Integrating Climate Basics, Climate Information Service, Climate Risk Management and Climate Smart Agriculture into the undergraduate agriculture Curriculum in Ethiopian Higher Education

By

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Executive summary

Agriculture contributes about 40% to the country's GDP, more than 75% to employment, and 80% to foreign exchange earnings of the Ethiopia's economy. However, climate change poses a serious risk to the sector. On the other hand, agriculture is a major contributor (i.e., about 55%) of the country's greenhouse gas emission. To address the strong and bidirectional interrelationships between climate change and agriculture, the agricultural sector needs to transform in a climate-smart way. Climate change education will have paramount importance for tackling the problems associated with climate change through generating climate smart technologies for the enhancement of sustainable agricultural production and biodiversity conservation. Climate Change Educations (CCE) and trainings have long been recognized by the national CCE strategy (2017-2030), United Nations Framework Convention on Climate Change, the Paris Climate Change Agreement, and the Sustainable Development Goals of the United Nations (Agenda 2030) as key tools to unravel the complex and multi-sectoral challenges induced/posed by climate change. Thus, specifically, including the concepts of Climate Information Service (CIS) Climate Risk Management (CRM) and Climate smart agriculture (CSA) in the existing climate related courses is critical to build climate resilient agricultural sector in Ethiopia. Thus, Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) in collaboration with Ethiopian Higher Educations initiated to integrate the concept of CIS and CSA in the agricultural program in Ethiopia. Therefore, this document, explore if there is a gap between climate related course contents and the current CIS, CRM and CSA knowledge and innovations to addresses climate related agricultural challenges in ten undergraduate agricultural curricula of Ethiopian Higher Education Institutes. Ten climate related course descriptions were content analyzed to analyze gaps related to the concepts of CIS, CRM and CSA. The study found that there were gaps between the current curriculum and the desired knowledge and innovation of CIS, CRM and CSA to addresses the current and emerging climate change challenges in the agricultural sector. These results emphasize the need for curriculum review and reform to ensure CIS, CRM and CSA knowledge and innovations equipping the university graduates with comprehensive knowledge of climate change.

1. Introduction

1.1.Background

As the backbone of the Ethiopian economy, agriculture contributes about 40% to the country's GDP, more than 75% to employment, and 80% to foreign exchange earnings of the country's economy (FAO 2021). Ethiopia's agriculture is heavily dependent on natural rainfall (Addisu et al. 2015) with only about 5% of the total cultivated land using irrigation (USAID 2021). As a result of this, the sector is 'highly vulnerable' to climate change. Climate change poses a serious risk to the country's agriculture development, natural resources, biodiversity conservation, and interferes with the government's poverty reduction efforts. Climate change related problems such as food-insecurity, malnutrition, poverty, loss of biodiversity and livelihood are profoundly intertwined and remain to be the country's primary development challenges. Just in 2021/2022, climate change has caused Ethiopia to suffer one of its worst droughts that has ravaged vast parts of the country. The drought has ravaged livestock and wildlife resources. Future prediction suggest that Ethiopia will continue to suffer from climate change related problems.

Average temperature have increased by 1°C since 1960, at an average rate of 0.25°C per decade with declined trends of an overall precipitation. There has been also frequent occurrence of extreme events like droughts and floods, in addition to rainfall variability and increasing temperature, which contribute to adverse negative impacts to agricultural sector. According to the Fifth Assessment Report of the IPCC, the mean annual temperature is projected to increase in the ranges of 0.9 to 1.1°C by the 2030s, 1.7°C to 2.1°C by the 2050s, and 2.73 to 4°C by 2080s (CRGE, 2011). Climate models indicate that climate change related hazards may cause 50% decline in the country's agricultural productivity towards 2080 (Cline, 2007). Thus, increase in the number of food insecure people in Ethiopia coupled with the current impacts of climate change on agricultural production systems and increasing trends of livelihood vulnerability to climate variability and change strongly suggest that the country will not be able to feed its growing population by 2080. These evidences suggest that climate change related vulnerability is a greater stake for Ethiopia.

On the other hand, agriculture is a major contributor (i.e., about 55%) of the country's greenhouse gas emission (FDRE MoFECC 2015). To address the strong and bidirectional interrelationships between climate change and agriculture, the agricultural sector needs to transform in a climate-smart way. Climate-smart agriculture (CSA) as an integrative approach addresses the interlinked challenges of food security and climate change through which a country will sustainably increase agricultural productivity to support equitable increases in farm incomes, food security and development. It also helps adapt and build resilience of agricultural and food security systems to climate change at multiple levels and reduce greenhouse gas emissions. FAO (2010) defines CSA as agriculture that sustainably increases productivity, enhances resilience of livelihoods and ecosystems, reduces and/or removes greenhouse gases (GHGs) and enhances achievement of national food security and development goals. The evolution of CSA is associated with an explicit consideration of climatic risks that are happening more rapidly and with greater intensity than in

the past. New climate-related risks drive changes in agricultural technologies and approaches to improve food security and reduce poverty and to prevent the loss of agricultural research and development gains. CSA entails greater investment in managing climate risks, understanding and planning for adaptive transitions that may be needed and exploiting opportunities for reducing or removing greenhouse gas emissions where feasible.

In recent years, climate information service (CIS) and climate risk management (CRM) have been incorporated into development agendas as a means of achieving development goals in a volatile and changing environment. Climate information has been used in Ethiopia for decades, particularly for drought monitoring and early warning (Hellmut et al., 2007). However, climate data availability, access, and utilization are far from optimal. The network of weather stations operated by Ethiopia Meteorology Institute (EMI) is the primary source of climatic data. In Ethiopia, EMI and the International Research Institute for Climate and Society (IRI) at Columbia University in the United States are working together to improve data availability, access, and usage (Tufa Dinku, 2011, 2018). Thus, whereas earlier CIS would have been structured around generating and making available climate information as map room for individuals to use however they saw fit, today the starting point for developing an effective CIS is paying attention to potential users of the service and their specific needs.

Capacity building in Ethiopia is vital to use CIS, CRM, and develop technologies and design strategies to implement CSA. People's knowledge of CIS, CRM and CSA can influence success of any planned climate change mitigation and adaptation programs and activities. Along this, the main task of Higher Education Institution in general and programs under the College of Agriculture and Environmental Sciences is to produce competent graduates through training and research to address challenges attributed to climate change and its impacts on agriculture over the next decades. Integrating the concept of CIS, CRM and CSA in the undergraduate agriculture curriculum is urgently needed to in order to make agriculture climate-smart. Thus, Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) in collaboration with Ethiopian Higher Educations initiated to integrate the concept of CIS, CRM and CSA in the undergraduate agriculture curriculum in Ethiopia. Therefore, this report aimed to assess undergraduate agriculture curricula whether the contents of climate related courses integrate the current CIS, CRM and CSA knowledge and innovations as well as satisfy the current needs.

1.2. The rationale behind the integration

Ethiopian agriculture is the most vulnerable sector to the impacts of climate variability and change as it is mostly practiced by smallholder farmers through rain-fed with very limited irrigation (<1%). Climate change poses the greatest threat to food security in Ethiopia. It has contributed to the vicious circle of poverty and recurrence of food shortages in the continent for several decades in the past. The country is expected to get hotter in the foreseeable future, where the combination of increasing temperature and changing rainfall patterns could make annual production of food crops on an increasingly eroded land and scarce water resource base, even more risky and largely

unpredictable (FAO, 2006). Burdened with growing weather variability with more frequent occurrence of drought, smallholder farmers are under further threat of becoming the most food-insecure, undernourished, and poverty-stricken sector of the African society (AGRA, 2014).

Crop and livestock production in Ethiopia are severely constrained by climate change and associated problems, and consequently, food security through direct effects on food availability such as reduced crop yields, and changes in the quantity and quality of livestock feed and forage, and through indirect impacts on livelihoods and income that in turn have consequences for food accessibility (USAID 2012).

Smallholders, as the main rural actors in Ethiopia, are extremely vulnerable to the impacts of a changing climate. They usually grow slow-maturing crops that needs two rainy seasons to harvest and are thus even more vulnerable to changes in seasonal rainfall. Recurring drought and increased desertification resulting from land use pressures have resulted in significant losses of arable land and rendered the country increasingly dependent on food aid. Crop productivity may increase in some areas (highlands and high-plateaus) in the short term due to warmer temperatures, but continued high temperatures will result in heat stress and crop failure. It is estimated that Ethiopia will lose more than 6% of each year's agricultural output if the current decline in average annual rainfall levels for primary agricultural zones continues to mid-century (USAID 2016).

Rising temperatures and shifting rainfall patterns may increase soil erosion and increase growing difficulties for many crops as well as shorten growing seasons. These scenarios are likely to also alter the occurrence and distribution of pests. Primary crops produced in Ethiopia include cereals, pulses, coffee, oilseeds, spices, herbs, vegetables, fruits, sugarcane, and potatoes. Rising temperatures are expected to increase suitable condition for crop diseases and pest infestations. Ethiopia also has the largest livestock population in Africa, with 54 million cattle, 25.5 million sheep, 24.1 million goats, 915,000 camels (downward trend) and 50.4 million poultry (2013; MEFCC 2015).

The agriculture sector relies heavily on ground and surface water supply, that is sensitive to localized land use and likely to experience decreasing recharge and quality due to reduced precipitation in some areas; increasing evaporation. An expected trend of reduction in rainfall can have consequences for agriculture and water quality, especially in more arid areas. Increased temperatures and the threat of waterlogging of fields may also result in an increased presence of pests and diseases harmful to yield production and quality. Changes in seasonality of precipitation will lead to further soil erosion and loss of soil fertility. By 2050, climate change may increase the rate of soil erosion by up to 40-70% (World Bank 2020).

