ENVIRONMENTAL SYSTEMS AND CLIMATE CHANGE

PREAMBLE

The postgraduate programme provides opportunities for graduates with backgrounds in physical, engineering and environmental disciplines to enhance their knowledge of the physical phenomena relating to the environmental systems. Degrees offered are M. Sc. and Ph.D. Environmental Systems and Climate Change. The programme is designed to provoke a multidisciplinary approach in tackling the complex issues of the environment and to train a new breed of scientists capable of effectively managing environmental issues, and mitigating the risks posed by the climate change to the environment. The training involves theoretical, practical, computational and internship components that will be needed to address emerging environmental challenges. A Ph.D. programme in Environmental Systems and Climate change shall be by a combination of taught courses, seminars, supervised teaching and research. Every Ph.D. student is expected to take and obtain satisfactory performances in all compulsory courses (except if there is evidence of having previously undertaken some courses in which case they shall be exempted) in addition to Seminars and Internship:

PHILOSOPHY

The philosophy of the programme is to foster multidisciplinary research on the issues of environmental sustainability with a view to improving agricultural development under different climate change scenarios. Degrees offered are M. Sc. and Ph.D. Environmental Systems and Climate Change with options in Hydrology and Climate Change, Environmental Geophysics, Remote Sensing and Climate Change, and Environmental Safety.

OBJECTIVES

Deriving from the foregoing philosophy the major objectives of this programme are as follows

1. To train graduates who would be sufficiently knowledgeable in different applications of the environmental systems.
2. To produce graduates who are practically and theoretically adept in environmental aspects that meet the needs of agro-industries.

Red colour indicates new input

3. To produce skilled and competent graduates who will effectively manage and critically assess information and issues relating to environmental safety.

4. To produce skilled professionals capable of developing environmental early warning systems and prediction for sustainable agriculture and national development.

5. To develop a crop of well-equipped manpower that will strive to sustain the environment even in the face of the risks posed by the issues of climate change.

LIST OF M.Sc. ENVIRONMENTAL SYSTEMS AND CLIMATE CHANGE COURSES AND UNITS

Table 1: Summary of the total number of units

Item	**Unit**
General Courses	22
Core Courses	22
Elective Courses	6
Total Units	**51**

Table 2: General courses for first semester

Course Code	**Course Title**	**Units**
ACE 801	Climate and Agriculture	2
GED 803	Short French Language Course	2
ACE 893	Internship 1	2
ACE 895	Seminar 1	1
ACE 899	Dissertation	6
	Total Units	**13**

Table 3: General courses for second Semester

Course Code	**Course Title**	**Units**
ACE 802	Information Systems and Agricultural Knowledge Management	3
ACE 804	International Trade and Commercial Policy	3
ACE 894	Internship 2	2
ACE 896	Seminar 2	1
	Total Units	**9**

Table 4: Programme courses for first semester

Course Code	**Course Title**	**Units**
Core courses		
ESC 801	Environmental Simulation Modeling	2
ESC 803	Climate Change Processes, History and Contemporary Issues	2

ESC 805	Research Methodology for Environmental Sciences	2
ESC 817	Hydrological Measurements	2
ESC 819	Environmental Statistics	2
	Total Units	**10**
Elective courses		
ESC 807	Mathematical Methods and Numerical Applications	2
ESC 809	Fluid Mechanics	2
[+]ESC 811	Hydrological Analysis	2
[*]ESC 813	Remote Sensing, GIS and Land Management	2
ESC 815	Waste Water Management and Pollution Control	2

[+] Compulsory elective for Hydrology and Climate Change
[*] Compulsory elective for Remote Sensing and Climate Change

