**Haramaya University**

**VICE-PRESIDENT FOR ACADEMIC AFFAIRS**

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**Syllabi for PhD Programs**

**Compiled By THE OFFICE OF ACADEMIC ProgramS Directorate**

**May 2020**

**HARAMAYA UNIVERSITY**

*Contents*

1. School of Agricultural Economics and Agribusiness
   1. Agricultural Economics
2. School of Animal and Rangeland Sciences
   1. Animal Breeding and Genetics
   2. Animal Nutrition
   3. Dairy Technology
   4. Range Ecology and Dryland Biodiversity
   5. Tropical Animal Production (*Streams: Meat, Dairy, and Monogastric streams*)
3. School of Natural Resource Management and Environmental Sciences
   1. Soil Science
4. Department of Rural Development and Agricultural Extension
   1. Rural Development and Agricultural Extension (*Streams: Knowledge Management and Capacity Development; Commercial and Rural Institutions*)
5. School of Plant Sciences
   1. Agronomy
   2. Horticulture
   3. Plant Breeding
   4. Plant Pathology
   5. Agricultural Entomology
6. African Center of Excellence for Climate Smart and Biodiversity Conservation
   1. Climate Smart Agriculture and Biodiversity Conservation (*Sub-specialization: Crops; Livestock; Soil and water; Policy, institutions & Innovation; and Biodiversity conservation*)

# SCHOOL OF AGRICULTURAL ECONOMICS AND AGRIBUSINESS

Syllabi for PhD Program in Agricultural Economics

**Program Name:**  **AGRICULTURAL ECONOMICS**

**1. Course Code**

The program courses are coded taking the first two letters in the two words of the program’s name i.e., Agricultural Economics. The departmental courses start with code “AgEc” followed by a three digit numerical code. The first digit indicates the level or year the course is offered. Accordingly, “7” is for Ph.D. program, and “8” is for dissertation. The second indicates the number of courses offered in the semester and the third digit indicates the semester in the academic year.

**2. Distribution of Courses by year and Semester**

**Year I; Semester I**

|  |  |  |
| --- | --- | --- |
| Course Code | Course Title | Credit Hours |
| AGEC 701  AGEC 711  AGEC 721  AGEC 731  AGEC 741  AGEC 751  AGEC 761 | **Advanced Research Methodology**  **Advanced Microeconomics Analysis**  **Advanced Econometrics**  **Seminar I**  Advanced Production Economics (E)  Institutional Economics (E)  Agricultural Finance (E) | **3**  **3**  **4**  **1**  3  3  3 |
| **Total** |  | **11/20** |

E= Elective courses

**Year I; Semester II**

|  |  |  |
| --- | --- | --- |
| Course Code | Course Title | Credit Hours |
| AGEC 712  AGEC 722  AGEC 732  AGEC 742  AGEC 752  AGEC 762  AGEC 772 | **Advanced Macroeconomic Analysis**  **Natural Resource and Environmental Economics**  **Seminar II**  Agricultural Marketing and Price Analysis (E)  International Trade and Finance (E)  Advanced Development Economic (E)  Agricultural and Food Policy Analysis (E) | **3**  **3**  **1**  3  3  3  3 |
| **Total** |  | **7/19** |

E=Elective courses, students are required to take one courses from the elective package to make a total credit hour of not less than 21.

**Year II. Semester I up to year III, semester II**

|  |  |  |
| --- | --- | --- |
| Course Code | Course Title | Credit Hours |
| AGEC 811 | Ph.D. Thesis Research | 30 |

**Total course work load overall 21/39**

**3. Course Descriptions**

**AGEC 501**: **Advanced Research Methodology (3)**

Concepts of Research Methodology: meaning, objective, types, approaches, methods and methodology, research process, criteria of good research, defining research problem, selecting a problem, techniques of defining a problem; Concepts of Research and Sampling Design: sample design (meaning, types and features of good design), meaning of sample survey, need for sampling, sampling frame, steps in sample design, characteristics of good sample design, sample size determination; Alternative Sampling Designs: non- probability sampling, probability sampling, simple random sampling, complex random sampling designs (systematic sampling, stratified sampling, cluster sampling, multistage sampling, proportionate sampling); Methods of Data Collection: collection of primary data (observation, interview, questionnaire, schedule), collection of secondary data, selection of appropriate methods, case study; (Processing and Analysis of Data: processing operations (editing, coding, classification, tabulation), problems in processing, types and elements of analysis; Interpretation and Report Writing: meaning and techniques of interpretation, steps in report writing, layout of a research report, types of reports, mechanics of writing a research report, precautions for writing research reports; applications of selected integrated software packages.

The course would be delivered through lectures, class discussions, case, term papers, computer tutorial, exercise and assignments. The methods of assessment and evaluation will be based on submitted written assignments, presentation and/or written examination.

**AGEC 711: Advanced Microeconomics Analysis (3)**

Profit maximization analysis and applications in various imperfectly competitive markets; demand side- monopoly, duopoly, oligopoly, monopolistic completion; supply side-monopsony, duopsony, oligopsony, bilateral monopoly; distribution and relative factor shares under dynamic situation of technological progress; general multi- market equilibrium production and exchange; Walras law, monetary equilibrium, static and dynamic stability analyses; discussion on various publications appeared in leading journals on imperfectly competitive markets, factors markets, and welfare economics.

The course would be delivered through lectures, class discussions, term papers, exercise and assignments. The methods of assessment and evaluation will be based on submitted written assignments, presentation and/or written examination.

**AGEC721: Advanced Production Economics (3) (E)**

Role of production economics under dynamic farming situations; economic efficiency, measurement, frontier production function estimation; technological change: concepts, measurement of factor shares, total factor productivity; decision theory and expected utility hypothesis; theory of a firm under uncertainty, estimation of price, production and income variability; estimation of the objective probability or risk and risk premium; Frontier and risk preferences of farmers; advanced production function forms: CES and VES production functions, flexible functional forms; generalized Leontif function, translog function, profit function, generalized Cobb-Douglas production function, duality between production and profit function.

The course would be delivered through lectures, plenary and group discussions, cases, term papers, computer tutorial, exercise and assignments. The methods of assessment and evaluation will be based on submitted written assignments, presentation and/or written examination.

**AGEC 731: Institutional Economics (3) (E)**

Neoclassical and Institutional Economics: basic concepts, old and new institutional economics, externalities and market failures, the Caosean theory; Institutions and Contracts: meaning of institutions and contracts, levels of institutional analysis, elements and forms of contracts, factors of contracts, contractual choice and transaction costs, opportunism in contractual relations; Theories of Institutional Change: induced institutional innovation, distributive bargaining theory, political-economy theory, property right theory, evolutionary theory; Trust, Collective Action and Social Capital: Basic concepts, theory of collective action, livelihood assets, definition, types, levels and forms of social capital, the roles of social capital in collective action, measurement of social capital, dimensions of social capital; Frameworks for Institutional Analysis: IAD framework, evaluative criteria, IOS framework, multilevel institutional analysis, game theory and the Nash equilibrium, methodological issues; Reform, Resource Governance and Public Policy: concept of governance, institutions of resource governance, centralization and decentralization of resource governance, policy coordination and accountability, principal-agent problem (governance failure).

The course would be delivered through lectures, plenary and group discussions, case, term papers, exercise and assignments. The methods of assessment and evaluation will be based on submitted written assignments, presentation and/or written examination.

**AGEC 741: Agricultural Finance (3) (E)**

Capital, credit and their importance in agricultural development; capital deepening and capital widening strategies of agricultural finance; credit allocation policies – their growth and equity aspects; economic principles applied to agricultural financial management; tools of financial analysis; role of both national and international institutions involved in financing the agricultural development projects.

The course would be delivered through lectures, plenary and group discussions, case, term papers, exercise and assignments. The methods of assessment and evaluation will be based on submitted written assignments, presentation and/or written examination.

**AGEC 751: Seminar I (1)**

The PhD candidate is expected to review and analyze the literature and present his observations in the seminar on the selected topic related to his field of specialization other than his dissertation research topic.

**AGEC 761: Agricultural and Food Policy Analysis (E) (3)**

Agricultural Policy Analysis Frameworks: meaning, objectives and instruments of policy intervention, constraints, Areas of Policy Intervention: production policy, marketing and/or processing policy, food consumption policy, exchange rate policy, trade/tax policies; Evolution of agricultural policy over time, important policy issues and institutions at the national and international levels; methods of policy analysis; Policy analysis tools and applications to specific policy problems; Policy issues related to food security, conservation, food safety, nutrition, health, consumption, production.

The course would be delivered through lectures, plenary and group discussions, cases, term papers, exercise and assignments. The methods of assessment and evaluation will be based on submitted written assignments, presentation and/or written examination.

**AGEC 712: Advanced Macroeconomics Analysis (3)**

Introduction to dynamic macro-economic models; inflation and unemployment; the supply side tax effects, the use of rational expectations, business cycle and its alternative equilibrium models, stability analysis; monetary and fiscal policies, fiscal policy as an instrument of development, incidence of tax and fiscal policies, policy mix; public borrowing- internal and external aid, deficit financing, development financing; the international general equilibrium system impediments to global efficiency; international macroeconomic policies, IMF, WB, WTO, etc.