Livestock is also likely to be impacted by increased heat conditions, including the effects of radiation, temperature, and humidity. Under present climate conditions, heat stress makes it difficult for animals to keep up with heat dissipation, rendering them vulnerable to heat stress during, at least, part of the year. Heat stress has a variety of detrimental effects on livestock, but

can include reductions on milk production and reproduction, particularly for dairy cows. Extreme events, such as heat waves, may particularly affect beef and dairy cattle. The projected increased heat will increase stress on crops and is also likely to alter the length of the growing seasons. Decreased water availability is likely to reduce yields and the reduction in soil moisture may alter suitable areas for agriculture or the production of specific crops. Increased heat and water scarcity conditions are likely to increase evapotranspiration, expected to further contribute to crop failure and overall yield reductions (MEFCC 2015). The changes to higher maximum temperatures throughout the year have implications for impacts to soil moisture and crop growth.

In Ethiopia, the estimated annual cost of land degradation, due to loss of vegetation and unsustainable land use, is estimated from 2 to 6.75% of the agricultural GDP. The annual rate of deforestation in the country is estimated at 1% exceeding the sub-Saharan Africa average of 0.6%. Failure to take action to prevent deforestation will result in loss of 9 million hectares of land by 2030. This is anticipated to occur partly due to an increase in demand for fuel wood consumption by 65% in the same period (IPCC, 2007).

The current human and institutional capacity of the country generally falls short of meeting these challenges. There is growing recognition that new approaches and technologies are needed, with new alliances and partnerships and a renewed vision for building country strengths to combat these challenges more effectively. Smallholder farmers in Ethiopia are opening up to scientific interventions and, demanding improvements in agricultural practices to increase agricultural production under the changing climate. Therefore, integration of CIS, CRM and CSA concepts in the undergraduate agriculture curricula is initiated by AICRA in collaboration with Ethiopian Higher Education Institutes to equip graduates with the current CIS and CSA knowledge and innovations that can transfer impactful scientific findings and relevant technologies to tackle the affirmation food security challenges under the changing climate.

1.3. Objective

The gap analysis study was initiated by AICRA with the objective of identify and document climate related courses in the undergraduate agriculture curricula in Ethiopian Higher Education Institutes, and explore if there is a gap between climate related course contents and the current CIS, CRM and CSA knowledge and innovations to addresses climate related agricultural challenges.

Major activities conducted included:

- review curricula of ten undergraduate agriculture program;
- identify climate related course in the curriculum;
- identify gaps between contents of climate related courses;
- integrate CIS, CRM and CSA concept into the existing climate related courses

1.4. Study programs

The gap analysis was conducted in ten undergraduate agriculture program curricula running in Ethiopian Higher Education Institute, namely;

1. Natural Resource Management;
2. Environmental Sciences Program;
3. Plant Science Program;
4. Rangeland Ecology and Biodiversity;
5. Rural Development and Agricultural Extension;
6. Agricultural Economics Program;
7. Agribusiness and Value Chain Management Program;
8. Forestry;
9. Horticulture; and
10. Animal Science

1.5. Study methodology

The main methodology used in this gap analysis study was desk review of ten current agricultural undergraduate program curricula. It involved identification of climate related courses and review the content of each courses from the context of CIS, CRM and CSA. The contents of the courses were reviewed and gaps were identified. Information from the desk review was used to integrate CIS, CRM and CSA concept into the existing climate related courses.

2. Gap analysis results

**** Gaps analysis** presented in this document reflects only the relative gaps in BSc. programs courses in contrast with the course description and content of Climate Information Service (CIS), Climate Risk Management (CRM) and Climate Smart Agriculture (CSA).

Courses Gap Analysis of Climate-Related BSc Programs Courses Offered in Programs under the College of Agriculture and Environmental Sciences in Ethiopian Higher Education

SN	BSc Program	Course name & Code	Credit Hr. /ECTS	Gaps identified relative to CSA	Amendment suggested
1	Natural Resource Management	Climatology and Agrometeorology **(NaRM 272)**	3(2+1)	❖ Course partially addressed topics related to CIS, CRM and CSA ❖ Content revision is needed to enhance the concept of CIS, CRM and CSA in the course	❖ Contents related to concept, characteristics and pillars of CSA suggested to add under chapter 7; ❖ Suggested to incorporate basics of CIS in chapter 2 and CRM in chapter 8
		Climate change adaptation and mitigation **(NaRM331)**	2(2+0)	❖ Course reasonably addressed topics related to CIS and CSA, ; ❖ Content revision is needed to enhance the concept of CIS, CRM and CSA in the course	❖ Contents related to climate-smart natural resource management technologies and practices suggested to add under chapter 5 ❖ Climate-smart natural resource management Ethiopian case

					studies suggested to address under chapter 6 ❖ Introduction to CIS suggested to be included in chapter 3 ❖ Advanced CIS and CRM suggested being included in chapters 5 and 6
2	Environmental Sciences Program	Climatology and Meteorology **(EnSc222)**	3(2+1)	❖ Course partially addressed topics related to CIS, CRM and CSA ❖ Content revision is needed to enhance the concept of CIS, CRM and CSA in the course	❖ Chapter 7 should add contents such as concept, characteristics and pillars of CSA ❖ Fundamentals of CIS suggested to incorporate in chapters 2 ❖ CRM suggested to add under chapter 8
		Climate Chang Mitigation and Adaptation **(EnSc222)**	2(2+0)	❖ Course reasonably addressed topics related to CIS, CRM and CSA; ❖ Content revision is needed to enhance the concept of CIS, CRM and CSA in the course	❖ Contents related to climate-smart natural resource management technologies and practices suggested to add under chapter 5 ❖ Climate-smart natural resource management Ethiopian case studies suggested to address under chapter 6 ❖ Introduction to CIS suggested to be included in chapter 3 ❖ Advanced CIS and CRM suggested being included in chapters 5 and 6

3	Plant Science Program	Climatology and Agrometeorology **(NaRM 251)**	2(1+1)	❖ Course partially addressed topics related to CIS, CRM and CSA; ❖ Content revision is needed to enhance the concept of CIS, CRM and CSA in the course	❖ Contents related to concept, characteristics and pillars of CSA suggested to add under chapter 7; ❖ Suggested to incorporate basics of CIS in chapter 2 and CRM in chapter 8
4	Rangeland Ecology And Biodiversity	Climate Change Adaptation and Mitigation **(REBD432)**	2(2+0)	❖ Course reasonably addressed topics related to CIS, CRM and CSA; ❖ Content revision is needed to enhance the concept of CIS, CRM and CSA in the course	❖ Basics of climate change and CIS suggested to being included in chapter 1; ❖ Concept, characteristics and pillars of CSA suggested to add under chapter 3 ❖ Suggested to include contents related to CSA technologies and practices and Ethiopian case studies under chapter 4 ❖ CRM suggested to be included in Chapter 5
5	Rural Development And Agricultural Extension	Introduction to Climate-Smart Agriculture **(RDAE 242)**	1(1+0)	❖ Course fully addressed contents related to CIS, CRM and CSA	❖ Basics of climate change and CIS suggested to being included in chapter 1; ❖ Inclusion of topics CSA knowledge management can enhance the content of the course

6	Agricultural Economics Program	Economics of Climate Change **(AgEc 462)**	2(2+0)	❖ Contents related to CIS, CRM and CSA are partially addressed	❖ Basics of climate change and CIS suggested to being included in chapter 1 and 2, respectively; ❖ Inclusion of topics CSA knowledge management can enhance the content of the course under chapter 2 ❖ Addition of topics related socio-economic and gender perspectives in CSA suggested under chapter 8
7	Agribusiness And Value Chain Management Program	Climate Change in Agribusiness **(ABVM422)**	3(3+0)	❖ Contents related to CIS, CRM and CSA are partially addressed	❖ Basics of climate change and CIS suggested to being included in chapter 1 and 2, respectively; ❖ Inclusion of topics CSA knowledge management can enhance the content of the course under chapter 2 ❖ Addition of topics related socio-economic and gender perspectives in CSA suggested under chapter 8
8	Forestry	Climate change & desertification **(For 1072)**	3 (3+0)	❖ Course partially addressed topics related to CIS, CRM and CSA;	❖ Basics of CIS suggested to being included in chapter 2 ❖ Contents such as concept, characteristics and pillars of

				❖ Content revision is needed to enhance the concept of CIS, CRM and CSA in the course	CSA suggested to add under chapter 2 ❖ Contents related to climate smart forest management and related Ethiopian case studies suggested to include under chapter 3
9	Horticulture			❖ No courses given in the pregame related to climate change	❖ Suggested to give concepts of CIS, CRM and CSA as a short course
10	ANIMAL SCIENCE	No courses related to climate change		❖ No courses given in the pregame related to climate change	❖ Suggested to give concepts of CIS, CRM and CSA as a short course

**** Gaps analysis** presented in this document reflects only the relative gaps in BSc. programs courses in contrast with the course description and content of CIS, CRM and CSA.