Table 5: Programme courses for second Semester

Course Code	Course Title	Units
Core courses		
ESC 802	Environmental Economics	2
ESC 804	Environmental Safety and Protection	2
ESC 806	Soil Processes Assessment and Management	2
ESC 808	Climate Change Impacts, Ecosystem Management and Sustainability	2
ESC 810	Environmental Impact Assessment and Safeguard Policies	2
ESC 812	Global Issues Negotiation Process 1	3
	Total Units	**13**
Elective courses		
[**]ESC 814	Public Health and Environmental Systems	2
[***]ESC 816	Environmental Geophysics	2

[**] Compulsory elective for Environmental Safety
[***] Compulsory elective for Environmental Geophysics

SYNOPSIS OF COURSES

ESC 801: Environmental Simulation and modeling (2 Units)
Criteria for the use of data for modeling: Accuracy, Time intervals, Error detection and correction. Classification of models: Terminology, model technique (physical models, analog and mathematical models), model - prototype relationship, limitations, Deterministic and stochastic principles, Lumped and distributed models, Linear and nonlinear models. Stochastic models: Introduction to stochastic processes, Random events, stationarity, Time series analysis, Markovian processes, Filtering. Deterministic models: Deterministic methods in system hydrology, Analytical and numerical solution of equation of motion and continuity, Black box

analysis, Conceptual models' Mathematical physical models, Flood routing models, Optimization of model parameters, criteria, techniques. Environmental forecasting: Hydrological forecasting, forecast methods: short-term forecast, on-line systems, updating of parameters; long-term forecast for seasonal runoff, off-line systems. Application to floods, draught, low □ow, water temperature.

ESC 802: Environmental Economics (2 Unit)
Economics of water resources planning: Engineering economy; financial and economic analysis, Cost-benefit analysis and rate of turnover criteria, Cost models for water resources schemes, Tarification policy, Analysis of project returns. Systems analysis: Analysis of linear input-output systems, Identification of objectives, economic benefits, cost and decision variables, Application of systems analysis to problems of water resources engineering, and environmental management Optimization methods (linear programming, dynamic programming, simulation, Sensitivity analysis etc.)

ESC 803: Climate Change Processes, history and Contemporary issues (2 units)
An overview of Paleo-climatology; Atmospheric components, structure and the general circulation of the atmosphere; History of climate, natural and anthropogenic greenhouse gases, global warming, climate variability and change; Formation of ozone and interaction with UV radiation; Tropospheric photo-chemistry (NOx, VOCs, formation of tropospheric ozone and impacts on radiation balance/ budget quantities on the earth and atmosphere systems); Causes of climate change (Natural and anthropogenic/human activities); Factors influencing climate change including interactions within the atmosphere, ocean, solid earth and biosphere; Stability and sensitivity of climate system, global warming,
ozone depletion, and other human influences; Greenhouse effects, remediation
techniques, air pollution consequences of global warming, acid rain and acidification; Evidences of climate change.

ESC 804: Environmental Safety and Protection (2 Units)
Major issues and public policy in environmental protection. Managerial problems associated with the prevention, mitigation and cleanup of environmental problems. Governmental involvement and regulation and emerging trends as they influence decision-making in the public and private sector. Physical, political, legal, economic and technological factors that help shape and constrain environmental protection policy. Rules that govern the management of hazardous and other solid wastes, including industrial, household and livestock wastes. Requirements governing solid waste generation, storage transportation, processing, treatment and disposal as well as the closure and remediation requirements for livestock waste sites. The course will also examine the relationship between federal and state rules as they apply to the management of waste and enforcement issues to waste management.

ESC 805: Research Methodology (3 Units)

Introduction, defining the research problem, research design, design of sample surveys, data collection, data preparation, descriptive and inferential statistics, interpretation and report writing. Types of environmental data, sampling methods of environmental data. Direct gradient analyses, ordination and classification techniques. Matrix approach to the management of renewable natural resources. Measurement of variability, evenness and similarity indices. Other inferential and descriptive statistical tools.