The course would be delivered through lectures, plenary and group discussions, cases, term papers, computer tutorial, exercise and assignments. The methods of assessment and evaluation will be based on submitted written assignments, presentation and written examination.

**AGEC 732: Advanced Econometrics (4)**

Multiple Linear Regression: assumptions, least squares, sample properties of least squares, instrumental variable and two-stage least squares, tests, inference and prediction, Structural Change and Specification Analysis: binary variables, nonlinearity, structural change, testing structural change and model stability, specification analysis, model selection criteria; Simultaneous Equation Models: basic concepts, identification, estimation methods, specification tests, Time-series Models: stationary stochastic process, nonstationary process and unit roots, cointegration; Models for Binary and Ordinal Outcomes: latent variable model, estimation and testing in logit and probit models, interpretation of logit and probit, ordered logit and probit, bivariate and multivariate probit; Models for Nominal and Count Outcomes: multinomial logit models (MLM), conditional logit models (CLM), estimation, testing, and interpretation of MLM and CLM, Poison distribution, the Poison regression model (PRM).

The course would be delivered through lectures, plenary and group discussions, cases, term papers, computer tutorial, exercise and assignments. The methods of assessment and evaluation will be based on submitted written assignments, presentation and/or written examination.

**AGEC 742: Agricultural Marketing and Price Analysis (3) (E)**

The Global Food Marketing System: trends, policies, constraints, prospects; Agricultural Price Policy Intervention and Analysis: areas and instruments of policy intervention, farm price intervention; Measuring Effects of Price Intervention: partial equilibrium analysis, single market analysis, multilevel analysis, sectoral analysis; Measuring Market Performance: meaning and scope, temporal price analysis, spatial market integration, vertical integration, spatial equilibrium models (SEM); Measuring General Effects of Price Policies: computable general equilibrium (CGE), foundations of CGE, data frameworks for CGE, social accounting matrix..

The course would be delivered through lectures, plenary and group discussions, cases, term papers, computer tutorial, exercise and assignments. The methods of assessment and evaluation will be based on submitted written assignments, presentation and/or written examination.

**AGEC 752: Seminar II (1)**

A PhD candidate is expected to do survey and analysis of literature and make observations on the subject concerned for making presentation. Seminar presentation should be on the topic related to the specific area of the study, other than the candidates ‘research topic.

**AGEC 762: International Trade and Finance (3) (E)**

Trends and emerging scenario in global agricultural trade and finance in the Ethiopian context; bases for international trade and scanning of trade environment: trade models and applications thereof; forex management; importance and functioning of international financial institutions; impact assessment of capital and credit inflow and outflow on economic health of developing countries; evolving international marketing mix particularly in the context of farm products; emerging policy environment for agricultural trade, marketing, and finance in Ethiopia.

The course would be delivered through lectures, plenary and group discussions, cases, term papers, exercise and assignments. The methods of assessment and evaluation will be based on submitted written assignments, presentation and/or written examination.

**AGEC 772:** Advanced Development Economic (E) (**3)**

Role of agricultural at various stages of economic development; changing scenario of agriculture sector in Ethiopian economy and its contribution in economic development; complimentarily between agriculture and industry; need for balance development; growth and development models applicable for countries like Ethiopia; role of national and international institutions in enhancing growth/ development in less developed countries via agriculture; problems and prospects of agricultural growth in less developed countries; existing and stipulated policy and planning environment for steady growth in agriculture sector.

The course would be delivered through lectures, plenary and group discussions, cases, term papers, exercise and assignments. The methods of assessment and evaluation will be based on submitted written assignments, presentation and/or written examination.

**AGEC 782: Natural Resources and Environmental Economic (3)(E)**

Exhaustible and non-exhaustible natural resources; stock and flow of non-exhaustible natural resources; determination of price of a natural resource; economics of use of natural resources; land distribution, forest use and water resource utilization; principles and perspectives of sustainable economic development in developing countries-progress and implications; the demand for environmental quality, the sources of environmental problems, air, water and land pollution, pollution control policy, property rights and environmental externalities; principles and techniques of impact assessment; environmental auditing, environment management system; biodiversity; energy conservation and environmental law.

The course would be delivered through lectures, plenary and group discussions, cases, term papers, computer tutorial, exercise and assignments. The methods of assessment and evaluation will be based on submitted written assignments, presentation and/or written examination.

**AGEC 811: Ph.D Thesis Research (30)**

A PhD candidate is required to identify a research problem relevant to the subject concerned and on national priority. Formulation of the research proposal should be according to the standard research methodology and in consultation with the advisory committee. The problem should reflect the current advances in the field and should have objectives intended fro new findings and/ or for confirmation of known facts for the Ethiopian conditions. After the approval the candidate is expected to execute the proposal and come up with the findings in the form of a thesis.

**School of Animal and Range Sciences**

Syllabi for PhD Program in Animal Breeding and Genetics

Syllabi for PhD Program in Animal Nutrition

Syllabi for PhD Program in Dairy Technology

Syllabi for PhD Program in Range Ecology and Dryland Biodiversity

Syllabi for PhD Program in Tropical Animal Production (*Streams: Meat, Dairy, and Monogastric Animals)*

**1. Program Name: Animal Breeding and Genetics (ABG)**

**COURSE PROFILE**

**Course Distribution by Year and Semester**

**Year I, Semester I**

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Course Code Course Title Credit Hours

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ABG 711 Advanced Biometrics in Animal Breeding 3

ABG 721 Advances in ABG 4

ABG 731 Animal Genetic Resource Conservation &

Management (E) 2

ABG 741 Molecular Genetics (E) 3

TAP 721 Tropical Livestock Production Systems (E) 2

ABG 751 Seminar I 1

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**Total 8/15**

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E = Elective courses

**Year I, Semester II**

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Course Code Course Title Credit Hours

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ABG 712 Planning Genetic Improvement Program 3

ABG 722 Methods of Genetic Evaluation 3

ABG 732 Bioinformatics (E) 2

ANNU 752 Animal Adaptation and Stress Physiology (E) 2

SWEN 672 Geographical Information Systems (GIS):

Technology and Applications (E) 2

ABG 742 Seminar II 1

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**Total 7/13**

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*E = Elective courses*

*NB: In order to attain the minimum requirement, i.e. 22 credit hours, of course work, students should have to take elective courses in each semester.*

Year II, Semester I up to Year III, Semester II

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Course Code Course Title Credit Hours

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**ABG 752 PhD Thesis Research 30**

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**Total course work 22/28**

**Overall total 52/58**

**2.2. Course Descriptions**

The following are the descriptions of the courses proposed for the specialization in ABG.

Course Title: Advanced Biometrics in Animal Breeding

**Course Code: ABG 711**

**Credit Hours: 3**

**Course Objectives**

* To educate about the various biometrical techniques for data analysis & their applications in animal breeding research
* To impart knowledge about recent advances in application of animal breeding

**Course Description**

Basic concepts in statistical inferences and experimental designs, nature of data in animal breeding and their sources of variation and adjustment; matrix algebra, Henderson’s methods for estimation of variance components, Least squares analysis, ML, REML; Linear mixed models, data management and use of software packages in animal breeding; mating designs, advances in studies on genotype by environment interaction

**Practical:** Matrix algebra, modeling different types of data, estimation of variance components, least square methods for analysis of research data, transformation and analysis of animal breeding data; estimation of genetic parameters. SAS software will be used.

**Course Delivery:** Classroom lectures assisted by audio-visual aids and group discussion on selected topics; reading assignment on relevant articles, book chapters and/or case studies to digest the concepts; individual &/or group assignments and presentations; term paper writing and presentation;

**Course Assessment:** Individual &/or group assignments, term-paper, reports of case studies, oral &/or written final examination

Course Title: Advances in ABG

**Course Code: ABG 721**

**Credit Hours: 4**

**Course Objectives**

* To impart knowledge about the latest tools & techniques of animal genetics & their uses in animal sciences
* To acquaint with recent trends in animal breeding & designing of need-based breeding strategies

**Course Description**

Different models and their analytical techniques on simulated and actual animal breeding data using computer applications and use of programme in the field of animal breeding; formulation of breeding plans, breed improvement programmes and their impact analysis in various species; advanced techniques in genetic manipulation for multiplication and improvement of livestock species; new directions in livestock and poultry breeding-selection for disease resistance, trypano-tolerance, etc.; genotype environment interactions and their significance in animal breeding; genetic response to selection and validity of prediction; review of experimental results in animal genetics and breeding.

**Course Delivery:** Classroom lectures assisted by audio-visual aids and group discussion on selected topics; reading assignment on relevant articles, book chapters and/or case studies to digest the concepts; individual &/or group assignments and presentations;

**Course Assessment:** Individual &/or group assignments, term-paper, reports of case studies, oral &/or written final examination

Course Title: Animal Genetic Resources Conservation & Management (E)

**Course Code: ABG 731**

**Credit Hours: 2**

**Course Objectives**

* To educate about the concept of conservation of AnGR & their sustainable utilization
* To educate about the concept of management of AnGR

**Course Description**

Decline and conservation of the genetic diversity of domestic animals; Genetic diversity: origin, types & assessment, driving forces affecting it, genetic shift, effective census; Population structure: genetic diversity analysis, genetic distance between populations, genetic singularity; Genetic management in conservation programmes: choice of population/breed and conservation methods, maintenance of allelic diversity; Principles for preservation of endangered species and breeds in the tropics; Domestic Animal Diversity System (DAD-IS); effective use of DAD-IS for national animal genetic resource management; global initiative for domestic animal diversity; technical guidelines for country use in action planning, in-situ and ex-situ conservation.