3. Conclusions and Recommendations

The agricultural sector in Ethiopia are highly climate-dependent. More than 95% of farmed land grows crops under rain-fed agriculture. Given a continually increasing trends of climate changes and variabilities, the country is expected to get hotter in the foreseeable future. Increase in atmospheric temperature and changes in rainfall patterns are expected to adversely affect the production and productivity of agriculture in Ethiopia. This situation will increase small farm households' vulnerability to climate-related shocks that may induce food insecurity, malnutrition, diet-related non-communicable diseases and large-scale displacements. On the other hand, in Ethiopia Agriculture contributes significantly to climate change, accounting for about 55% of total greenhouse gas emissions (GHG). This implies the importance of creating synergy between adaptation and mitigation strategies and actions to increase the efficiency and effectiveness of the efforts to tackle climate change related challenges. Since there is no vaccine to climate change, equipping next generation agricultural science graduates with the concepts of CIS and CSA are one of the best way to address climate change related challenges and envision knowledge-based innovative practices that strengthen adaptation to climate change and leverage mitigation actions. However, in the undergraduate agricultural curricula, the concept of CIS and CSA were not adequately incorporated into the existing climate related courses. Thus, the concept of CIS and CSA that bring productivity gains, enhance resilience and reduce emissions needs to be integrated into the existing climate related courses of the undergraduate agricultural program. Lastly, this study focused only courses offered in undergraduate program but Agricultural policies and strategies usually developed by MSc and PhD holders. Thus, we suggest conducting a gap analysis for post-graduate programs to integrate the concept of CIS and CSA.

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Appendix 1: Climate-related courses offered with the integration of CIS and CSA in the undergraduate agricultural curricula in Ethiopian Higher Education Institute

Program: NATURAL RESOURCES MANAGEMENT

Course 1 Title and Code: Climatology and Agrometeorology (NaRM 272)

Course Credit; Cr. Hr./ECTS: 3(2+1)/5

Course Structure:

The actual performance of the students shall be evaluated against the intended learning outcomes continuously during the study. Generally, evaluation of learning outcomes should be made by the following method of assessment depending on the nature of the course, which may include, quizzes and tests, practical report, assignment, mid and final semester written exam.

COURSE DESCRIPTION:

This course covers general topics of the impact of weather and climate that give an insight into the basics of theoretical principles and their applications in Agriculture. Description of Climatic system and their interaction, Climatic controls and climatic elements, observation, and measurements of climatic elements, the nature, and scope of climatology and Agrometeorology, the importance of weather and climate for agricultural activities. Atmospheric composition structure and stability, The Greenhouse effect, Solar radiation and energy balance, general atmospheric circulation and thermal circulation link with climate, organized weather systems, including air masses, fronts, and severe weather. Global and local climates classification, factors affecting the climatic system of Ethiopia, Agro-Climate Classification of Ethiopia, Adverse effects of weather and climate on Agriculture and its management, use of weather and climate forecast for Agrometeorology advisory and response farming, Agrometeorological observation and forecast, micro-meteorological modification, Climate data sets, and processing, analyzing and interpreting meteorological and climatological data in a variety of applied contexts.

Course Objective

Students will be able to

- Define various terms related to weather, Climate, Climatology, Meteorology, Agro-meteorology, and Agro-Climate
- Explain factors affecting the spatial distributions of climate
- Explain basic concepts about the atmosphere and its characteristics
- Operate weather Instruments and understand units of measurements of weather variables
- Explain basic concepts of Climate/weather and its variables
- Identify the concepts and have skills of climate classification
- Identify on inter-relationship between climate and Agriculture

- Obtain the skills of weather and climate data processing, interpretation and analysis

COURSE OUTLINE:

1. INTRODUCTION

1.1 Concepts and Definitions of key terms;
1.2 Nature and Scope of Climatology and Agro-meteorology
1.3 Application of Climatology and Meteorology on Agriculture

2. **DESCRIPTION OF THE CLIMATIC SYSTEM AND CLIMATIC CONTROLS**

2.1. The Components of Earth's Climate System
2.2. Interactions Between Earth's Climate System
2.3. Climatic Controls and Climatic Elements
2.4. Human Impacts on Weather and Climate
2.5. Observation and Measurement of Climatic Data
2.6. Characteristics of climate information service
2.7. Climate Data Processing and Analysis
2.8. Climate information service products
2.9 Climate service communication strategies

3. ATMOSPHERIC COMPOSITION, STRUCTURE, AND STABILITY

3.1. Atmospheric Composition
3.2. Greenhouse Gases and their Effect on Atmosphere
3.3. Aerosol and its Effects
3.4. Vertical Structure of the Atmospheric Temperature, Pressure, Density, and Mass
3.5. Layers of the Atmosphere
3.6. Atmospheric Moisture
3.7. Atmospheric Stability
3.8. Cloud Development and Stability

4**. SOLAR RADIATION AND SURFACE ENERGY BALANCE**

4.1. Source of Heat for Climatic System
4.2. Factors Affecting Incoming Solar Radiation
4.3. Interaction of Radiation with Atmosphere
4.4. Controls of Radiation and Temperature
4.5. Annual Solar Energy Balance

5**. GENERAL ATMOSPHERIC CIRCULATION AND CLIMATE**

5.1. Scales of Atmospheric Motion
5.2. Horizontal Surface Pressure and Winds Movements
5.3. The Driving Force of Atmospheric Motions
5.4. Atmospheric General Circulation and Precipitation Patterns
5.5. Air mass movement and frontal system
5.6. Tropical and extra-tropical cyclones
5.7. Regional wind systems
5.8. The Monsoon winds circulation

5.9. Intertropical Convergence Zone (ITCZ)
5.10. Atmospheric circulation about El Nino and La Nina (ENSO)

6. GLOBAL CLIMATE CLASSIFICATION AND SEASONAL CLIMATE OF ETHIOPIA

6.1. Overview of Global Climate Classification Concept
6.2. Methods of Climate Classification
6.3. Rainfall Distribution in Ethiopia
6.4. Rainfall Regime of Ethiopia
6.5. Climate Types of Ethiopia
6.6. Agro-climate Classification of Ethiopia
6.7. Factors Affecting Ethiopian Weather and Climate System
6.8. Impacts of various ENSO phase on Ethiopian Climate

7. ADVERSE EFFECTS OF WEATHER AND CLIMATE VARIABILITY ON AGRICULTURE

7.1. Potential Impacts of Climate Variability on Agriculture
7.2. Seasonal Rainfall Variability and Its Role in Agricultural
7.3. Extreme Weather and Climate Events
7.4. Effects of Drought on Crops Growth
7.5. Effects of Excess Rainfall (waterlogging)
7.6. Effects of Extreme Temperature on Plant
7.7. Weather and Climate caused Damage due to Plant's Pathogens
7.8. Effects of Heat and Humidity on Livestock
7.9. Water Budget, Climate Variability, and Climate Impacts
7.10. Concept, Characteristics and Pillars of Climate Smart Agriculture

8. USE OF WEATHER AND CLIMATE OUTLOOK FOR RESPONSE FARMING

8.1. The importance of CIS in climate risk management
8.2. Foundations of Weather Forecasting
8.3. Type of Forecasts on Time and Spatial Scale
8.4. Weather Forecasting Methods and Tools
8.5. Extreme Weather and Climate Events
8.5. Climate Prediction
8.6. Interpretation of Observed and Predicted Map and Graph of Weather and Climate
8.7. Application of ENSO Forecasts for Agricultural Decision Making
8.8. Benefits of Weather and Climate Services
8.9. Role of Agricultural Meteorology in Decisions Making
8.10. Severe Weather Observation and Early Warning
8.11. Application of Weather and Climate Outlook for Agro-met Advisories
8.12. Ago-meteorological Observation and Forecast
8.13. Response Farming based on Forecasted Seasonal Climate
8.14. Micro-meteorological Modification in Agro-meteorology

8.15. Climate Risk Management in Agricultural Development

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Course 2 Title and Code: Climate Change Adaptation and Mitigation (NaRM331)
Course Credit; Cr. Hr./ECTS: 2(2+0)/3

Class Year III; Sem.I

COURSE STRUCTURE:

The actual performance of the students shall be evaluated against the intended learning outcomes continuously during the study. Generally, evaluation of learning outcomes should be made by the following method of assessment depending on the nature of the course, which may include, quizzes and tests, assignments, mid and final semester written exam, practical exam

COURSE DESCRIPTION:

This course covers general topics of the impact of climate change and its adaptation that give an insight into the basics of theoretical principles and their applications in the Environment. The course gives an overview of the physical science of our climate system, Patterns and causes of climate change, greenhouse effect, and evidence of climate changes. The Earth's climate history, a survey of proxy records of past climate and environmental changes, and the limitations of these proxy records. Earth's energy balance, the interaction of the climatic system, and the basic mechanisms that govern the climate system respond to drivers of change. Climate Forcing, Response, Sensitivity and Feedback Mechanisms, Overview of Global Climate Models and Climate Change. Potential Impact of climate change on natural resources, impact, vulnerability, resilience; Impacts of climate change and possible scenarios; Explore climate change from multiple perspectives: paleoclimatic change, recent historical variability, and change, future climate projections as well as its impacts on Natural resources, social, environmental and economic issues. Exploring Adaptation and Mitigation Strategy of Climate Change impacts, Climate change policy and law, and Overview of Impacts of Climate change and adaptation in Ethiopia.

Course Objective

This course aims to give a fundamental understanding of the scientific basis of the cause and impacts of global climatic change and its adaptation and mitigation strategy.