ESC 806: Soil Processes Assessment and management (2 Units)
Soils in the ecosystem, soil genesis and factors of soil formation. Soil Resources Inventories: soil morphology and characterization. Physical and morphological properties of soils. Main soil processes. Physical and Chemical properties of soils: colour, texture, structure, consistency, porosity, permeability, drainage. Soil reaction, soil clays, Cation Exchange Capacity, Anion absorption and exchange, soil buffering, organic colloids. Soil classification and mapping. Soil data interpretations and multi-criteria evaluations: Soil Fertility Assessment and Management, Soil Organic Matter (SOM) Management (continuation) and Soil Carbon and Carbon Sequestration, Soil Erosion and Soil Conservation Measures. Soil Toxicity and Soil Contamination*:* Land Degradation Assessment

ESC 807: Mathematical methods and numerical application (2 Units)
Mathematical methods, Numerical methods, Statistics and probability and Computer application. Matrix algebra, Laplace transforms and Fourier series, Z-transforms, differential and partial equations Classification of differential equations (elliptic, parabolic, hyperbolic), Differential equations, Solution methods (finite difference and introduction to finite elements), Initial and boundary conditions. Probability problems in hydrology, Statistical parameters, Distributions, Extreme values, Regression and correlation, Likelihood and hypothesis testing. Applications to surface water and groundwater problems.

ESC 808: Climate Change Impacts, Ecosystem Management and Sustainability (2 units)
Climate change and disasters/hazards consequences (erosion, floods, storms, axis rain, heat waves, resource depletion, etc.); Challenges on agricultural production and food security - soils, cropping/farming systems, food and animal production, distribution and accessibility; Impacts on livestock, fisheries, forestry, post-harvest and farm produce storage, water resources; Land use, savanna and forest □res and implications for ecosystem structure, food chain and biodiversity loss; Climate change, ecosystem degradation and food security situation in sub- Saharan Africa; Vulnerability assessment and strategies for ecosystem management in a changing climate (adaptation, mitigation, resilience, etc.); adaptive management of ecosystems for sustainable development; Principles and concept of sustainability and carrying capacity; Climate change and sustainability of environmental resources (soil, vegetation and forest resources, water resources and aquatic organisms, agriculture and crop biodiversity); Climate change- human activities nexus and concept of ecological rehabilitation.

ESC 809: Fluid mechanics (2 Units)
Types of fluids, Physical properties of fluid. Flow mechanism in hydrological studies. Fluid mechanics: Mechanics of ideal fluid, Potential flow, flow nets, Laplace equation, Flow in

porous media, Mechanics of viscous flow, Navier-Stokes equation, Reynold stresses, Reynold's equation, Boundary layer theory, velocity distribution. Physical properties of water, Uniform flow in open channels, Equation of continuity and motion, Gradually varied uniform flow, back water curves), Hydraulics, Flow in hydraulic structures, hydraulic jump and head losses, Hydraulic models, Theory of groundwater flow and mathematical treatment of a number of important flow problems.

ESC 810: Environmental Impact Assessment and Safeguard Policies (2 Units)
This course introduces the methodology of environmental impact assessment (EIA) as a vital tool for sound environmental decision-making. It considers Overview of Nigerian. Environmental Framework. It provides an introduction to the concepts, methods, issues and various stages of the EIA process including the EIA process in Nigeria. The various stages of the EIA process, such as screening, scoping, EIA document preparation, public involvement, review and assessment, monitoring and auditing, appeal rights and decision-making are treated. Mention of the World Bank Safeguard Policies (OP 10+1) and procedures in particular (OP 4.01), Environmental Assessment. , Environmental Screening, Project categories, Policy triggers, Environmental Social Management Plan (ESMP). The course draws on case studies from Nigeria.