**Course Delivery:** Classroom lectures assisted by audio-visual aids and group discussion on selected topics; reading assignment on relevant articles, book chapters and/or case studies to digest the concepts; individual &/or group assignments and presentations;

**Course Assessment:** Individual &/or group assignments, term-paper, reports of case studies, oral &/or written final examination

Course Title: Molecular Genetics (E)

**Course Code: ABG 741**

**Credit Hours: 3**

**Course Objectives**

* To educate about molecular techniques to identify molecular markers as an aid to selection

**Course Description**

Nucleic acids. Animal viruses (DNA and RNA) and their importance; tumor viruses, retroviruses, conjugation, transformation and transduction, integration of viral DNA, consequences of integration; Transposition: transposable elements, detection of transposition in bacteria; genetic phenomena mediated by transposons, gene expression in pro- and eukaryotes; genetic transformation; regulation of simple and complex transcription unit; current developments in molecular genetics; molecular techniques viz. Southern, Northern and Western blotting, PCR, RFLP, AFLP’s, RAPDs, Micro-sattelites, SNPs; DNA sequencing; Gene cloning and recombinant DNA technology; cDNA and genomic library.

**Practical:** Molecular standard buffer preparation, Nucleic acid isolation or purification from different animal tissues, qualitative and quantitative measurements of nucleic acids, DNA cloning technology (transformation), different protein expression systems, PCR (using different marker systems such as RAPD, ISSR, SSR, AFLP and PCR-RFLP), restriction digest of genomic DNA and PCR products using restriction enzymes, gel electrophoresis (Agarose, Polyacrylamide and starch).

**Course Delivery:** Classroom lectures assisted by audio-visual aids and group discussion on selected topics; reading assignment on relevant articles, book chapters and/or case studies to digest the concepts; individual &/or group assignments and presentations;

**Course Assessment:** Individual &/or group assignments, lab reports, term-paper, reports of case studies, oral &/or written final examination

Course Title: Tropical Livestock Production Systems (E)

**Course Code: TAP 721**

**Credit Hours: 2**

**Course Objectives**

* To equip the students with knowledge, skill and attitude about tropical livestock productions systems in relation to changing global trends and how different development interventions could be designed and executed in different livestock production systems.

**Course Description**

Classic concept of livestock production systems, methods/tools of classification of production systems, characterization of major livestock production system in the tropics and in Ethiopia based on objectively verifiable variables with a view to identify constraints and develop viable opportunities for sustainable agricultural and natural resource management, constraints of livestock production in Ethiopia.

**Course Delivery:** Classroom lectures assisted by audio-visual aids and group discussion on selected topics; reading assignment on relevant articles and/or case studies to digest the concepts; individual &/or group assignments and presentations;

**Course Assessment:** Individual &/or group assignments, term-paper, reports of case studies, oral &/or written final examination

Course Title: Seminar I Credit Hour: 1 Course Code: ABG 751

**Course Objective**

The objective of this course is to make the students updated and familiar with issues of contemporary importance in the country and the world with regard to ABG. Seminar will also help to improve technical presentation skills and report writing abilities.

**Course Description**

The PhD candidate is expected to review and analyze the literature and present his observations in the seminar on the selected topic related to his field of specialization other than his dissertation research topic.

This seminar will address selected topics of contemporary importance as suggested by the School Graduate Council ensuring their relevance. The students have to make exhaustive information gathering from primary and secondary sources and prepare elaborate concept notes on the themes suggested. Preferably, experts on the topics will be invited to have a discourse on the topic. The seminar report will include detail discussions of the topic content, contextual interpretations and brief recommendations.

**Assessment Methods**

This course will be assessed based on depth of topic coverage, style of presentation, presentation aids used, and quality of report. The assessment will be done by team of experts assigned for this purpose based on fixed evaluation criteria.

Course Title: Planning Genetic Improvement Program

**Course Code: ABG 712**

**Credit Hours: 3**

**Course Objectives**

* To educate about the concept of genetic improvement programs planning
* To educate about the concept of designing breeding programs and evaluating animals

**Course Description**

Present status of animal genetic improvement program, problems encountered, detailed case study; Genetic improvement of livestock and poultry; factors affecting rate of genetic improvement; Selection objectives and criteria; Breeding goals, traits in breeding goals; Constraints and issues in animal genetic improvement programme; methods for developing the optimum breeding programs for the different species;

**Course Delivery:** Classroom lectures assisted by audio-visual aids, videos and group discussion on selected topics; reading assignment on relevant articles, book chapters and/or case studies to digest the concepts; individual &/or group assignments and presentations; assignments & presentations based on visit to resource centers and organizations of advanced technologies in the country;

**Course Assessment:** Individual &/or group assignments, term-paper, reports of case studies, oral &/or written final examination

Course Title: Methods of Genetic Evaluation

**Course Code: ABG 722**

**Credit Hours: 3**

**Course Objectives**

* To educate about the different methods used in genetic evaluation of livestock and poultry

**Course Description**

A general approach to different sources of information used in genetic evaluation; Genetic parameters: heritability, repeatability, correlations, methods of their estimations; specific approaches- selection index theory – finding selection index weights, adjustment of phenotypic records, types and precision of indices; mixed linear models (BLUP) – univariate and multivariate BLUP, animal model, sire model, maternal trait model, analysis of longitudinal data, non-additive models, analysis of categorical traits; precision of predicted breeding values, usefulness of BLUP in ranking and selection.

**Practicals:** Problems on determination of genetic parameters and breeding values with applications of different softwares in animal breeding like PEST, VCE, ASREML.

**Course Delivery:** Classroom lectures assisted by audio-visual aids and group discussion on selected topics; reading assignment on relevant articles, book chapters and/or case studies to digest the concepts; individual &/or group assignments and presentations;

**Course Assessment:** Individual &/or group assignments, term-paper, reports of case studies, oral &/or written final examination

Course Title: Bioinformatics (E)

**Course Code: ABG 732**

**Credit Hours: 2**

**Course Objectives**

* To educate about basic concepts of bioinformatics & their applications in ABG

**Course Description**

Introduction to bioinformatics, available genome sequence databases (EMBL, NCBI, PIR, DDBJ, SWISS-PROT, PROSITE); methods of DNA, RNA and protein sequence retrieval from public databases; sequence analysis programs, methods of sequence comparison (sequence alignment); using sequences to study phylogeny; prediction of RNA secondary structure; predicting sequence of protein from DNA; predicting protein structure; primer designing; gene prediction; uses of bioinformatics tools for identifying QTL in ABG.

**Course Delivery:** Classroom lectures assisted by audio-visual aids and group discussion on selected topics; reading assignment on relevant articles, book chapters and/or case studies to digest the concepts; individual &/or group assignments and presentations;

**Course Assessment:** Individual &/or group assignments, lab-reports, term-paper, reports of case studies, oral &/or written final examination

Course Title: Animal Adaptation & Stress Physiology (E)

**Course Code: ANNU 752**

**Credit Hours: 2**

**Course Objectives**

* To teach students about livestock adaptation to tropical climates and related stress factors that limit animals’ productivity and strategies to ameliorate environmental stress and increase livestock productivity.

**Course Description**

Modern theories of adaptation; physiological and genetic adaptation; adaptation in relation to environment, management and physiology; an overview of factors acting as stress, quantifying factors of stress, physiological responses to stress in relation to genetic makeup, effect of stress on production, reproduction and adaptation; modification / control of factors of stress; pharmacological, management and physiological basis of alleviating stress.

**Course Delivery:** Classroom lectures assisted by audio-visual aids and group discussion on selected topics; reading assignment on relevant articles, book chapters and/or case studies to digest the concepts; individual &/or group assignments and presentations;

**Course Assessment:** Individual &/or group assignments, term-paper, reports of case studies, oral &/or written final examination

Course Title: Geographical Information Systems (GIS): Technology & Application (E)

**Course Code: SWEN 672**

**Credit Hours: 2**

**Course Objectives**

* To equip students with knowledge, skill and attitude of topographic and thematic databases, terminologies in GIS

**Course Description**

Ground rules; topographic and thematic databases; terminology in GIS; map projection and scales; traditional cartography, vector map and raster map representation; digital mapping, processing, and analysis; relational database; GIS components, networks, and types; GIS selection and testing, land resource planning- surveys, capability evaluation, and modeling; environmental monitoring-water quality, pollution, soil erosion, and impact assessment; landscape monitoring-mapping, change analysis and impact assessment; remote sensing-input to GIS, need for data from GIS.

**Course Delivery:** Classroom lectures assisted by audio-visual aids and group discussion on selected topics; reading assignment on relevant articles and/or case studies to digest the concepts; individual &/or group assignments and presentations;

**Course Assessment:** Individual &/or group assignments, term-paper, reports of case studies, oral &/or written final examination

Course Title: Seminar II Course Code: ABG 742 Credit Hour: 1

**Course Objective and mode**

The course will cover a theme related to the Doctoral thesis research, and concepts, theories and issues on the ground will form the basis of presentation. Students have to make an exploratory survey using PRA tools in the proposed study location using basic research questions. Adequate time should be taken for field work and review of literature. This seminar will help to write the full research proposal later, incorporating the feedback obtained in the presentation.