Upon completion of this course, students will be able to:

- Explain and evaluate the evidence for human-caused climate change, in the context of historical climate change, as well as the relevant scientific uncertainties and possible evidence to the contrary
- Describe the components, drivers, and interactions of climate, at global and local levels
- Students will be able to explain the elements of climate and analyze the earth's energy balance that affects climate change.
- Students will be able to identify various sources of evidence used to chart climate and apply the evidence to determine the proximate and ultimate causes

- ❖ Students will be able to analyze the impact of climate change on environmental, biological, and social systems.
- ❖ Identify potential responses and solutions to climate change challenges, as well as assess their feasibility and potential effectiveness

COURSE OUTLINE

1**. INTRODUCTION**

1.1. Concept and Definitions of key terms;
1.2. Basic Climate Change Science
1.3. Evidence for Global Climate Change in the Recent, Past and Future
1.4. Cause of Global Climate Change
1.5. Consequences of Global Climate Change

2. HISTORICAL CLIMATE CHANGE AND DATA PROCESSING

2.1. The Nature of Earth's Climate Science
2.2. Past Climate Observations and Abrupt Climate Changes
2.3. The Components of Earth's Climate System
2.4. Gases Composition in the Atmosphere
2.5. Greenhouse Gases Effect
2.6. Climate Construction from Instrumental Data
2.7. Paleoclimate Reconstruction from Proxy Data
2.8. Data Analysis Methods in Weather and Climate Research

3. CLIMATE FORCING, RESPONSE, SENSITIVITY AND FEEDBACK MECHANISMS

3.1. Characteristics of climate information service
3.2.Types and Roles of climate information service
3.3.Climate information service products
3.4.The importance of CIS in risk management
3.5.Concept of Climate Forcing and Feedbacks
3.6. Major Climate Forcing
3.7.Positive & Negative Forcing
3.8.External and Internal Forcing Mechanisms of Earth System
3.9.Equilibrium, Sensitivity and Transient Climate Response
3.10. Climate Feedback and Feedback Process

4. **GLOBAL CLIMATE MODELS AND CLIMATE CHANGE**

4.1.Modeling Concepts
4.2.Components of the Climate System
4.3.Process in Each Climatic System
4.4.Climate Model Components
4.5.Timeline of Climate Model Development
4.6.Special Report on Emission Scenarios (SRES)
4.7.Global Climate Projection under Different Representative Concentration Path (RCP)
4.8.Interpretation and Applications of Climate Model Output

4.9.Sources of Uncertainty in Climate Models

5. **IMPACTS, ADAPTATION, AND MITIGATION OF CLIMATE CHANGE**

5.1. Impacts of Climate Change on Agriculture, Water cycle, Health, and Environment

5.1.1. Ecosystems, biodiversity, and ecosystem services

5.1.2. Plant pests and disease

5.1.3. Future climate changes, risks, and impacts

5.1.4. Climate change and extreme weather events

5.2. Climate Change Impact Adaptation

5.2.1. How to adapt to climate change

5.2.2. Assessing and managing the risks of climate change

5.2.3. Climate services for disaster prevention

5.2.4. Climate change adaptation strategy

5.2.5. Adaptation now and in the future

5.3. Mitigation of Climate Change

5.3.1. Low emission land-use planning

5.3.2. Carbon measurement & monitoring

5.3.3. Carbon trading

5.3.4. The various international climate change agreements or global environmental accords (e.g., UNFCCC, the Kyoto Protocol, valid action plan)

5.3.5. Legal and policy frameworks

5.4.Climate information service for adaptation and mitigation strategy

5.5.Climate-smart Natural Resource Management

5.6.Climate Risk Management in Natural resource

6. **CLIMATE CHANGE IMPACT, ADAPTATION, AND MITIGATION IN ETHIOPIA**

6.1. Climate Change Impacts in Ethiopia

6.1.1. Historical evidence of climate change

6.1.2. Future risk of climate change

6.2. Adaptation and Mitigation Strategy

6.2.1. Different approaches to climate change adaptation

6.2.2. The national environmental policy: The strength and weakness of the policy

6.2.3. The national environmental laws

6.2.4. Sources of national environmental laws

6.2.5. Challenges & opportunities on climate change adaptation and mitigation (e.g., MRV system)

6.3. Climate-smart Natural Resource Management Ethiopian Case Studies

REFERENCES

- Houghton, J., & Firor, J. (1995). Global warming: The complete briefing. Nature, 373(6509), 30-30.
- Sene, K. (2010). *Hydrometeorology*. Springer.

- Rafferty, J. P. (Ed.). (2010). Climate and Climate Change. Britannica Educational Publishing.
- Singh, S. N. (Ed.). (2009). *Climate change and crops*. Springer Science & Business Media
- Benjamin J R., Yves Le B., Heather M., Stepan W. (eds) (2011). Climate Law and Developing Countries: Legal and Policy Challenges for the World Economy (Edward Elgar Publishing, 2011)
- Dowden, M. (2013). Climate change and sustainable development: law, policy, and practice. Taylor & Francis
- McCarthy, J. J. (2001). Climate change 2001: impacts, adaptation, and vulnerability: contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Program: ENVIRONMENTAL SCIENCES PROGRAM (BSc)

Course 1 Title and Code: Climatology and Meteorology (EnSc222)

Course Credit; Cr. Hr./ECTS: 3(2+1)/5

Class Year II; Sem.II

COURSE STRUCTURE

The actual performance of the students shall be evaluated against the intended learning outcomes continuously during the study. Generally, evaluation of learning outcomes should be made by the following method of assessment depending on the nature of the course, which may include, quizzes and tests, assignments, mid and final semester written exam, practical exam

COURSE DESCRIPTION:

This course covers general topics of impact of weather and climate that give an insight into basics of theoretical principles and their applications in Environmental risk management. This course will introduce and discuss the basic topics of weather and climate, climatic system and controls, interaction among climatic system, observation and measurement of climatic elements, Atmospheric composition structure and stability. Atmospheric humidity and precipitation; Solar radiation and surface energy balance, Atmospheric general circulation and thermal circulation link with climate, Temperature; Atmospheric pressure and wind systems; El Nino, La Nina and the monsoon; organized weather systems, including air masses, fronts, and severe weather. Global and local climate classification, factors affecting climatic system of Ethiopia, Agroclimate Classification of Ethiopia, tools of applied climatology, adverse effects of weather and climate on our life and activity, Topics include: Synoptic Climatology and Meteorology; Climate and Agriculture; Climate and Energy; Climate and Human health; Urban and Climate and how its concepts can be used in everyday planning and operations. Weather forecasting, Climate data sets and processing, analyzing and interpreting meteorological and climatological data in a variety of applied contexts, application weather and climate forecast for managing Environmental related risk

Course Objectives

At the end of this course, students will be able to:

- Define various terms related to weather, Climate, Climatology, Meteorology, Agrometeorology and Agro-Climate.
- Explain basic concepts about the atmosphere and its characteristics
- Explain basic concepts of Climate/weather and its variables
- Explain factors affecting the spatial distributions of climate
- Identify the concepts and have skills of climate classification
- Operate weather Instruments and understand units of measurements of weather variables

- Identify on inter-relationship between climate and Agriculture
- Familiar with some of the key interactions between weather and climate with selected human and environmental systems.
- Obtain the skills of weather and climate data processing, interpretation and analysis
- Obtain the skills of weather and climate forecast for early warning application

COURSE OUTLINE

1. INTRODUCTION

1.1. Concepts and Definitions of key terms;
1.2. Nature and Scope of Meteorology and Climatology
1.3. Application of Climatology and Meteorology on Environment and Society

2. DESCRIPTION OF THE CLIMATIC SYSTEM AND CLIMATIC CONTROLS

2.1. The Components of Earth's Climate System
2.2. Interactions in the Climate System
2.3. Climatic Controls and Climatic Elements
2.4. Human Impacts on Weather and Climate
2.5. Observation and Measurement of Climatic Data
2.6. Characteristics of climate information service
2.7. Climate Data Processing and Analysis

3. ATMOSPHERIC COMPOSITION, STRUCTURE AND STABILITY

3.1. Atmospheric Composition
3.2. Greenhouse Gases and its Effect in Atmosphere
3.3. Aerosol and its Effects
3.4. Vertical Structure of the Atmospheric Temperature, Pressure, Density, and Mass
3.5. Layers of the Atmosphere
3.6. Atmospheric Moisture
3.7. Atmospheric Stability
3.8. Cloud Development and Stability

4. SOLAR RADIATION AND SURFACE ENERGYBALANCE

4.1. Source of Heat for Climatic System
4.2. Factors Affecting Incoming Solar Radiation
4.3. Interaction of Radiation with Atmosphere
4.4. Controls of Radiation and Temperature
4.5. Annual Solar Energy Balance

5. GENERAL ATMOSPHERIC CIRCULATION AND CLIMATE

5.1. Scales of Atmospheric Motion
5.2. Horizontal Surface Pressure and Winds Movements
5.3. The Driving Force of Atmospheric Motions
5.4. Atmospheric General Circulation and Precipitation Patterns
5.5. Moisture, aerosol, temperature and heat transfer
5.6. Air mass movement and frontal system

5.7. Tropical and extra-tropical cyclones
5.8. Regional wind systems
5.9. The Monsoon winds circulation
5.10. Inter tropical Convergence Zone (ITCZ)
5.11. Atmospheric circulation in relation to El Nino and La Nina (ENSO) events
5.12. Thermal Messo-scale wind currents

6. GLOBAL CLIMATE AND SEASONAL CLIMATE OF ETHIOPIA

6.1. Overview of Global Climate Classification Concept
6.2. Methods of Climate Classification
6.3. Global Patterns of Climate
6.4. Rainfall Distribution in Ethiopia
6.5. Rainfall Regime of Ethiopia
6.6. Climate Types of Ethiopia
6.7. Agro-climate Classification of Ethiopia
6.8. Factors Affecting Ethiopian Weather and Climate System
6.9. Impacts of various ENSO phase on Ethiopian Climate

7. ADVERSE EFFECTS OF WEATHER AND CLIMATE ON OUR LIVES

7.1. The Link Between Climate and Society
7.2. Adverse Effects on Environment
7.3. Adverse Effects of Weather and Climate on Soil, Water and Plant we Use
7.4. Adverse effects on Human Health, Comfort, and Behavior
7.5. Concept, Characteristics and Pillars of Climate Smart Agriculture
7.6. Effects of Weather and Climate on Logistical Decisions and Energy Resource
7.7. Adverse Effects on Building Climatology

8. USE OF WEATHER AND CLIMATE PREDICTIONS FOR RISKMANAGEMENT

8.1. Foundations of Weather Forecasting
8.2. Type of Forecasts on Time and Spatial Scale
8.3. Weather Forecasting Methods and Tools
8.4. Extreme Weather and Climate Events
8.5. Climate Prediction
8.6. Interpretation of Observed and Predicted Map and Graph of Weather and Climate
8.7. The importance of CIS in climate risk management
8.8. Severe Weather Observation and Early Warning
8.9. Application of ENSO Forecasts for Early Warning
8.10. Climate Risk Management practices in Agricultural Development

REFRENCES

- Stigter, K. (Ed.). (2010). Applied agro-meteorology. Springer Science & Business Media.

