkage of ice cap on Mount Kilimanjaro	54.9	5.5	39.4
s48	Developing countries as primary victims of extreme weather	54.9	39.6	5.5
s17	Average global temperature rise since 1900	53.8	9.9	36.3
s38	20th century trends in precipitation in the Sahel, the Mediterranean and southern Africa	48.4	20.9	30.8
s20	Magnitude of shrinkage of glaciers in European Alps	42.9	9.9	47.3
s22	Magnitude of thinning of sea ice around the North Pole	33.0	4.4	62.6
s4	20th century trends in precipitation in America, Europe and Asia	29.7	23.1	47.3
s18	Reduction in illnesses/death due to cold as effects of global warming	19.8	65.9	14.3
s13	Magnitude of global sea level rise in the 20th century	16.5	30.8	52.7
s24	20th century trends in precipitation in Ethiopia	15.4	68.1	16.5

The participants of this study had inadequate information about the magnitude of global warming that took place over the past century. A little more than half gave correct answers to the statement: 'Average global temperature had risen by about 0.6ºC since 1900' (s17). More surprisingly, only 16.5% of the respondents had correct information about the magnitude of sea level increases in the twentieth century. Similarly, close to half of the participants (47.3%) had no information about the magnitude of the loss of glaciers in Europe (s20). The proportion of participants who had no information grew to 62.6% for a statement related to the thinning of sea ice around the North Pole (s22). On the other hand, more than half of the participants knew that 'Mount Kilimanjaro has lost three quarters of its ice cap in the last century' (s31).

It is projected that 'climate change could threaten the existence of over one million species' (s6), a fact endorsed by more than three quarters of the respondents (76.9%). It is also widely

believed that '[e]ven if greenhouse gas concentrations were kept constant at today's level, some anthropogenic warming would continue for many centuries' (s40). This fact was endorsed by 68.1% of the respondents. Furthermore, the ongoing change in climate is highly expected to 'slow the pace of progress toward sustainable development' (s41). A great majority of the participants (83.5%) endorsed this prediction.

The fact that climate change leads to warming in some areas and cooling in others (s12) was known to 80.2% of the respondents. Similarly, the impact of climate change on crop production, namely its potential to 'reduce crop growing season thereby forcing some regions to abandon production altogether' (s43) was recognised by 84.5% of the respondents. However, the positive impact often associated with global warming, namely its potential to 'reduce the number of deaths and illnesses resulting from extremely cold weather' (s18) was known to only about one fifth of the respondents (Table 6).

Recent reports also reveal an inconvenient truth that 'almost all deaths in the world due to weather-related disasters take place in developing counties' (s48). This fact was recognised by 54.9% of the respondents. Nearly 40% rejected this statement as wrong, showing that a large proportion of graduate students do not appreciate the heavy burden put on developing countries due to global climate change. With regard to the African continent, experts estimate that 'every fourth African already suffers from a shortage of water' (s44). This was known to 61.5% of the respondents. In Ethiopia, the frequency of drought increased from 'once every ten years' in the 1950s to 'every second or third year' at present (s46). This was known to 70.3% of the respondents. On the other hand, nearly one quarter of the respondents (23.1%) were not aware of the current change in the pattern of distribution of malaria in Ethiopia (s36) (Table 6).

The causes of climate change

Nine out of the 56 statements are related to the causes of climate change. The statement related to the relative contribution of fossil fuels to the world energy mix (s8) and received correct responses from 57.1% of the respondents, whereas close to two thirds of the respondents rightly rejected the statement: 'The largest source of human emissions contributing to global climate change is methane' (s45). More than four fifths of the respondents (81.3%) knew that chlorofluorocarbons (CFCs) 'trap heat thereby contributing to global warming' (s23). An even larger proportion of the respondents knew the fact that renewable sources of energy result in less pollution (Table 7). On the other hand, close to 60% of the respondents had no idea as to the role El Nino plays in influencing the global pattern of temperature and rainfall (s11). This is one of the statements that received the lowest proportion of correct responses. Another area of difficulty relates to the use of oil for the production of plastics. More than half of the respondents (52.7%) did not know that 'oil is used for the production of plastic bags' (s33), a reality that compounds the contribution of plastics to environmental pollution.

At present, China is the largest contributor to overall greenhouse gas emissions (s5), a fact known to more than four fifths of the respondents (76.9%). It is also evident that the the African continent's contribution to global warming via emissions is insignificant. However, one third of the participants of this study either had wrong information or no information with regard to Africa's contribution to global climate change. Interestingly, 16.5% of the respondents wrongly

approved the statement: 'Africa is responsible for about one quarter of global emissions of greenhouse gases' (s26). Like other poor countries in Africa, 'Ethiopia is extremely vulnerable to climate change mainly because of high dependence on rain-fed agriculture' (s49). A great majority of the respondents (93.4%) gave a correct response to this statement. This is one of the statements which received the highest proportion of correct responses (Table 7).