**Course Assessment**

The report should be in detail and bound hard copy and soft copy will have to be submitted to the school after presentation. Assessment of the seminar will be based on depth of information gathered using primary and secondary sources and field work, style of presentation slides, and the final report.

Course Title: PhD Thesis Research Corse Code: ABG 752 Credit Hour: 30

A Ph.D. candidate is required to identify a research problem relevant to the subject concerned and on national priority. A research proposal should be developed according to the standard research methodology and in consultation with the advisory committee. The problem should reflect the current advances in the field and should have objectives intended for new findings and / or for confirmation of known facts for the Ethiopian conditions. The proposal should then be defended in an open forum created for this purpose. Taking the feedback of this presentation and collecting additional information, the proposal has to be developed and finalized. After that the candidate is expected to execute the proposal and come up with the findings in the form of a thesis.

**2. Program Name: Animal Nutrition**

*Distribution of Courses by Year and Semester*

**Year I; Semester I**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Course Code Course Title Credit Hours**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

ANNU 711 Recent Advances in Animal Nutrition 3

ANNU 721 Nutritional physiology and Biochemistry 3

TAP 721 Tropical Livestock Production System (E) 2

ANNU 731 Mineral and Vitamin Nutrition (E) 3

ANNU 741 Biotechnology in Animal Nutrition (E) 2

ANNU 751 Analytical Techniques in Animal Nutrition (E) 3

ANNU 761 Seminar I 1

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Total 7/17**

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E = Elective courses

**Year I; Semester II**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Course Code Course Title Credit Hours**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

ANNU 712 Advances in Feed Inventory & Feed Resources Utilisation 3

ANNU 722 Animal Science Research and Biometrics 3

ANNU 732 Seminar II 1

ANNU 742 Advanced Bioenergetics and Protein Utilisation (E) 3

ANNU 752 Animal Adaptation and Stress Physiology (E) 2

SWEN 672 Geographical Information Systems (GIS) Technology

and Applications (E) 2

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Total 7/14**

*E = Elective courses*

**Year II; Semester I up to Year III; Semester II**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Course Code Course Title Credit Hours**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

ANNU 782 PhD Thesis Research 30

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Total Course Work 22/31**

**Overall Total 52/61**

*2.4. Course Descriptions*

**ANNU 711: Recent Advances in Animal Nutrition (3)**

**Course Objectives:**

* To impart knowledge about feed resources and feed resource utilization for different production purposes;
* To acquaint students with recent trends of production, research and development related to feed resources and feed utilization by livestock.

**Course description:**

Present status of feed and fodder availability for livestock and approaches for the improvement in feed resources availability; feeding standards for farm animals; mechanism of partitioning and utilization of nutrients for different productive and reproductive purposes; system to find out nutritive requirements for body processes and productive functions; recent trends of specialized feeding of various species of animals at different production and physiological stages of life; emerging economic concepts in animal nutrition like margin over feed cost; conversion of feeding standards in to feed specifications; strategy formulation for feeding of animals during scarcity.

**Course delivery:**

Course will be handled by students with minimal guidance by the instructor. Introductory lecture, assignments, term paper, presentation and discussion will be employed.

**Course assessment:**

Assignments, term paper, presentation and discussion.

**ANNU 721: Nutritional Physiology and Biochemistry (3)**

**Course Objectives:**

* To teach the comparative metabolism of different nutrients in ruminants and monogastric animals;
* To pass on knowledge about the biochemical processes of nutrient utilization in ruminants and monogastrics

**Course description:**

Comparative evaluation of energy and protein metabolism in ruminants and non-ruminants; physiology and microbiology of the rumen; digestion and absorption of carbohydrate, lipid and protein in ruminants and non-ruminants; use of NPN compounds as a protein re-placer.

**Course delivery:**

Lectures, assignments, term paper, presentation and discussion.

**Course assessment:**

Assignments, term paper, presentation and discussion, and final written examination.

**TAP 721: Tropical Livestock Production System (2) (E)**

For course content see PhD Tropical Animal Production program (Common course for Animal Nutrition and Tropical Animal Production PhD Program)

**ANNU 731: Mineral and Vitamin Nutrition (3) (E)**

**Course Objectives:**

* To impart knowledge on the role, deficiency symptoms and sources of major and trace mineral for different species of livestock;
* To teach the significance, deficiency symptoms and sources of vitamins for different species of livestock

**Course description:**

Significance of minerals in animal production; interaction of minerals with each other and with other nutrients; absorption, physiological functions and requirement of major and trace minerals in farm animals; importance of vitamins in livestock productivity; chemistry, physiological role and deficiency symptoms of minerals and fat and water soluble vitamins in animals; important sources of minerals and vitamins for livestock and poultry.

**Course delivery:**

Introductory lectures, assignments, term paper, presentation and discussion.

**Course assessment:**

Assignments, term paper, presentation and discussion, and final written examination.

**ANNU 741: Biotechnology in Animal Nutrition (2) (E)**

**Course Objectives:**

* To acquaint students the different biotechnological tools used in animal nutrition;
* To impart knowledge on how different biotechnological tools can be applied to improve efficiency of feed utilization by livestock

**Course description:**

Scope of the use of biotechnology in animal nutrition; non-genetic manipulation of rumen; defaunation; role of fungi in fibre digestion in the rumen; various microbial, fugal and chemical agents in rumen manipulation; biodegradation of lignin; solid state fermentation; enzymes, probiotics, production enhancers.

**Course delivery:**

Lectures, assignments, term paper, presentation and discussion.

**Course assessment:**

Assignments, term paper, presentation and discussion, and final written examination.

**ANNU 751: Analytical Techniques in Animal Nutrition (3) (E)**

**Course Objective:**

* To acquaint students with the different laboratory tools used in feed evaluation and forecasting of feed insecurity;
* To impart knowledge about the different anti nutritional substances of feeds and forage

**Course description:**

Recent advances in feed analyses and forecasting of feed insecurity in livestock crisis mitigation; estimation of important anti nutritional substances and inherent toxicants of feeds and forage; energy determination; special methods for measuring digestibility; determination of NPN and nucleic acids in feeds; estimation of microbial protein supply; kinetics of digestion and estimation of passage rates; use of isotopes in animal nutrition; mechanisms of manipulation of rumen metabolism to mitigate methane production.

**Course delivery:**

Introductory lectures, assignments, term paper, presentation and discussion, laboratory.

**Course assessment:**

Assignments, term paper, presentation and discussion, and laboratory reports.

**ANNU 761: Seminar I (1)**

**Course Objective:**

* To develop skill of students in reviewing literature, presentation preparation and presentation in a selected current topic

**Course description:**

The PhD candidate is expected to review and analyze the literature and present his observations in the seminar on the selected topic related to his field of specialization other than his dissertation research topic.

**Course delivery:**

Introductory lectures, title selection, term paper, presentation and discussion.

**Course assessment:**

Term paper, and presentation and discussion.

**ANNU 712: Advances in Feed Inventory & Feed Resources Utilisation (3)**

**Course Objectives:**

* To impart knowledge about feed resources inventory, processing and utilization;
* To acquaint students with recent trends in ration formulation and quality control

**Course description:**

Processing of concentrate and roughage to improve efficiency of utilisation in animal system; anti-nutritional factors in animal feed stuffs; recent developments in formulation and compound feed preparation; formulation of area specific mineral mixtures; significance of complete feed system for ruminants in developing countries; quality control in animal nutrition, measuring feeds and fodder availability and quality.

**Course delivery:**

Course will be handled by students with minimal guidance by the instructor. Introductory lecture, assignments, term paper, presentation and discussion.

**Course assessment:**

Assignments, term paper, presentation and discussion.

**ANNU 722: Animal Science Research and Biometrics (3)**

**Course Objective:**

* To highlight basic concepts in formulating animal science research and application of experimental techniques;
* To impart knowledge about designing, collecting, handling and interpretation of experimental data

**Course description:**

Problems arising in formulating Animal Science research; application of experimental techniques to animal science research; recording, processing, interpretation and critical appraisal of experimental data; selection, designing and management of animal nutrition research; missing data and methods of handling missing data in the analysis; confounding; methods of data transformation; analysis of results of series of experiments; experimental design considerations and application of current procedures associated with large scale research projects.

**Course delivery:**

Lectures, assignments, term paper, presentation and discussion.

**Course assessment:**

Assignments, term paper, presentation and discussion, and final written examination.

**ANNU 732: Seminar II (1)**

**Course Objective:**

* To develop skill of students in doing literature survey, making analysis of available literature, preparation and presentation in a selected current topic

**Course description:**

A PhD candidate is expected to do survey and analysis of literature and make observations on the subject concerned for making presentation. Seminar presentation should be on the topic related to the specific area of the study, other than the candidate’s research topic.

**Course delivery:**

Introductory lectures, title selection, term paper, presentation and discussion.

**Course assessment:**

Term paper, and presentation and discussion.