- Frederick K. Lutgens Edward J. Tarbuck (2013). The Atmosphere and an introduction to meteorology, 12th edition.
- Gonfa, L.1996. Climatic Classification of Ethiopia NMSA, Addis Ababa, Ethiopia
- Donald C. Ahrens, Stigter, K. (Ed.) (2010). Essentials of meteorology an invitation to the atmosphere.3rd edition, Applied agro-meteorology. Springer Science and Business Media.
- Harrison.M, Troccoli A, Coughlan M and Williams. J. 2007. Seasonal Climate Forecast. In: Troccoli, Harrison, Anderson, Mason (eds.), Seasonal Climate Forecasting and Managing risk. Springer Academic Publishers, London.

Course 2 Title and Code: Climate Chang Mitigation and Adaptation (EnSc222)

Course Credit; Cr. Hr./ECTS: 2(2+0)/3

Class Year III; Sem.I

COURSE STRUCTURE:

The actual performance of the students shall be evaluated against the intended learning outcomes continuously during the study. Generally, evaluation of learning outcomes should be made by the following method of assessment depending on the nature of the course, which may include, quizzes and tests, assignments, mid and final semester written exam, practical exam

COURSE DESCRIPTION:

This course covers general topics of impact of climate change and its adaptation that give an insight into basics of theoretical principles and their applications in Environment. The course gives an overview of the physical science of our climate system, Patterns and causes of climate change, greenhouse effect and evidence of climate changes. The Earth's climate history, a survey of proxy records of past climate and environmental changes and the limitations of these proxy records. Earth's energy balance, interaction of climatic system and the basic mechanisms that govern climate system responds to drivers of change. Climate Forcing, Response, Sensitivity and Feedback Mechanisms, Overview of Global Climate Models and Climate Change. Potential Impact of climate change on natural resources, Environment, vulnerability, resilience; Impacts of climate change and possible scenarios; Explore climate change from multiple perspectives: paleoclimatic change, recent historical variability and change, future climate projections as well as its impacts on Natural resources, social, Environmental and economic issues. It explores Adaptation and Mitigation strategy of Climate Change impacts, Climate change policy and law, and Overview of Impacts of Climate change and adaptation in Ethiopia.

Course Objectives

Upon completion of this course, students will be able to:

- Explain and evaluate the evidence for human-caused climate change, in the context of historical climate change, as well as the relevant scientific uncertainties and possible evidence to the contrary
- Describe the components, drivers, and interactions of climate, at global and local levels
- Students will be able to explain the elements of climate and analyze the earth's energy balance that affects climate change.
- Students will be able to identify various sources of evidence used to chart climate and apply the evidence to determine the proximate and ultimate causes.

- Identify potential responses and solutions to climate change challenges, as well as assess their feasibility and potential effectiveness

COURSE DESCRIPTION

1. INTRODUCTION

1.1. Concept and Definitions of Key Terms
1.2. Basic Climate Change Science
1.3. Evidence for Global Climate Change in the Recent Past and Future
1.4. Cause of Global Climate Change
1.5. Consequences of Global Climate Change

2. HISTORICAL CLIMATE CHANGE AND DATA PROCESSING

2.1. The Nature of Earth's Climate Science
2.2. Past Climate Observations and Abrupt Climate Changes
2.3. The Components of Earth's Climate System
2.4. Gases Composition in the Atmosphere
2.5. Greenhouse Gases Effect
2.6. Climate Construction from Instrumental Data
2.7. Paleoclimate Reconstruction from Proxy Data
2.8. Data Analysis Methods in Weather and Climate Research

3. CLIMATE FORCING, RESPONSE, SENSITIVITY AND FEEDBACK MECHANISMS

3.1. Characteristics of climate information service
3.2. Types and Roles of climate information service
3.3. Climate information service products
3.4. The importance of CIS in risk management
3.5. Concept of Climate Forcing and Feedbacks
3.6. Major Climate Forcing
3.7. Positive and Negative Forcing
3.7. External and Internal Forcing Mechanisms of Earth System
3.8. Equilibrium, Sensitivity and Transient Climate Response
3.9. Climate Feedback and Feedback Process

4. GLOBAL CLIMATE MODELS AND CLIMATE CHANGE

4.1. Modeling Concepts
4.2. Components of the Climate System
4.3. Process in each Climatic System
4.4. Climate Model Components
4.5. Timeline of Climate Model Development
4.6. Special Report on Emission Scenarios (SRES)
4.7. Global Climate Projection under Different Representative Concentration Path (RCP
4.8. Interpretation and Applications of Climate Model Output

4.9. Sources of Uncertainty in Climate Models

5. IMPACTS, ADAPTATION AND MITIGATION OF CLIMATE CHANGE

5.1. Impacts of Climate Change on Agriculture, Water cycle, Health and Environment

5.1.1. Ecosystems, biodiversity and ecosystem services

5.1.2. Plant pests and disease

5.1.3. Future climate changes, risks and impacts

5.1.4. Climate change and extreme weather events

5.2. Climate information service for adaptation and mitigation strategy

5.3. Climate Change Impact Adaptation

5.3.1. How to adapt to climate change

5.3.2. Assessing and managing the risks of climate change

5.3.3. Climate services for disaster prevention

5.3.4. Climate change adaptation strategy

5.3.5. Adaptation now and in the future

5.4. Mitigation of Climate Change

5.4.1. Low emission land use planning

5.4.2. Carbon measurement and monitoring

5.4.3. Carbon trading

5.5. Climate-smart natural resource management

5.3.4. The various international climate change agreements or global environmental accords (e.g., UNFCCC, Kyoto protocol, Bali Action Plan)

5.3.5. Legal and policy frame works

6. CLIMATE CHANGE IMPACT, ADAPTATION AND MITIGATION IN ETHIOPIA

6.1. Climate Change Impacts in Ethiopia

6.1.1. Historical evidences of climate change

6.1.2. Future risk of climate change

6.2. Adaptation and Mitigation Strategy

6.2.1. Different approaches of climate change adaptation

6.2.2. The national environmental policy: The strength and weakness of the policy

6.2.3. The national environmental laws

6.2.4. Sources of national environmental laws

6.2.5. Challenges and opportunities on climate change adaptation and mitigation (e.g., MRV system)

6.3. Climate-smart natural resource management Ethiopian case studies

REFERENCES

- Houghton, J., & Firor, J. (1995). Global warming: The complete briefing. Nature, 373 (6509), 30-30.
- Sene, K. (2010). Hydrometeorology. Springer.

- Rafferty, J. P. (Ed.). (2010). Climate and Climate Change. Britannica Educational Publishing.
- Singh, S. N. (Ed.). (2009). Climate change and crops. Springer Science & Business Media
- Dowden, M. (2013). Climate change and sustainable development: law, policy and practice. Taylor & Francis.
- Benjamin J R., Yves Le B., Heather M., Stepan W. (eds) (2011). Climate Law and Developing Countries: Legal and Policy Challenges for the World Economy (Edward Elgar Publishing, 2011)
- McCarthy, J. J. (2001). Climate change 2001: impacts, adaptation, and vulnerability: contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Program: PLANT SCIENCE PROGRAM (BSc)
Course 1 Title and Code: Climatology and Agrometeorology (NaRM 251)

Course Credit; Cr. Hr./ECTS: 2(1+1)/3

Class Year II; Sem.I

COURSE STRUCTURE:

The actual performance of the students shall be evaluated against the intended learning out comes continuously during the course of the study. Generally, evaluation of learning outcomes will be made by the following method of assessment depending on the nature of the course, which may include, quizzes and tests, assignment, mid and final semester written exam.

COURSE DESCRIPTION

This course covers general topics of impact of weather and climate that give an insight into basics of theoretical principles and their applications in agriculture; description of climatic system and their interaction, climatic controls and climatic elements, observation and measurements of climatic elements, the nature and scope of climatology and agrometeorology, importance of weather and climate for agricultural activities; atmospheric composition structure and stability, the greenhouse effect; solar radiation and energy balance, general atmospheric circulation and thermal circulation link with climate, organized weather systems, including air masses, fronts, and severe weather; global and local climates classification, factors affecting climatic system of Ethiopia, agro-climate classification of Ethiopia, adverse effects of weather and climate on agriculture and its management, use of weather and climate forecast for agrometeorology advisory and response farming, agro-meteorological observation and forecast, micro-meteorological modification, climate data sets and processing, analyzing and interpreting meteorological and climatological data in a variety of applied contexts.

Course Objective

By the end of the course, students will be able to:

- Define various terms related to weather, climate, climatology, meteorology, agro-meteorology and agro-climate
- Explain factors affecting the spatial distributions of climate
- Explain basic concepts about the atmosphere and its characteristics
- Operate weather instruments and understand units of measurements of weather variables
- Explain basic concepts of climate/weather and its variables
- Identify the concepts and have skills of climate classification
- Identify on inter-relationship between climate and agriculture
- Obtain the skills of weather and climate data processing, interpretation and analysis; and
- Obtain the skills of seasonal climate outlook for response farming and early warning application.