Table 7. Performance in statements related to category 3: Causes

Code	Issues addressed in the statements	Correct (%)	Wrong (%)	'Don't know' (%)
s49	Factors behind Ethiopia's vulnerability to CC	93.4	6.6	0.0
s37	Characteristic features of renewables (no severe air pollution)	87.9	11.0	1.1
s23	CFCs as contributors to global warming	81.3	18.7	0.0
s5	China as the biggest emitter of overall GHGs	76.9	15.4	7.7
s26	Contribution of Africa to emission of GHGs	67.0	16.5	16.5
s45	The gas making the largest contribution to CC	62.6	22.0	15.4
s8	Share of fossil fuels in global energy mix	57.1	16.5	26.4
s33	Use of oil for the production of plastic bags	29.7	17.6	52.7
s11	Influence of El Nino on temperature and rainfall distribution	18.7	22.0	59.3

Adaptation and mitigation measures

It is difficult to 'completely prevent global warming from happening though one can influence how much harm it does' (s34). This statement was endorsed by 84.6% of the respondents. The highest proportion of correct responses in this category (95.6%) goes to the definition of adaptation to climate change (s14). Adaptation measures are aimed not only at 'moderating harm caused by climate change' (s47) but also 'exploiting beneficial opportunities that result from climate change' (s51). The first part of this assertion was approved by three quarters of the respondents whereas a relatively lower proportion of the participants (62.6%) regarded the second part as correct. It is thus interesting to note that 26.4% of the participants seemed to have no information about the 'beneficial opportunities that result from climate change' (Table 8).

The statement that declares: 'The African continent has the highest capacity to adapt to climate change' (s10), was rightly rejected by 68.1% of the respondents. It is, however, worrisome that nearly one third of the participants either had wrong information or no information about the capacity of the African continent to adapt to climate change. In Ethiopia, 'consumption of wild foods is one of the traditional coping mechanisms to climate change' (s52). Strangely, one third of the respondents rejected this fact as incorrect (Table 8).

The participants of this study seemed to be well-informed about the notion of climate change mitigation (s54). However, a little more than one quarter (28.6%) knew the key requirements of one of the international conventions (s16). Besides, more than half (52.7%) of the respondents wrongly thought that industrialised countries agreed to cut greenhouse gases

by 25%! Similarly, the information with regard to the targeted ceiling of global temperature increase seems disturbingly poor. The statement (s21): 'Scientists recommend that increase in global temperature should be kept below one degree Celsius so as to prevent dangerous anthropogenic interference with the climate system' was rightly rejected by only 7.0%. More than 90% of the participants either wrongly approved the statement (61.1%) or had no idea (32.6%).

Table 8. Performance in statements related to category 4: Mitigation and adaptation measures

Code	Issues addressed in the statements	Correct (%)	Wrong (%)	'Don't know' (%)
s14	Adaptation to CC: definition	95.6	3.3	1.1
s54	Mitigation measures: definition	87.9	7.7	4.4
s34	Difficulty to completely prevent global warming	84.6	11.0	4.4
s47	Adaptation as a strategy to moderate harm caused by CC	75.8	14.3	9.9
s10	Capacity of Africa to adapt to climate change	68.1	18.8	12.1
s51	Adaptation as a strategy to exploit benefits of global warming	62.6	26.4	11.0
s52	Consumption of wild foods as CC coping strategy in Ethiopia	47.3	33.0	19.8
s39	Function of carbon sequestration	46.2	14.3	39.4
s16	Magnitude of emission cuts as per Kyoto Protocol	28.6	52.7	18.7
s42	Availability of technological options to replace fossil fuels	23.1	60.4	16.5
s21	Recommended ceiling of global temperature increase	7.0	61.1	32.6

Carbon sequestration as a process of trapping and storing carbon (s39) is known to 46.2% of the respondents. Another interesting finding is that 60.4% of the respondents wrongly approved the statement: 'There are technological alternatives developed over the last five years that could replace fossil fuels quickly and cheaply' (s42).

Discussion

The analysis of the students' responses reveals a number of issues worth discussing in some depth. However, space does not allow us to discuss all the interesting aspects of the responses. The paper therefore focuses on three of the key findings and their implications.