**ANNU 742: Advanced Bioenergetics and Protein Utilisation (3)(E)**

**Course Objectives:**

* To teach about the dynamics of energy metabolism and utilization in the animal body and about systems of expressing the animal energy requirements;
* To educate about the metabolism and/or fate of proteins in the animal body

**Course description:**

Recent systems of expressing energy requirements for animals; control of energy in animal metabolism and efficiency of utilisation of free energy in the body; energy cost of production and work; specific dynamic action; energy and carbon balance studies; recent systems of expressing protein quality evaluation and requirements for animals; avenues through which nitrogen is excreted; protein reserve; protein turn over; the fate of dietary protein vs. dietary energy.

**Course delivery:**

Lectures, assignments, term paper, presentation and discussion.

**Course assessment:**

Assignments, term paper, presentation and discussion, and final written examination.

**ANNU 752: Animal Adaptation and Stress Physiology (2) (E)**

For course content see PhD Animal Genetics / Breeding program (Common course for Animal Nutrition and Animal Genetics and Breeding PhD Program)

**SWEN 672: Geographical Information Systems (GIS) Technology and Application (2)(E)**

Ground rules; topographic and thematic databases; terminology in GIS; map projection and scales; traditional cartography, vector map and raster map representation; digital mapping, processing, and analysis; relational database; GIS components, networks, and types; GIS selection and testing, land resource planning- surveys, capability evaluation, and modelling; environmental monitoring-water quality, pollution, soil erosion, and impact assessment; landscape monitoring-mapping, change analysis and impact assessment; remote sensing-input to GIS, need for data from GIS.

**ANNU 782: PhD Thesis Research (30)**

A PhD candidate is required to identify a research problem relevant to the subject concerned and on national priority. Formulation of the research proposal should be according to the standard research methodology and in consultation with the advisory committee. The problem should reflect the current advances in the field and should have objectives intended for new findings and/or for confirmation of known facts for the Ethiopian conditions. After the approval, the candidate is expected to execute the proposal and come up with the findings in the form of a thesis.

## 3. Program Name: Dairy Technology

## *Course distribution by year and semester*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***S. No*** | ***Course code*** | ***Course title*** | | ***Credit hours*** | |
| **First Year First Semester** | | | | | |
|  | **DaTe 711** | | Dairy Products Technology I | | 3 |
|  | **DaTe 721** | | Dairy and Food Microbilogy (E) | | 3 |
|  | **DaTe 731** | | Camel milk composition and processing characteristics (E) | | 2 |
|  | **DaTe 741** | | Research Methods & Experimental Design (E) | | 3 |
|  | **DaTe 751** | | Dairy Process Biotechnology | | 3 |
|  | **DaTe 761** | | Seminar in Dairy Technology I | | 1 |
| **Total** | | | | | **7/15** |
| **First Year Second Semester** | | | | | |
|  | **DaTe 712** | | Dairy Product Technology II | | 3 |
|  | **DaTe 722** | | Cheese Technology | | 3 |
|  | **DaTe 732** | | Lactic Actid Bacteria and Probiotics | | 2 |
|  | **DaTe 742** | | Dairy processing and Equipment (E) | | 3 |
|  | **DaTe 752** | | Analystical Technics and Instrumentation (E) | | 3 |
|  | **DaTe 762** | | Seminar in Dairy Technology II | | **1** |
|  | **Total**  **Second year** | | | | **9/15** |
|  | **DaTe 821** | | PhD Thesis Research | | 30 |

E = Elective courses

**Course Description**

**DaTe 711: Dairy Product Technology I (3)**

**Course objectives**

Composition, properties, chemistry, microbiology of milk will be covered with the physical and chemical properties of milk and milk products during processing. Different dairy products and their processing methods will be covered.

**Course description**

**Fluid milk products:** pasteurized milk and cream products, including flavored milks, UHT milk and other dairy products, milk separation, standardization and homogenization. Effects of homogenization on milk. recombined milk. **Dried and concentrated milks:** evaporated milk, sweetened condensed milks. Milk and whey powders. Influence of processing on the properties of condensed milks, Milk powder, dried whey powder and caseinates. **Dairy Equipment:** Common Dairy ingredients and equipment. Pasteurizers, homogenizers, separators, clarifiers, driers, pumps and conveyors, UF, RO, and MF equipment.

**Delivery methods:**

* Lecture, labratory practicals, term papers and assignment

**DaTe 721: Dairy and Food Microbiology (3) (E)**

**Course objectives**

* This course is designed to teach about the most important microbes in dairy and food industry as well as their roles

**Course description**

The course will cover topics on raw milk microflora; Sweet dairy products microflora; Pathogenic and spoilage microflora; Primary (Lactic acid bacteria) and secondary (Yeasts, molds, propionibacterium, red smear microflora, LAB ripening cultures) starter cultures microflora; Bacteriophage and bacteriophage resistance; Role of starter culture physiology on growth and end products (aroma formation, proteolysis, glycolysis, amino acid catabolism); Non-starter lactic acid bacteria, adjunct cultures and their role in cheese ripening. Microorganisms that inhabit, create, or contaminate food as well as miroorganisms causing food spoilage will be discussed. Focus will additionally be on microbial interactions including topics such as quorum sensing, and bacteriocin formation.

**Delivery methods:**

* Lecture, assignment, data analysis using different statistical software, term papers, presentations, and case studies

**DaTe 731: Camel milk composition and processing characteristics (2) (E)**

**Course objectives**

* To equip students with knowledge and skill of special characteristics of camel milk, its composition and cares to be taken while processing.

**Course description**

The camel milk composition and processing characteristics is designed to assess and understand the special characteristics of camel milk, its composition and processing. Consider characteristics of protein, carbohydrate, fat, minerals and vitamin content and its unique characteristics that attribute for its difference from other domestic animals milk composition; Effects of basic dairy operations like pasteurization, homogenization, filtration, sterilization on camel milk composition; Effect of feed type, age, breed on milk composition and its properties as well its relation with therapeutic value. Understand and acquire a profound knowledge on camel milk chemistry and chemical composition *visa vise* cow’s milk, nutrient composition, particularly milk protein and whey protein content and characteristics, Fat content and its fatty acid profiles, lactose and minerals contents including their implication in the processing of milk for butter, cheese and yoghurt productions. Consider in some details on other milk components like enzymes, hormones and various immune globulins and their potential benefits for human health.

**Delivery methods:**

* Lecture, video, term papers and presentations

**DaTe 741: Research Methods and Experimental Design (3) (E)**

**Course objectives**

To equip students with knowledge and skill of research methods and about different biometrical analysis. This especially designed to enable the students to exercise different statistical packages and methods to be employed in dissertation research data analysis.

**Course description**

Problems arising in formulating dairy technology research; application of experimental techniques to dairy technology research; planning, method of error control, starting experiment, recording, processing, interpretation and critical appraisal of experimental data; selection, designing and management of milk collection and processing, and survey research; missing data and methods of handling missing data in the analysis; confounding; methods of data transformation; analysis of results of series of experiments; experimental design considerations and application of current procedures associated with large scale research projects; principles and steps of writing scientific papers.

**Delivery methods:**

* Lecture, assignment, data analysis using different statistical software, term papers, presentations, and case studies

**DaTe 751: Dairy Process Biotechnology (3)**

**Course objectives**

* The objectives of this course is to equip students with knowledge, skill and attitude of dairy process biotechnologies.

**Course description**

The course primarily deals with designing milk through genetic engineering, genetic modification of starter culture, food grade biopreservatives in dairy, recombinant dairy enzymes and proteins, accelerated cheese ripening, probiotics, functional dairy foods, dairy waste management and pollution control, gene probe and PCR based pathogen detection.

.**Delivery methods:**

* The course is based on a series of lectures and tutorials providing an overview of dairy process biotechnologies and their application.
* Term papers and presentations

**DaTe 761: Seminar in dairy Technology I (1)**

**Course objectives**

* Students will search for current topics in dairy technology and gather up to date data and information and write a paper which will be presented in open forum discussion in the presence of teaching staffs and students.

**Course description**

A PhD candidate is expected to do survey and analysis of literature and make observations on the subject concerned for making presentation in a form of departmental seminar in the presence of senior scientists and graduate students. Seminar presentation should be on the topic related to the specific area of the study, other than the candidate’s research topic.

**Delivery methods:**

* Paper write up and presentation in the presence of senior academic staff

**DaTe 712: Dairy product Technology II (3)**

**Course objectives**

* This course will help the students to develop knowledge, skill and attitude about dairy product processing with practical exposure to different dairy processing plants.

**Course description**

Fluid milk products: Pasteurized milk and cream products, including flavored milks, UHT milk and other dairy products, Recombined milk, Fermented milks, Effect of fermentation on milk components, Structure formation in acidified milk gels, Processing of specific fermented milks; Cheese: Milk treatment for cheese making, renneting of milk, production of different cheese types, ripening of cheese; Dried and concentrated milks: Influence of processing on the properties of condensed milks, milk powder, dried whey products and caseinates; Butter and dairy spreads: Treatment of cream, Processing of cream into butter and spreads, Properties of final products; Ice cream: Ingredients and their influence, Ice cream mix, Processing and freezing of mix, Properties of final ice cream.