COURSE OUTLINE

1. INTRODUCTION

1.1 Concepts and Definitions of key terms;

1.2 Nature and Scope of Climatology and Agro-meteorology

1.3 Application of Climatology and Meteorology on Agriculture

2. **DESCRIPTION OF THE CLIMATIC SYSTEM AND CLIMATIC CONTROLS**

2.1. The Components of Earth's Climate System

2.2. Interactions Between Earth's Climate System

2.3. Climatic Controls and Climatic Elements

2.4. Human Impacts on Weather and Climate

2.5. Observation and Measurement of Climatic Data

2.6. Characteristics of climate information service

2.7. Climate Data Processing and Analysis

2.8. Climate information service products

2.9 Climate service communication strategies

3. ATMOSPHERIC COMPOSITION, STRUCTURE, AND STABILITY

3.1. Atmospheric Composition

3.2. Greenhouse Gases and their Effect on Atmosphere

3.3. Aerosol and its Effects

3.4. Vertical Structure of the Atmospheric Temperature, Pressure, Density, and Mass

3.5. Layers of the Atmosphere

3.6. Atmospheric Moisture

3.7. Atmospheric Stability

3.8. Cloud Development and Stability

4**. SOLAR RADIATION AND SURFACE ENERGY BALANCE**

4.1. Source of Heat for Climatic System

4.2. Factors Affecting Incoming Solar Radiation

4.3. Interaction of Radiation with Atmosphere

4.4. Controls of Radiation and Temperature

4.5. Annual Solar Energy Balance

5**. GENERAL ATMOSPHERIC CIRCULATION AND CLIMATE**

5.1. Scales of Atmospheric Motion

5.2. Horizontal Surface Pressure and Winds Movements

5.3. The Driving Force of Atmospheric Motions

5.4. Atmospheric General Circulation and Precipitation Patterns

5.5. Air mass movement and frontal system

5.6. Tropical and extra-tropical cyclones

5.7. Regional wind systems

5.8. The Monsoon winds circulation

5.9. Intertropical Convergence Zone (ITCZ)
5.10. Atmospheric circulation about El Nino and La Nina (ENSO)

6. GLOBAL CLIMATE CLASSIFICATION AND SEASONAL CLIMATE OF ETHIOPIA

6.1. Overview of Global Climate Classification Concept
6.2. Methods of Climate Classification
6.3. Rainfall Distribution in Ethiopia
6.4. Rainfall Regime of Ethiopia
6.5. Climate Types of Ethiopia
6.6. Agro-climate Classification of Ethiopia
6.7. Factors Affecting Ethiopian Weather and Climate System
6.8. Impacts of various ENSO phase on Ethiopian Climate

7. ADVERSE EFFECTS OF WEATHER AND CLIMATE VARIABILITY ON AGRICULTURE

7.1. Potential Impacts of Climate Variability on Agriculture
7.2. Seasonal Rainfall Variability and Its Role in Agricultural
7.3. Extreme Weather and Climate Events
7.4. Effects of Drought on Crops Growth
7.5. Effects of Excess Rainfall (waterlogging)
7.6. Effects of Extreme Temperature on Plant
7.7. Weather and Climate caused Damage due to Plant's Pathogens
7.8. Effects of Heat and Humidity on Livestock
7.9. Water Budget, Climate Variability, and Climate Impacts
7.10. Concept, Characteristics and Pillars of Climate Smart Agriculture

8. USE OF WEATHER AND CLIMATE OUTLOOK FOR RESPONSE FARMING

8.1. The importance of CIS in climate risk management
8.2. Foundations of Weather Forecasting
8.3. Type of Forecasts on Time and Spatial Scale
8.4. Weather Forecasting Methods and Tools
8.5. Extreme Weather and Climate Events
8.5. Climate Prediction
8.6. Interpretation of Observed and Predicted Map and Graph of Weather and Climate
8.7. Application of ENSO Forecasts for Agricultural Decision Making
8.8. Benefits of Weather and Climate Services
8.9. Role of Agricultural Meteorology in Decisions Making
8.10. Severe Weather Observation and Early Warning
8.11. Application of Weather and Climate Outlook for Agro-met Advisories
8.12. Ago-meteorological Observation and Forecast
8.13. Response Farming based on Forecasted Seasonal Climate
8.14. Micro-meteorological Modification in Agro-meteorology

8.15. Climate Risk Management in Agricultural Development

REFERENCES

- Stigter, K. (Ed.). (2010). Applied agrometeorology. Springer Science & Business Media.
- The Atmosphere and an introduction to meteorology,12th edition. (2013). Frederick K. Lutgens Edward J. Tarbuck
- Gonfa, L.1996. Climatic Classification of Ethiopia NMSA, Addis Ababa, Ethiopia
- Harrison.M, Troccoli A, Coughlan M and Williams. J. 2007. Seasonal Climate Forecast. In: Troccoli, Harrison, Anderson, Mason (eds.), Seasonal Climate Forecasting and Managing risk. Springer Academic Publishers, London.

Program: RANGELAND ECOLOGY AND BIODIVERSITY PROGRAM
Course 1 Title and Code: Climate Change Adaptation and Mitigation (REBD432)

Course Credit; Cr. Hr./ECTS: 2(2+0)/3

Class Year IV; Sem.II

COURSE STRUCTURE

The assessment will be made mainly through assignments, tests and examination. Students are also expected to review articles and present to the class and the best ones to a wider audience. Continuous assessment: article review, assignments, tests and Final exam

COURSE DESCRIPTION:

The course gives a brief introduction to the science of climate change, reviews the climate change impacts on the status of natural rangeland and biodiversity, the trend in magnitude and the frequency of climatic extremes and change in average climatic conditions. Climate change indicators; climate and land use/land cover changes; climate change adaptation and technological needs; adaptation and coping mechanisms; national and local adaptation strategies; ecosystem change adaptation mechanisms; vulnerability analysis and adaptation need, climate change risk reduction and risk sharing strategies; relations and synergy between adaptation, development and environment; adaptive capacity analysis.

Learning outcomes:

Successful completion of this course will make students able to:

- Explain cause of global warming, as well as emission trends and driving forces that are responsible for fossil fuel emissions and deforestation;
- Identify technological options to reduce emissions, their barriers and costs and co-benefits;
- Explain climate policy tools, their theoretical merits and practical experiences;
- Explain the understanding of climate mitigation in difference disciplines and the discipline's contribution to climate mitigation;
- Recognize co-benefits, trade-offs, potentials, and limitations of a wide range of climate change mitigation options, from the energy to the land sector (including negative emission technologies and geoengineering);
- Understand the implications of climate change for disaster risk management;
- Present the causes, trends and impacts and introduces options – methods, tools; and
- Able to consider for integrating climate change in disaster risk management so that ecological biodiversity and natural rangeland resources will better be managed.

COURSE CONTENT:

1. Introduction

1.1. Concepts and definitions of key terms

1.2. History of climate and the Earth System

1.3. The Components of Earth's Climate System and their role and interactions

1.4. Observing and modeling the Climate

1.5. Main feature of Ethiopian Climate

1.6. General atmospheric circulation

1.7. Climate variability and change

1.8. Evidence for Global Climate Change

1.9. Observed trends and impacts of climate change

1.10. Projected trends and impacts of climate change

1.11. Major greenhouse gases and their emissions (livestock, plants)

1.12. Characteristics of climate information service

1.13. Climate information service products

1.14. The importance of CIS in climate risk management

2. Climate Change Scenarios in Africa and Global Contexts

2.1. Why does climate change threaten biodiversity?

2.2. Implications of rapidly rising CO2

2.3. Global fingerprints of climate change on biodiversity

2.3.1. Can climate change cause extinctions of local populations?

2.3.2. Species loss and system degradation with emphasis to biodiversity & vulnerability indices

3. Climate Change Impacts on Natural Rangeland and Biodiversity

3.1. Impacts of climate variability and change on soil health, and environment,

3.2. Impacts of climate variability and change on plant-water interactions and biodiversity

3.3. The vulnerability of rangeland-based livelihoods to climate change

3.4. Concept, Characteristics and Pillars of Climate Smart Agriculture

3.5. Climate Smart Natural Resource Ethiopian Case Studies

4. Interplay Between Rangeland Biodiversity, Climate Change and Food Security

4.1. Unsustainable grazing management:

4.2. Grazing-induced desertification and its impacts on biological diversity

4.3. Fire and land-conversion as drivers of degradation and GHG emissions;

4.4. Conversion of rangelands to cropland, including biofuel production

4.5. The role of rangeland biodiversity to combat climate change effects

5. Integrated Adaptation and Mitigation Solutions to Reduce Climate Change Vulnerability

5.1. Climate information service for adaptation and mitigation strategy

5.2. Climate risk management in rangeland

5.3. Improved grazing management, mitigation heat effects on livestock

5.4. Reversing degradation, restoration and rehabilitation of wetlands

5.5. Agroforestry practice (planting trees, grasses and shrubs)

6. Role of Traditional Communities on Climate Change Adaptation and Mitigation

6.1. Traditional knowledge/systems/

6.2. Skills/institutions/practices

7. Concepts on Neglected and Underutilized Species

REFERENCES

- Adams, R.M, Hurd, B.H, Lenhart, S and Leary, N. 1998. Effects of global Climate change on Agriculture: An Interpretative Review. Climate Research. 11: 19–30.
- Admassu H, Getinet M, Thomas TS, Waithaka M, Kyotalimye M. 2012. East African Agriculture and Climate Change: A Comprehensive Analysis – Ethiopia. Washington, DC: International Food Policy Research Institute.
- AETFAT Conference. 1994. The Biodiversity of African Plants.
- Brush, S.B. (ed.). 2000. Genes in the Field. On-Farm Conservation of Crop Diversity

Program: RURAL DEVELOPMENT AND AGRICULTURAL EXTENSION

Course 1 Title and Code: Introduction to Climate-Smart Agriculture (RDAE 242)

Course Credit; Cr. Hr./ECTS: 1(1+0)/2

Class year II: semester II

Course Description

Course objectives

At the end of this course, students will be able to:

- ☞ Knows the basic concepts of climate change and agriculture, and finally gender and social inclusion in CSA practices;
- ☞ Understand the definition of climate-smart agriculture and their practice and technology;
- ☞ Appreciates the importance of policies, strategies and institutions relevance to CSA practice in Ethiopia;
- ☞ Familiar with the enabling environments for CSA implementation activities;
- ☞ Create awareness on the existing CSA practices that promote agricultural productions;
- ☞ Explain the role of gender equality and social inclusion in CSA practices.