ESC 811: Hydrological Analysis (2 Units)
Precipitation Analysis: Determination of areal rainfall; depth-area analysis; depth-area-duration; rainfall frequency; intensity-duration-frequency analysis and extreme values of precipitation. Evaporation Calculations: Calculation of E ; Calculation of E ; Calculation of PE and Soil moisture deficit. River Flow Analysis: River regimes; peak discharges; flow frequency; flood frequency; flood probabilities; analysis of an annual maximum series; flood prediction; droughts and frequency of low flows. Rainfall-Runoff Relationships: Rational Method; Time-area method; hydrograph analysis. Catchment modeling and Stochastic hydrology

ESC 812: Global Issues Negotiation Process 1 (3 units)
Protection of Ozone layer: International Legal Framework for the protection of the Ozone Layers, Montreal protocol, Sri-Lanka Amendment to the Montreal Protocol, The Beijing Amendments, Climate Change: World Climate Conference in 1979, Establishment of Intergovernmental Panel on Climate Change (IPCC) in 1988 by UN Environment Programme (UNEP) and the World Meteorological Organisation. Adoption of the United Nations Framework Convention on Climate Change (UNFCCC), Earth Summit in Rio de Janeiro, Kyoto Protocol (marks the first international agreement to place legally binding limits on greenhouse gas emissions from developed countries), adoption of the Paris Agreement in 2015

ESC 813: Remote Sensing, GIS and Land Management (2 units)
Mapping, photo interpretation: Cartography, projections, Hydrological legends, Presentation on maps of variables in space and time, computer maps; presentation of three-dimensional problems, Surface water maps, water quality maps, groundwater maps, continental, hydrogeological maps, Remote sensing, aerial surveying; interpretation of aerial photographs and

space imagery, Global Positioning Systems (GPS), Geographical Information Systems (GIS), yield monitor, variable rate technology, and remote sensing. Applications, Adaptation and implementation of GPS and GIS for precision livestock farming.

ESC 814: Public Health and Environmental Systems (2 units)

Definition of concepts in community and public health. Hippocrates viewpoint of community Health. Influence of the Environment and development on community health. Distinction between community / public health in DCs and LDCs. Methods for investigating community / public health problems (John Snow's example of Cholera control). Sources of community / public health problems in rural and urban areas in LDCs. Control of health problems arising from contamination of water, air etc. in communities. Spatial epidemiological approach to community / public health problems analysis. Planning intervention programme for community / public health problems

ESC 815: Waste water management and Pollution Control (2 units)

Water chemistry and water biology: Composition and characteristics of surface and groundwater, Biochemical cycles, C, N, P and S, Main chemical and bacteriological water quality parameters, Introduction to instruments, Genetics, breeding of plants and animals, Ecosystems (principal system, baseline surveys), Aquatic ecology, Population dynamics, carrying capacity; Surface water quality: Factors affecting water quality and pollution by human, industrial and Agricultural wastes, Water quality criteria, Stratification and eutrophication in lakes and reservoirs, Thermal pollution, Self-purification, Water-related. diseases, Water quality monitoring; water quality classification, accumulation of heavy metals and toxic organic metals in sediments; Groundwater quality: Processes determining groundwater quality, Sources of groundwater pollution and effects on groundwater quality (N-, P-organic micro-pollutants, heavy metals, nuclear wastes), Artificial groundwater recharge, Flow lines and residence time of polluted groundwater, Leaching from waste disposals, Protection of groundwater, sanitation and prevention, Groundwater quality monitoring, sampling techniques.

ESC 816: Environmental Geophysics (2 units)

Description of near-surface physical processes. Principles and applications of geophysical investigation for environmental studies (e.g. surface and groundwater, archeological investigations, waste disposal, buried objects, contaminated water and land, geothermal etc). Theoretical background and practical applications of geophysical techniques such as electrical resistivity, seismic refraction/reflection, gravity, magnetic and electromagnetic survey. Field work, data collection, results processing and results interpretation.

ESC 817: Hydrological Measurements

Hydrometric Networks: Gauging networks; design considerations; precipitation networks; evaporation networks; surface water networks and groundwater networks. Precipitation: Storage gauges; rainfall recorders; siting the rain gauge; international practice and recent developments. Evaporation: Factors affecting evaporation, measurement of evaporation from an open water surface and measurement of evaporation loss from transpiration from vegetation (evapotranspiration) and measurement of potential evaporation. Soil moisture: Soil structure and composition; soil properties; water in soil; soil water retention and methods of measurement.