**Delivery methods:**

* Lecture, term papers, e-learning, laboratory practicals and analysis, excursion to dairy plants

**DaTe 722: Cheese Technology (3)**

**Course objective**

* To enable graduates to equipped with the knowledge, skill and attitude about cheese manufacturing, ripening, types, packaging and milk treatment for cheese production. Also the underlining chemical and enzymatic process that leads to ripening of cheese.

**Course description**

The course deals with cheese technology, cheese structure, and cheese ripening. Under cheese technology topics such as cheese milk treatment, characterization of cheese varieties and legislation, gross composition of cheese and its relation to cheese technology, special cheeses such as low-fat, low-salt and from concentrated milk (UF and MF) will be covered. Cheese structure: Milk coagulation, syneresis and formation of cheese structure, cheese rheology, slicing, cutting and packaging. Cheese ripening: acidification and glycolysis, lipolysis and esterolysis, proteolysis, peptidolysis, amino acid release, amino acid catabloism and flavour formation, roles of starter, adjunct and non-starter bacteria, ripening enzymes, chemical methods to evaluate cheese proteolysis and flavour formation

**Delivery methods:**

* Lecture, labratory practicals, term papers and assignment, excursion to cheese industries

**DaTe 732: Lactic Acid Bacteria and Probiotics (2)**

**Course objectives**

* This course is designed to equip students with knowledge and skill about lactic acid bacteria and their fermentation activities in dairy product development, their role of health promoting and digestion.

**Course description**

Types of lactic acid bacteria (LAB) and methods for isolation including both culture and culture in-dependent techniques will be covered. This will include techniques such as DGGE, RT-PCR and high through put sequencing as well as various tools for bioinformatics. Fermentation activities, screening, isolation and culturing, screening of LAB species from natural culture, LAB as starter-cultures for cheese processing; LAB resistance to bacteriophage and prevention techniques to lower phage contamination in dairy fermentation; redox potential: monitoring and role in development of aroma compounds, rheological properties and survival of oxygen sensitive strains during the manufacture of fermented dairy products; LAB in biopreservation and the enhancement of the functional quality of milk; health applications purposes; LAB as probiotics; characteristics, selection criteria and role in immunomodulation of human GI muccosal barrier; lactic fermentation and bioactive peptides; dynamic stresses of lactic acid bacteria; associated to fermentation processes; LAB as source of functional ingredient;

**Delivery methods:**

* Lecture, labratory practicals, term papers and assignment

1. **DaTe 742 Dairy Processes and Equipment (E) (3)**

**Course objective**

* To equip students with the knowledge, skill and attitude of dairy product process along with equipments used in processing like homogenizers, heating, membrane filtration, drier, slicer and other related equipments.

**Course description:**

Processes and equipment with applications specific to the dairy industry (e.g. equipment for homogenization, specialised heating processes, membrane filtration, cheese production, drying, freezing, slicing, dicing and shredding). The rheological properties of fluids and viscoelastic materials in dairy processing are also covered. The content concentrates on understanding the individual dairy process components and on dairy process equipment with respect to obtaining optimal processes and desired product characteristics.

**Delivery methods:**

* Lecture, labratory practicals, term papers and assignment

1. **DaTe 752 Analytical Techniques and Instrumentation (E) (3)**

**Course objective**

* To equip students with knowledge, skill and attitude on the use and application of analytical techniques and instrumentation in dairy technology and its quality assurance as well operation of laboratory equipments.

**Course description**

This course will cover advanced analytical techniques of instruments used in laboratories for analysis of different components of milk and dairy products like protein profile, fat profile, minerals, etc and precautions, methods of calibration to use different instruments. It also covers the application these instruments in analysis of different components. Instruments including different types of chromatography, spectrophotometer, and others will be covered with their underlining principles and application will be covered in this course with main emphasis in dairy technology.

**Delivery methods:**

* Lecture, labratory practicals, term papers and assignment

**DaTe 762: Seminar in Dairy Technology II (1)**

A PhD candidate is expected to do survey and analysis of literature and make observations on the subject concerned for making presentation. Seminar presentation should be on the topic related to the specific area of the study, other than the candidate’s research topic.

**DaTe 821: PhD Thesis Research (30)**

**Objectives**

* To enable students to carry out research in Dairy Technology (dairy product development from camel milk)

**Description**

A PhD candidate is required to identify a research problem relevant to camel dairy technology. Formulation of the research proposal should be according to the standard research methodology developed by the school of graduate studies of HU and in consultation with the advisory committee. The problem should reflect the current advances in dairy technology and should have objectives intended for new findings and/or for confirmation of known facts for the Ethiopian conditions. The candidate is also required to identify a research problem relevant to the subject concerned and national priority consistent with the mission and mandate of the School/University. The experiment should be planned in such a way that at least 3 manuscripts of publishable quality papers could be extracted. After the approval, the candidate is expected to execute the proposal and come up with the findings in the form of a dissertation according to the SGS guideline and the norm of the School of Animal and Range Sciences.

**4. Program Name: PhD in “Range Ecology and Dryland Biodiversity”**

## Course Breakdown

### *Core courses*

|  |  |  |  |
| --- | --- | --- | --- |
| No. | Course code | Course Title | **Cr. Hrs** |
|  | REDB 711 | Advances in Rangeland Ecology | 3 |
|  | REDB 721 | Advances in Biodiversity Conservation and Management | 3 |
|  | REDB 731 | Quantitative Ecology | 3 |
|  | REDB 741 | Climate Change Adaptations and Mitigations | 2 |
|  | REDB 712 | Advances in Wildlife Ecology and Management | 3 |
|  | REDB 722 | Environmental Degradation and Restoration Ecology | 2 |
|  | REDB 732 | Camel and Ruminant Production | 2 |
|  | REDB 742 | Sustainable Land and Watershed Management | 2 |
|  | REDB 781 | PhD Seminar in Rangeland Ecology | 1 |
|  | REDB 782 | PhD Seminar in Dryland Biodiversity | 1 |
|  | REDB 761 | PhD Dissertation | 30 |
|  | **Total Credit Hours** | | **52** |

### *Elective Courses*

|  |  |  |  |
| --- | --- | --- | --- |
| No. | Course code | Course Title | **Cr. Hr.** |
|  | REDB 751 | Environmental Risk and Impact Assessment (E) | 2 |
|  | REDB 761 | Ecological Economics (E) | 2 |
|  | REDB 771 | Fire Ecology and Management in Rangelands (E) | 2 |
|  | REDB 752 | Soil, Plant (Feed) and Water Analyses (E) | 2 |
|  | REDB 762 | Political Ecology and Natural Resources Management (E) | 2 |
|  | REDB 772 | Plant Taxonomy (E) | 2 |
|  | Total Credit Hours | | 12 |

### *Distribution of Courses by Year and Semester*

**Year I - Semester I**

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Course Code** | **Course title** | **Cr. Hr.** |
|  | REDB 711 | Advances in Rangeland Ecology | 3 |
|  | REDB 721 | Advances in Biodiversity Conservation and Management | 3 |
|  | REDB 731 | Quantitative Ecology | 3 |
|  | REDB 741 | Climate Change Adaptations and Mitigations | 2 |
|  | REDB 751 | Environmental Risk and Impact Assessment (E) | 2 |
|  | REDB 761 | Ecological Economics (E) | 2 |
|  | REDB 771 | Fire Ecology and Management in Rangelands (E) | 2 |
|  | REDB 781 | PhD Seminar in Rangeland Ecology | 1 |
| **Subtotal** | | | **12/14** |

E = elective course, and a PhD student can register t one elective course per semester.

**Year I - Semester II**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Course ode** | **Course title** | **Cr. Hrs** |
|  | REDB 712 | Advances in Wildlife Ecology and Management | 3 |
|  | REDB 722 | Environmental Degradation and Restoration Ecology | 2 |
|  | REDB 732 | Camel and Ruminant Production | 2 |
|  | REDB 742 | Sustainable Land and Watershed Management | 2 |
|  | REDB 752 | Soil, Plant (Feed) and Water Analyses (E) | 2 |
|  | REDB 762 | Political Ecology and Natural Resources Management (E) | 2 |
|  | REDB 772 | Plant Taxonomy (E) | 2 |
|  | REDB 782 | PhD Seminar in Dryland Biodiversity | 1 |
| **Subtotal** | | | **10/12** |

**Year II – Year IV**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Course Code** | **Course title** | **Cr. Hr.** |
|  | REDB 811 | PhD Seminar | P/F |
|  | REDB 821 | PhD Dissertation Research | 30 |
| **Subtotal** | | | **30** |

## Course Descriptions

**REDB 711: Advances in Rangeland Ecology (3 Cr. Hr)**

**Course objectives:** to understand the principles and practices of rangeland management paradigms and device appropriate and optimum utilization of rangeland resources in dry land areas.

**Course descriptions:** The course will cover the principles of range and grassland sciences, their geographical distribution worldwide. The rangeland management paradigms such as the concept of rangeland success theory, range condition and trend analyses, rangeland equilibrium, disequilibrium theories and stable states and transition models, range and grassland population, community and ecosystem ecology. The course will address the interaction between plant – animal – and soil under the influence of biotic and abiotic factors, nutrient cycling (island of fertility) in rangelands, the interaction effect of trees/shrubs and herbaceous/grass species on rangeland vegetation dynamics, causes and mechanisms of bush encroachment in semi-arid rangelands of the world. Historical perspectives of pastoralism in Ethiopia and worldwide, types of pastoral livelihoods (nomadism, transhumance, sedentary pastoralism), status and trends of pastoral livelihoods, indigenous knowledge in pastoral systems for the management of rangeland resources (grazing lands), water and livestock, conflict resolution and management.