Course Outline:

1. Introduction to Climate change and the agriculture concept

1.1. Concepts and definitions of key terms
1.2. History of climate and the Earth System
1.3. The Components of Earth's Climate System and their role and interactions
1.4. Observing and modeling the Climate
1.5. Main feature of Ethiopian Climate
1.6. General atmospheric circulation
1.7. Climate variability and change
1.8. Evidence for Global Climate Change
1.9. Characteristics of climate information service
1.10. General overview of Climate change and the agriculture
1.11. Observed trends and impacts of climate change in agriculture
1.12. Projected trends and impacts of climate change in agriculture
1.13. The importance of CIS in climate risk management
1.14. Cause of CC on agricultural production
1.15. Consequence of CC on agricultural production
1.16. Methods to control CC effect on agricultural production
1.17. CC mitigation in agricultural production
1.18. CC adaptation in the agriculture production
1.19. Relationships between Climate change and the agriculture production

2. Introduction to Climate Smart Agriculture (CSA)

2.1. Concept of Climate-Smart Agriculture

2.2. Why is climate-smart agriculture needed?

2.3. Principles of defining CSA

2.4. The pillars of CSA

2.5. The climate-smart agriculture approach

3. Climate Smart Agriculture (CSA) Practices and Technologies

3.1. Definition of CSA Practices

3.2. CSA practices as a strategy to reduce climate risk in agriculture

3.3. Major components of CSA Practices and Technologies

- 3.3.1.CSA practices for water management
- 3.3.2.CSA practices for Soil Management
- 3.3.3.CSA practices for Crop production management
- 3.3.4.CSA practices for Livestock and range land Management
- 3.3.5. CSA practices for Sustainable forest management

3.4. CSA Knowledge Management

3.5. Role of agricultural extension to scaling up of CSA practices.

4. Policies, Strategies and Institutions relevant to CSA practice in Ethiopia

4.1. Policies and Strategies for CSA

4.2. Key institutions for CSA initiatives

4.3. Effectiveness of CSA Policies, Strategies and Institutions

4.4. Key challenges for Implementing CSA in Ethiopia

4.5. Untapped Opportunities for Implementing CSA

References

Lamboll R, Nelson V and Nathaniels N. 2011. *Emerging approaches for responding to climate change in African agricultural advisory services: Challenges, opportunities and recommendations for an AFAAS climate change response strategy.* AFAAS, Kampala, Uganda and FARA, Accra, Ghana.

Leslie Lipper, Nancy McCarthy, David Zilberman, Solomon Asfaw Giacomo Branca. 2018. Climate Smart Agriculture: Building Resilience to Climate Change,FAO, Rome.

Aklilu, A. and Alebachew, A. 2009. Assessment of climate change-induced hazards, impacts and responses in the southern lowlands of Ethiopia. Forum for Social Studies, Addis Ababa.

FAO. 2010. Climate-Smart" Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation. Paper prepared for Hague Conference on Agriculture, Food Security and Climate Change.

Sintayehu, W. 2011. Presentation made at the National Policy Workshop on Climate Change Adaptation and Mitigation. Climate Change Forum and CCAFS, 2011.

Program: AGRICULTURAL ECONOMICS PROGRAM (BSc)

Course 1 Title and Code: Economics of Climate Change (AgEc 462**)**

Course Credit; Cr. Hr./ECTS: 2(2+0)/3

Class year IV: semester II

Content Description

Climate Change in Agricultural Economics aims to provide students with a foundational understanding of climate change science, as well as the opportunity to think critically about its economic consequences and opportunities to apply that expertise in climate change response activities and market studies. The course covers theoretical understanding of the evolving climate system, as well as the causes of climate change and its biophysical implications. Implement and evaluate economic analyses of climate change. This study focuses on cost-benefit analyses of climate change mitigation, the role of adaptation, and alternative approaches to quantifying climate change impacts, particularly in agriculture and agricultural business. The course encourages critical thinking about economic analysis, including uncertainties about the underlying science and how to value costs and benefits; and the role of norms and values, especially concerning the health effects of climate change. The course also provides an introduction to the climate change policies and carbon emission arguments. Putting climate change in the framework of economic analysis, we can consider greenhouse gas emissions, which cause planetary warming and other changes in weather patterns, as both a cause of environmental externalities and a case of the overuse of a common property resource.

Course Objectives

At the end of the course, the student should be able to:

- ✓ Understand the concepts and theories of climate change
- ✓ Understand causes and relationships between agriculture and climate change.
- ✓ Describe climate change effects on major economic activities (agriculture, industry and service sectors) and impacts and contributions of these activities to climate change
- ✓ Explain and critically evaluate alternative approaches to assessing the economic effects of climate change, particularly in agriculture, and the role for adaptation and mitigation.
- ✓ Apply knowledge of the science and responses against climate change including climate smart agricultural practices, adoption and mitigation and effective communication strategies
- ✓ Apply cost and benefit analysis concepts in valuation of climate change damage in agriculture and cost and benefits climate change adaptation and mitigation practices
- ✓ Assess the link between climate change and food and nutrition security in developing countries

- ✓ Explain the scientific and economic implications of climate change in agriculture and develop ideas for effective policy responses in the context of your country

Topic One: Introduction to climate change

1.1.Concepts of climate change
1.2.Concepts and definitions of key terms
1.3.History of climate and the Earth System
1.4.The Components of Earth's Climate System and their role and interactions
1.5.Observing and modeling the Climate
1.6.Main feature of Ethiopian Climate
1.7.General atmospheric circulation
1.8.Causes of climate change
1.9.Predictable and unpredictable climate change
1.10. Climate change and land resource degradation

Topic Two: Climate change and Agriculture

2.1 Climate change vs crop production
2.2 Climate change vs livestock production
2.3 Climate change and agriculture sector
2.4 Climate change and Industry sector
2.5 Climate change and Service sector
2.6 Characteristics of climate information service (CIS)
2.7 The importance of CIS in climate risk management in agriculture
2.8 Concept, Characteristics and Pillars of Climate Smart Agriculture

Topic Three: Causes and Consequences of Climate Change

3.1 Major causes of climate change
3.2 Major consequences of climate change
3.3 Trends in Global Carbon Emissions
3.4 Trends and Projections for Global Climate

Topic Four: Impacts of Climate Change

4.1 Environmental impacts of climate change
4.2 Climate change and crop production
4.3 Health impacts of climate change
4.4 Livestock production and climate change
4.5 Climate change and food security

Topic Five : Responses to Climate Change

5.1 Climate Change and Forest Management
5.2 Climate Change and Water Resources: Responses and Adaptation
5.3 Principles and Practices of Climate Vulnerability Assessment
5.4 Uncertainties in Climate Change

5.5 Climate Change and Ecosystem Services
5.6 Effective Communications in Climate Change

Topic Six: Economics of climate change in agriculture

6.1 types of costs in the valuation of climate change damages
6.2 assumptions and uncertainties in the economic analyses of climate change
6.3 Cost and benefit of adaptation and mitigation
6.4 Economics health control of climate
6.5 Economic valuation of climate change effect on agriculture
6.6 challenges in valuation of costs and benefits from mitigation and adaptation activities

Topic Seven: Climate Change Policies and Economic development

7.1 climate change and well-being in developing countries
7.2 roles for adaptation and mitigation efforts in growing water crisis
7.3 climate-smart development policies
7.4 one health approach in livestock practice
7.5 carbon emission police and argument
7.6 socio-economic and gender perspectives in climate smart agriculture

References

Harris, J.M., Roach, B. and Environmental, J.M.H., 2017. The economics of global climate change. Global Development And Environment Institute Tufts University.

Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof.2008. Climate Change and Water. IPCC Technical Paper VI. Intergovernmental Panel on Climate Change, Geneva,Switzerland.

Dana Brown Haine. 2016. A Student Exploration of the Impacts of Climate Change on Human Health in the United States. Teaching module

Charles Fant and Len Wrigh. 2010. Adapting to Climate Change: An Integrated Biophysical and Economic Assessment. UN World Institute for Development Economics Research, Helsinki, Finland. Working Paper 101.

Collier, Paul, Gordon Conway and Tony Venables, 2008. Climate Change and Africa: Adaptation and Mitigation.

Congressional Budget Office. 2003. The Economics of Climate Change: A

Munasinghe, 2010. Global Climate Change: Economic and Policy Issues. World Bank Environment, World Bank, Washington, DC. Paper No. 12

Walthall, C.L. et al. 2012. Climate Change and Agriculture in the United States: Effects and Adaptation. USDA Technical Bulletin 1935. Washington, DC. 186 pp.