River flow: River gauging; stage-discharge relationship; flumes and weirs; dilution gauging and modern gauging techniques. Groundwater: Infiltration; groundwater flow equations; flow nets; groundwater measurement and groundwater exploration.

ESC 819: Environmental Statistics (2 units)
Basic concepts, empirical frequency distribution, binominal and normal distributions, introduction to statistical inference, principles of scientific experimentation, major experimental designs and treatment comparisms, linear regression and correlation.

LIST OF Ph.D. PROGRAMME-SPECIFIC COURSES AND UNITS

Students without Environmental Sciences background are expected to take all the courses prescribed for M. Sc. Environmental Systems and Climate Change and pass at 50% or higher grades in addition to PhD Courses.

Table 6: Summary of the total number of units

Item	**Unit**
General Courses	28
Core Courses	8
Total Units	**36**

Table 7: General courses for first semester

Course Code	**Course Title**	**Units**
ACE 801	Climate and Agriculture	2
GED 803	Short French Language Course	2
ACE 993	Internship 1	2
ACE 995	Seminar 1	1
ACE 999	Dissertation	10
	Total Units	**17**

Table 8: General courses for second Semester

Course Code	**Course Title**	**Units**
ACE 802	Information Systems and Agricultural Knowledge Management	3
ACE 804	International Trade and Commercial Policy	3
ACE 994	Internship 2	2
ACE 996	Seminar 2	1
ACE 998	Seminar 3	2
	Total Units	**11**

Table 9: Programme courses for first Semester

Course Code	**Course Title**	**Units**
ESC 901	Advance Research Methodology for Environmental Sciences	2
ESC 903	Environmental Policy and Governance	2
	Total Units	**4**

Table 10: Programme courses for second Semester

Course Code	Course Title	Units
ESC 902	Global Issues Negotiation Process II	2
ESC 904	Advanced Environmental Statistics	2
	Total Units	**4**

SYNOPSIS OF COURSES

ESC 901: Advance Research Methodology (2 Units)
Introduction, defining the research problem, research design, design of sample surveys, measurement and scaling, data collection, data preparation, descriptive statistics sampling and statistical inference, testing of hypothesis, chi-square tests, analysis of variance, linear regression analysis, factor analysis, discriminant analysis, cluster analysis, other multivariate techniques, interpretation and report writing.

ESC 902: Global Issues Negotiation Process 2 (3 units)
International Legal Framework for the protection of the Ozone Layer, Climate Change Convention, Convention on Biological Diversity, Trans-boundary movement of toxic wastes: Basel Convention, Lome IV Convention, Bamako Convention, Acid rain, Desertification, Solid waste management; Erosion / Land degradation, Hydrofluorocarbons, Radioactivity Pollution.

ESC 903: Environmental Policy and Governance (2 units)
Environmental policy making in the developed and developing countries, comparative analysis of institutional structures for decision-making on the environment, the nature of policy mechanisms used by different countries and modes of implementation. International Law on Environment, Legal aspects of environmental pollution in Nigeria Legal System; Common laws applicable to environmental control, focusing on such matters as strict liability and torts of nuisance, trespass and negligence statutory controls relating to environmental protection (including general controls in the summary offences ordinance and Public Health and Urban Services Ordinance and Delegated Legislation; The Water Pollution Control Ordinance, Waste Disposal Ordinance and Noise Control Ordinance).

ESC 904: Advance Environmental Statistics (2 units)
Basic concepts, empirical frequency distribution, binominal and normal distributions, introduction to statistical inference, principles of scientific experimentation, major experimental

designs and treatment comparisms, linear regression and correlation. Principal Component Analysis (PCA). Use of Statistical Analysis Systems (SAS), R-Statistics