**Course delivery systems:** Lecture, assignments, rangeland data analysis, practical field trips, term papers, presentation, video and case study.

**Assessment mechanisms:** Assignment, critical review of scientific papers, independent study, presentation/seminars, examinations (quiz, mid and final exam)

**REDB 721: Advances in Biodiversity Conservation and Management (3 Cr. Hr)**

**Course objectives**: To understand the concepts and theory of biodiversity and ecosystem sciences and management from interdisciplinary perspectives and at an advanced level and contribute to the knowledge of *in situ* and *ex situ* biodiversity conservation methods.

**Course Descriptions:** Understanding of the science and practice of biodiversity conservation, management and ecosystem services, biodiversity assessment and monitoring, site survey, management and restoration, data analysis, ecological principles, methods available for conservation of biodiversity, biodiversity conservation area selection and management techniques, methods for habitat restoration and species reintroduction, international agreements in biodiversity conservation, policy instruments and governance approaches to biodiversity conservation, biodiversity economics and regulatory frameworks.

**Course delivery systems:** Lecture, assignments, biodiversity data analysis, term papers, presentation, video and case study.

**Assessment mechanisms:** Assignment, report on biological data analyses, independent study, review of scientific papers, seminars, examinations (quiz, mid and final exam)

**REDB 731: Quantitative Ecology (3 Cr.Hr)**

**Course objectives:** Formulate appropriate hypotheses for ecological research questions; select the best statistical tool to test the ecological data; analyze ecological data using appropriate statistical procedures; interpret the statistical results in an ecologically meaningful sense; design, plan, and set up ecological field research projects on plants, animals, or their interactions

**Course descriptions:** Aspects of sampling design, methods and sampling procedures, field investigations and analysis of ecological field data plants, animals, and their environment, appropriate choice and application of statistical techniques for the analysis of ecological data; sample size estimation; sampling procedures and methods of vegetation and wildlife; the logical structure of an experiment; experimental designs commonly used in ecological research; special issues about pseudoreplications; fixed and random factors in ecological and rangeland research, data explanation and some common cases in which statistics are misapplied; spatial and temporal pattern measurement of populations, analysis of variance (one and Multiways), analysis of covariance, ordination: principal, component analysis, discriminant analysis, cluster analysis, generalized linear models, logistic and multinomial logistic regression and log linear models.

**Course delivery systems:** Lecture, assignments, ecological data analysis, presentation

**Assessment mechanisms:** Assignment, independent and group work on ecological data analyses, presentation/seminars, examinations (quiz, mid and final exam)

**REDB 741: Climate Change Adaptations and Mitigations (2 Cr. Hr.)**

**Course objectives:** examine and understand climate change and climate variability and predict its impact on pastoral livelihoods, rangeland ecosystems, livestock production in dryland areas to develop adaptation, coping, and mitigation management strategies.

**Course descriptions:** Knowledge of climate change and its impact across the various sectors and at different levels (global, national, local and community), climate change impact analysis; climate change models; climate change indicators; climate and land use land cover change; climate change adaptation and technological needs; adaptation and coping mechanisms; national and local adaptation strategies; ecosystem change adaptation mechanisms; vulnerability analysis and adaptation needs, climate change risk reduction and risk sharing strategies; relations and synergy between adaptation, development and environment; adaptive capacity analysis; designing climate proof development policies, adaptation strategies as risk management; Climate change mitigation and clean development.

**Course delivery systems:** Lecture, assignments, climatic data analysis, term papers, presentation

**Assessment mechanisms:** Assignment, independent and group analyes of climatic and meteorological data, presentation/seminars, examinations (quiz, mid and final exam)

**REDB 751: Environmental Risk and Impact Assessment (E) (2 Cr. Hr.)**

**Course objectives:** understand and explain the methodology of environmental risk and impact assessment and describe the kinds of projects for environmental risk and impact assessment is required

**Course descriptions:** Methodology of environmental risk and impact assessment (ERIA) as a vital tool for sound environmental decision-making, concepts, methods, issues and various stages of the ERIA process. The various stages of the ERIA process, such as screening, scoping, ERIA document preparation, public involvement, review and assessment, monitoring and auditing, appeal rights and decision-making are examined. It also discuss direct and indirect impacts; impact assessment and analysis; planning tools; assessment methodologies; water, air, biodiversity, noise, social and economic impacts and planning issues; management of impacts; assessment indices and reports; environmental legislations.

**Course delivery systems:** Lecture, assignments, term papers, presentation, and case study.

**Assessment mechanisms:** Assignment, individual or group case studies, critical review of scientific papers, presentation/seminars, examinations (quiz, mid and final exam)

**REBD 761: Ecological Economics** **(E) (2 Cr. Hr.)**

**Course objectives:** to understand the principles and practices of natural resource economics in the context of drylands and develop ecological scenarios for the proper and optimum utilization of scarce resources.

**Course descriptions:** Exhaustible and non-exhaustible natural resources, stock and flow of non-exhaustible natural resources, determination of prices of natural resources, the economics of use of natural resources and ecosystem services, rangeland and biodiversity resources utilization in dry land ecosystems, the demand for rangeland resources and its environmental quality, the sources of rangeland problems, causes, effects and consequences of rangeland degradation on pastoral livelihoods and sustainable development, environmental externalities in arid and semi-arid rangeland ecosystems, principles and techniques of impact assessment in rangeland areas, rangeland and biodiversity conservation strategies, policies and law.

**Course delivery systems:** Lecture, assignments, term papers, presentation, and case study.

**Assessment mechanisms:** Assignment, individual or group economical data analyses, review of scientific papers, presentation/seminars, examinations (quiz, mid and final exam)

**REBD 771: Fire Ecology and Management in Rangelands (E) (2 Cr. Hr.)**

**Course objectives:** understand the principles of prescribed and wild fires vis-à-vis its impacts on the rangeland ecosystems, peoples and develop controlling mechanisms and appropriate applications of fire in dryland areas.

**Course descriptions**: Distribution and ecology of fire worldwide and in Ethiopia, principles of fire ecology in rangelands, fire behavior, cause, effects and consequences of fire in rangeland vegetation, soil, livestock and biodiversity, prescribed fire in rangelands, the use of fire in rangeland vegetation dynamics and bush encroachment, the relationships of fire with plant growth, production and quality, policies in relation to wild and prescribed fire.

**Course delivery systems:** Lecture, assignments, term papers, presentation, and video show

**Assessment mechanisms:** Assignment, review of scientific papers, presentation/seminars of current topics, examinations (quiz, mid and final exam)

**REDB 781: PhD Seminar in Rangeland Ecology (1 Cr. Hr.)**

**Course descriptions:** A PhD student in Range Ecology and Dryland Biodiversity is expected to give a seminar on current issues in rangeland/grassland ecology and related issues in the 1st semester of the 1st year as part of the course.

**REDB 712: Advances in Wildlife Ecology and Management (3 Cr. Hr.)**

**Course objectives:** understand the application of wildlife conservation and management through understanding of various models of population dynamics, become familiar with the application of concepts and models in wildlife ecology for conservation and management, and understand the concepts of species interaction, population regulation and population cycles

**Course descriptions:** Concepts and models in wildlife ecology, and their application to conservation and management of wildlife populations, application of wildlife ecology, wildlife population regulation, levels of wildlife ecological organization, ecological factors affecting wildlife population, demographic and life history parameters, evolution of life history parameters: selection strategies, allometry, aging and sexing, life tables, age and stage structures models, methods of estimation of life history parameters, population dynamics: exponential, logistic and other forms of growth of population, density dependent and independent growth, food, population simulation, predator-prey systems, carrying capacity, Sampling designs for population estimation, population estimation methods, wildlife-livestock-human interaction, wildlife ecosystem and its productivity, wildlife management types, species interaction, the interaction between wildlife – livestock – human on disease ecology, principles wildlife conservation, wildlife harvest and economics and policy of wildlife.

**Course delivery systems:** Lecture, assignments, wildlife data analysis, term papers, presentation, video and case study.

**Assessment mechanisms:** Assignment, independent and group work on wildlife data analyses, presentation/seminars, examinations (quiz, mid and final exam)

**REDB 722: Environmental Degradation and Restoration Ecology (3 Cr. Hr)**

**Course objectives:** understand the causes, effects and consequences of environmental degradation on the ecosystems, pastoral livelihoods and the people and reccognize the opportunities and methods for habitat restoration and species reintroduction and ecosystem stability.