Program: AGRIBUSINESS AND VALUE CHAIN MANAGEMENT PROGRAM
Course 1 Title and Code: Climate Change in Agribusiness (ABVM422)

Course Credit; Cr. Hr./ECTS: 3(3+0)/5

Class year IV: semester II

Content Description
The goal of Climate Change in Agribusiness is to provide students with core knowledge of the science of climate change; an ability to think critically about its economic implications; and opportunities to apply this knowledge in climate change response activities and business research. The course introduces the scientific knowledge of the changing climate system, causes of climate change and its biophysical implications. Implement and evaluate economic analyses of climate change. This study focuses on cost-benefit analyses of climate change mitigation, the role of adaptation, and alternative approaches to quantifying climate change impacts, particularly in agricultural business. The course encourages critical thinking about economic analysis, including uncertainties about the underlying science and how to value costs and benefits; and the role of norms and values, especially with respect to health effects of climate change. The course also provides an introduction to the climate change polices and carbon emission arguments

Course Objectives
At the end of the course, the student should be able to:

- ✓ Understand causes and relationships between agribusiness and climate change.
- ✓ Explain climate change effects on major agribusiness enterprises and impacts and contribution of agribusiness activities to climate change
- ✓ Explain and critically evaluate alternative approaches to assessing the economic effects of climate change, particularly in agriculture, and the role for adaptation and mitigation.
- ✓ Apply knowledge of the science and responses against climate change including climate smart agricultural practices, adoption and mitigation and effective communication strategies
- ✓ Apply cost and benefit analysis concepts in valuation of climate change damage in agriculture and cost and benefits climate change adaptation and mitigation practices
- ✓ Identify the link between climate change and food and nutrition security in developing countries
- ✓ Explain the scientific and economic implications of climate change in agriculture and develop ideas for effective policy responses in the context of your country

COURSE CONTENTS:

Topic One: Introduction to climate change

1.1.Concepts of climate change
1.2.Concepts and definitions of key terms

1.3.History of climate and the Earth System
1.4.The Components of Earth's Climate System and their role and interactions
1.5.Observing and modeling the Climate
1.6.Main feature of Ethiopian Climate
1.7.General atmospheric circulation
1.8.Causes of climate change
1.9.Predictable and unpredictable climate change
1.10. Climate change and land resource degradation

Topic Two: Climate change and Agribusiness

2.1 climate change vs crop production
2.2 climate change vs livestock production
2.3 Climate change and agro industry
2.4 Climate Change and Human Health
2.5 Climate change and environmental resources
2.6 Characteristics of climate information service (CIS)
2.7 The importance of CIS in climate risk management in agriculture
2.8 Concept, Characteristics and Pillars of Climate Smart Agriculture

Topic Three: Impacts of Climate Change

3.1.Environmental impacts of climate change
3.2.Climate change and crop production
3.3.Health impacts of climate change
3.4.Livestock production and climate change
3.5.Climate change and food security

Topic Four : Responses to Climate Change

4.1. Climate Change and Forest Management
4.2. Climate Change and Water Resources: Responses and Adaptation
4.3. Principles and Practices of Climate Vulnerability Assessment
4.4. Uncertainties in Climate Change
4.5. Climate Change and Ecosystem Services
4.6. Effective Communications in Climate Change

Topic Five: Economics of climate change in agriculture

5.1 types of costs in the valuation of climate change damages
5.2 assumptions and uncertainties in the economic analyses of climate change
5.3 Cost and benefit of adaptation and mitigation
5.4 Economics health control of climate
5.5 Economic valuation of climate change effect on agribusiness
5.6 challenges in valuation of costs and benefits from mitigation and adaptation activities

Topic Six: Climate Change Policies and Economic development

6.1.climate change and well-being in developing countries
6.2.roles for adaptation and mitigation efforts in growing water crisis
6.3.climate-smart development policies
6.4.one health approach in livestock practice
6.5.carbon emission police and argument
6.6.socio-economic and gender perspectives in climate smart agriculture

References

Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof.2008. Climate Change and Water. IPCC Technical Paper VI. Intergovernmental Panel on Climate Change, Geneva,Switzerland.

Dana Brown Haine. 2016. A Student Exploration of the Impacts of Climate Change on Human Health in the United States. Teaching module

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Collier, Paul, Gordon Conway and Tony Venables, 2008. Climate Change and Africa: Adaptation and Mitigation.

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Munasinghe, 2010. Global Climate Change: Economic and Policy Issues. World Bank Environment, World Bank, Washington, DC. Paper No. 12

Walthall, C.L. et al. 2012. Climate Change and Agriculture in the United States: Effects and Adaptation. USDA Technical Bulletin 1935. Washington, DC. 186 pp.

Program: Forestry department

Course 1 Title and Code: Climate change and Desertification (For1072)

ASTU & WU, Program of Forestry					
Degree program	B.Sc Degree in Forestry				
Course title /code	Climate change and Desertification (For1072)				
Module Title	Environmental science (MFor2101)				
Course credit	2(2+0)				
Course Information	Academic Year: I Semester: I Meeting Day _____ Meeting Time____ Meeting Location_____				
Instructor's Name					
Instructor's contact information					
ECTS	3				
Student Work	Lecture	Field	Tutorial	Home	Total
Load		practice		study	
	32 hrs			94hrs	96hrs
Course objective and competences to be acquired	Course objective At the end of the course students should be able to ✓ Define climate change and variability and account for the causes of climate change, ✓ Define desertification and account for the causes of desertification, ✓ understand the actual and projected impacts of climate change, ✓ Understand the vulnerability and adaptation and adaptive capacity to the actual and projected impacts of climate change, ✓ Elucidate the roles of forests in mitigating (sequestering carbon) climate change and combating desertification, ✓ Clearly understand the role of REDD and CDM projects to minimize greenhouse gasses ✓ Understand international conventions on climate change and desertification and ✓ Realize concerns regarding sharing responsibilities and policy responses on mitigation of climate change as well as adaption.				
Course description	Concepts of climate change and atmosphere; causes of climate change; Effect of climate changes on Air Quality, Ocean and Coastal Resources, Agriculture, Forestry, Infrastructure, Biodiversity and Habitats and Public Health; adaptation and mitigation to climate change: Forestry and Climate Change, The effect of vegetation change on climate, The effect of climatic changes on vegetation, Carbon sequestration and Carbon trade, desertification; Concept of Desertification, Extent of Desertification Causes of Desertification, Consequences of Desertification, Mechanisms for combating desertification, international				

		conventions and protocols on climate change and desertification; international concerns: policy response on climate change and desertification.		
Pre-requisite		None		
Schedule				
Date	Lecture Hr.	Conceptual Focus and Contents	Activities/ Task	Reading/Assign ments/
Week 1 -3		CHAPTER 1. CLIMATE AND ATMOSPHERE 1.1. Climate 1.1.1. Is it Climate or is it Weather? 1.1.2. Why is Climate Important? 1.1.3. What Factors Determine Climate? 1.1.4. What is The Climate System? 1.1.5. The Greenhouse Effect 1.1.6. What is Global Warming? 1.2. The Atmosphere 1.2.1. Composition of the Atmosphere 1.2.2. Atmospheric Moisture 1.2.3. Water in the Atmosphere	-following lectures -take part in readings -feedback for confusions during home study	
Week 4-6		CHAPTER 2. CLIMATE CHANGE 2.1. History 2.2. Causes of Climate Change 2.2.1. Natural causes 2.2.2. Human-induced causes 2.3. Characteristics and roles of climate information service 2.4. Effect of climate changes 2.4.1. Effect of Clime Change in Air Quality 2.4.2. Climate Change Risks for Ocean and Coastal Resources	• following lectures • take part in readings • feedback for confusions during home study	

		2.4.3. Climate change Risks for Agriculture 2.4.4. Climate Change Risks for Forestry 2.4.5. Climate Changing Risks for Infrastructure 2.4.6. Climate Change Risks for Biodiversity and Habitats 2.4.7. Climate Change Risks to Public Health 2.4.8. The importance of CIS in climate risk management 2.4. Climate Change: adaptation and mitigation 2.4.1. Vulnerability to climate change 2.4.2. Climat Change adaptation 2.4.3. Climat Change mitigation 2.5. Concept, characteristics and pillars of climate smart agriculture		
Week 7 & 8		CHAPTER 3. FORESTRY AND CLIMATE CHANGE 3.1. How can forests affect climate change? 3.2. The effect of vegetation change on climate 3.3.The effect of climatic changes on vegetation 3.4.Carbon sequestration 3.5.Carbon trade 3.6. Climate smart forest management Ethiopian case studies	• following lectures • take part in readings feedback for confusions during home study	
Week 8		Individual Assignment	Submission on Time	
Week 9-11		CHAPTER 4. DESERTIFICATION	• following lectures	

		4.1.Concept of Desertification 4.2.Extent of Desertification 4.3.Causes of Desertification 4.3.1. Climatic variability 4.3.2. Human activities 4.4. Consequences of Desertification	• take part in readings feedback for confusions during home study	
Week 12		Group Assignment on Review of progress and achievements made in combating desertification and mitigating impacts of drought		
Week 13		CHAPTER 5. INTERNATIONAL CONVENTIONS ON 5.1. Climate change 5.2. Désertification	• following lectures • take part in readings feedback for confusions during home study	
Week 14-16		CHAPTER 6: INTERNATIONAL CONCERN & POLICY RESPONSE ON 6.1. Climate change 6.2. Désertification	• following lectures • take part in readings feedback for confusions during home study	
Week 15		Group Assignments and presentation		
Mode of delivery		Classroom lectures, assignment, presentation		
Assessment		Test 1 (10%) Week 4 Group presentation (10%) Group assignment (10%) Test 2 (10%) Week 11 Individual assignment (10%) Final exam (50%) Week 16		
Reference				