A blurred understanding of the scientific base of climate change

Many students seemed to attribute all the greenhouse effect to anthropogenic causes. A study by Boon (2010:109) also came up with a similar observation that both secondary students and pre-service teachers demonstrated 'a very low rate of understanding of the science of the greenhouse effect'. Furthermore, most of the students did not understand the role of water

vapour as the most prevalent greenhouse gas. A study by Darcin (2010) also shows that only 17% of the trainee science teachers knew water vapour was a factor in increasing the greenhouse effect. Similarly, Dove (1996:92) indicates that greenhouse gases such as 'methane were hardly mentioned and nobody referred to nitrous oxide and water vapour'. Close to one third of the students who took part in this study wrongly endorsed the statement: 'The greenhouse effect is caused by gases that trap rays radiated from the sun'. In relation to such a misconception, Dove (1996:92) reported a more dramatic result that only 4% of the students who took part in his study correctly distinguished incoming solar, short-wave radiation from out-going, long-wave, trapped rays. One can thus see that the observed gap in students' knowledge about key scientific principles underlying climate change could affect their contribution as would-be teachers and/or workers in one or another area related to environmental management.

Poor knowledge about past trends in rainfall and temperature

More than two thirds of the respondents wrongly thought that 'in Ethiopia, rainfall declined significantly when averaged for the whole country over the last 50 years'. It thus appears that the all-too-common (but scientifically unfounded) association of Ethiopia as drought-ridden blurred views about the pattern of spatio-temporal distribution of rainfall in the country. Similarly, many students had inadequate information about the magnitude of global warming that took place over the past century (only 16.5% of the respondents had, for instance, correct information about the magnitude of sea-level increase in the twentieth century). What is more, students' knowledge about the targeted ceiling of global temperature increase is found to be disturbingly poor. The same is true of their understanding about some of the key conventions on climate change (for instance, more than half of the respondents wrongly thought that industrialised countries agreed to cut greenhouse gases by 25% as part of their commitment to the Kyoto Protocol). These results, taken as a whole, imply that participants of this study clearly have inadequate information about issues underpinning global climate change negotiations.

Poor knowledge about the impacts of climate change on Africa

It is known that warming in Africa occurs faster than the global average, while its greenhouse gas emissions represent only a minuscule fraction of the global total (Bauer & Sholtz, 2010). A large proportion of the students failed to appreciate such a heavy burden already put on Africa owing to global climate change. Surprisingly, 16.5% of the respondents wrongly approved the statement: 'Africa is responsible for about one quarter of global emissions of greenhouse gases'. This is more evidence for the urgency to build the capacity of university students, some of whom expected to represent Africa in international climate change debates and negotiations.

Conclusions and Recommendations

Dr Knapp, President of the University of Georgia, is said to have made the following statement with regard to the need for promoting environmental literacy throughout his university system: 'we can no longer afford to grant degrees to students who are environmentally illiterate … I will be asking the faculty and my administration to consider basic policy changes in three separate areas that will address the University's ability to address environmental issues: curriculum, organisational issues and financing' (Roth, 1992:40). Roth (1992:17) emphasises that developing environmental literacy at some level of competency is the primary objective of environmental education.

The study reported here was aimed at assessing the level of climate change literacy among graduate students in four programmes that lead to a master's degree in Environmental Science; Geography and Environmental Education; and Geography and Environmental Studies. To this end, a questionnaire was developed and administered to a total of 91 students. An attempt was made to include all the major conceptual and geographical aspects of climate change literacy. Results indicate that the students who participated in the study demonstrated an average performance on the whole but clearly poor performance in some of the key areas related to the science behind climate change; past trends in rainfall and temperature; and the impacts of climate change on Africa. It is particularly worrisome that many of the students had inadequate or no information about the projected or actual impact of climate change on poor countries including those in Africa. Students' performance in issues related to measures proposed at global level is also low.

Participants from Geography and Environmental Education (extension) programme had the lowest score on average. This group is composed of relatively older participants most of whom are currently teaching geography in high schools in Addis Ababa. The results thus reveal that those who are actually teaching Geography in high schools performed far worse than the others. This, in turn, implies that the teachers are likely not to be in a position to properly handle issues related to climate change. With regard to this, Spellman *et al.* (2003: 214) suggest that despite considerable media interest in climate change, 'many geography teachers have opted to omit the meteorology section. This could be due to the complexity of the issues involved, or the feeling that they did not possess expertise or competence in these areas, compared with other options in physical geography.'

This study has not tried to investigate factors that could explain the observed level of climate change literacy. It is therefore strongly recommended that follow-up studies be conducted to see the effects of such factors as programme syllabi, teaching approaches used, key sources of information, etc., on students' climate change literacy. Sanni *et al.* (2011) suggest, for instance, that 'as important as study of climate change is, very few universities in the world have climate change as a distinct course of study at the undergraduate level'. The extent to which climate change has been integrated into the curricula for higher education institutions in Ethiopia needs to be assessed in order to better understand the roots of the deficiencies in the key aspects of climate change literacy observed in this study.

Note on the Contributor

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