**Course descriptions: C**auses, effects, consequences and assessment of land degradation, principles and types ecological restoration, concept of holistic restoration of degraded ecosystems, practice of restoration and conceptual and philosophical issues underlying the field. Topics include ecological restoration and relationship of biodiversity resources and ecosystem services, technologies and models for ecosystem restoration, evaluation of ecosystem services and ecosystem health for better ecosystem management, establishing sustainable models for degraded ecosystems (e.g., hilly lands, dry regions, rangeland ecosystems); bio-indicators of ecosystem health, restoration of degraded rangeland ecosystems, ecological benefits of restoration (e.g., carbon sequestration, biomass production, soil microbial diversity, etc.), ecosystem health, integrity and sustainability, practices of ecological restoration (landscape engineering, soil erosion control, reforestation)

**Course delivery systems:** Lecture, assignments, land degradation and restoration data analysis, term papers, presentation, field visit to degraded and restored areas.

**Assessment mechanisms:** Assignment, practical group work, presentation/seminars, examinations (quiz, mid and final exam)

**REDB 732: Camel and Ruminant Production (2 Cr. Hr.)**

**Course objectives:** To equip the students with knowledge, skill and attitude about camel and ruminant productions in relation to changing global trends and how different development interventions could be designed and executed in different livestock production systems.

**Course descriptions:** Concept of livestock production systems, methods/tools of classification of livestock production systems, characterization of major livestock production system in the tropics and in Ethiopia based on objectively verifiable variables with a view to identify constraints and develop viable opportunities for sustainable agricultural and natural resource management, constraints of livestock production in arid and semi rangeland areas of Ethiopia. Understand their evolution and pathways of livestock production system in relation to driving forces (population, land use change, and climate change); Contribution of rangeland areas for camel and ruminant production in Ethiopia, Diversity of meat sources and consumption; description and evaluation of various meat production systems; constraints for improvement of meat and milk production; improvement through range, feedlot, nutrition, management; role of cattle, camel, goat and sheep for meat and meat production based on rangeland resources; evaluation of slaughter animals and meat quality, milk production systems in the tropics, housing and management of meat and dairy animals in warm climate. Efficient utilization of land, labor, feed and fodder for the production of meat and milk in rangeland areas.

**Course delivery systems:** Lecture, term papers, laboratory and field practices, and presentations

**Assessment mechanisms:** Assignment, review of scientific papers, presentation/seminars of current topics, examinations (quiz, mid and final exam)

**REDB 742: Sustainable Land and Watershed Management (2 Cr. Hr.)**

**Course objectives:** examine and understand the concepts and approaches of sustainable and integrated watershed management and develop appropriate integrated watershed projects and its implementation, monitoring and evaluation in the context arid and semi-arid rangeland ecosystems

**Course descriptions:** Principles and components of sustainable land watershed management, approaches of conservation (soil, water and vegetation), managements of rangelands for the conservation of biodiversity and sustainable development, dry land farming, grazing land management strategies in arid and semi-arid rangeland ecosystems, animal-plant-soil interactions in rangelands, water harvesting techniques and evaluation of water balance, causes of salt and leaching in rangeland ecosystems, principles and applications of irrigations in arid and semi-arid rangeland ecosystems.

**Course delivery systems:** Lecture, assignments, practical field visit, term papers, presentation  **Assessment mechanisms:** Assignment, report on group work, presentation/seminars, examinations (quiz, mid and final exam)

**REDB 752: Soil, Plant (Feed) and Water Analyses (E) (2 Cr. Hr.)**

**Course objectives:** to familiarize students to the methods and procedures of laboratory techniques in feed (plant), soil and water analyses and able to interpret the results for developing feed, water and soil development projects.

**Course Descriptions:** It is based on field and laboratory activities consisting of sample collection, drying, and storage for laboratory analysis, determination of physical (texture, particle size and bulk densities, porosity, field capacity, permanent wilting point, and available water holding capacity), chemical (Soil pH, electrical conductivity, exchangeable acidities, organic matter content, total nitrogen, available phosphorus, available potassium, exchangeable bases, cation exchange capacity, and micronutrients) and biological properties of soil samples, analysis and determination of chemical composition (DM, CP, ether extract, fiber fraction, macro and micro nutrients) and *in-vitro* digestibility of feed resources and plant parts. The course includes analyses of water for various macro – and micro nutrients.

**Course delivery systems:** Lecture, field and laboratory practices, assignments, presentation

**Assessment mechanisms:** Assignment, report on laboratory work, examinations (quiz, mid and final exam)

**REDB 762: Political Ecology and Natural Resources Management (E) (2 Cr. Hr.)**

**Course objectives:** to familiarize students to the existing policies, laws and legislation and advice mechanisms for their appropriate implementations in federal, regional and local levels

**Course descriptions:** Protection and multiple uses of rangeland and natural resource systems; regulation of federal public lands for agriculture, grazing, and other uses; public and private vegetation (forests) in rangeland ecosystems; establishment of the national parks (wildlife parks) and protected areas in rangeland ecosystems; the wilderness preservation system; the wildlife refuge system; fish and wildlife management (including the endangered species act and other sources of protection for fisheries and marine mammals); and use rights for rangeland resources, ownership, scientific management, decision making, community-based approaches, governance, common interest, sustainability, and professionalism; the use of integrated land use planning for proper grazing land management, conservation of biodiversity (water, wildlife and fish, vegetation) and protected area management.

**Course delivery systems:** Lecture, assignments, term papers, presentation, and case study.

**Assessment mechanisms:** Assignment, review of scientific papers, presentation/seminars of examinations (quiz, mid and final exam)

**REDB 772: Plant Taxonomy (E) (2 Cr. Hr.)**

**Course objectives:** to understand the procedures of plant classification, identifications at plant and genetic levels

**Course descriptions:** Basic and contemporary taxonomic and systematic principles and methods as applied to plants, including classification, identification skills, molecular approaches, and surveys of important families of plants; field identification, plant morphology, principles of classification and taxonomy, and concepts in evolutionary research, nomenclature, phylogenetics, and morphological evolution, historical and contemporary botany. Students are expected to achieve the following objectives after successfully completing the course: describe a plant using botanical terms, identify a plant using the key mechanics, name and publish a new species, recognize large and common families of plants, interpret plant relationships depicted on phylogenetic trees with proper terms, exhibit basic knowledge in molecular approaches applied to systematics, demonstrate knowledge in the current understanding of angiosperm phylogeny and evolution.

**Course delivery systems:** Lecture, assignments, vegetation data analysis, practical field trip, term papers, presentation, and case study.

**Assessment mechanisms:** Assignment, report on laboratory and field works, examinations (quiz, mid and final exam)

**REDB 782: PhD Seminar in Dryland Biodiversity (1 Cr. Hr.)**

**Course description:** A PhD student in Rangeland Ecology and Dry Land Biodiversity is expected to give a seminar on current issues in dryland biodiversity and related issues in the second semester of the 1st year as part of the course.

**REDB 811: PhD Dissertation Research (30 Cr. Hr.)**

**Course descriptions:** A PhD candidate is required to identify a research problem relevant to the subject concerned and on national priority and conduct cutting edge PhD dissertation research based on existing scientific theories and general laws through testing research questions and hypotheses to contribute for knowledge/innovation to science and/or to solve societal problems using well defined and structured research methodology or procedures. Moreover, formulation of the research proposal should be according to the standard research methodology and in consultation with the advisory committee. The finding should be prepared in a dissertation form consisting of chapters, presented in a scientific forum and published in reputable scientific journals to obtain a degree of doctor (PhD).

**5. Program Name: PhD in Tropical Animal Production**

**1. Course distribution by year and semester**

**Year I; Semester I**

*(COMMON FOR ALL STREAMS)*

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**Course Code Course Title Credit Hours**

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TAP 711 Adaptation physiology of farm animal in the Tropics 2

TAP 721 Tropical livestock production systems (E) 2

TAP 731 Animal Science research and biometrics 3

TAP 741 Tropical farm animal reproduction and fertility 2

ABG 731 Animal genetic resources conservation and management (E) 2

TAP 761 Seminar I (Current topics in Tropical animal production) 1

TAP 771 Geographical Information Systems (GIS) technology (E) 2

TAP 781 Livestock resource economics and marketing (E) 2

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**Total 8/16**

E = Elective courses

**Year I; Semester II**

**DAIRY ANIMAL PRODUCTION STREAM**

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**Course Code\* Course Title Credit Hours**

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TAPD 712 Tropical dairy animals production & management 3

TAPD 722 Lactation physiology of dairy animals (E) 2

TAPD 732 Advances in dairy animals’ nutrition & feeding 3

TAPD 742 Dairy products processing and technology 2

TAP 722 Camel productions and management (E) 2

TAPD 752 Seminar II (Current topics in dairy animal production) 1

TAPD 762 Dairy development policy and trade (E) 2

TAP 772 Livestock products value chain analysis (E) 2

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***Total 9/17***

\*D= refers to Dairy Production Stream

**MEAT ANIMAL PRODUCTION STREAM**

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**Course Code\* Course Title Credit Hours**

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TAPM 712 Tropical meat animals production & management 3

TAPM 722 Advances in meat animals’ nutrition and feeding 3

TAPM 732 Meat technology 2

TAP 722 Camel productions and management (E) 2

TAPM 752 Seminar II (Current topics in tropical meat animal production) 1

TAPM 762 Muscle physiology and biochemistry (E) 2

TAP 772 Livestock products value chain analysis (E) 2

***Total 9/15***

\*M= refers to Meat Animal Production Stream

**NON RUMINANT ANIMALS PRODUCTION STREAM**

**Course Code Course Title Credit Hours**

TAPN 712 Poultry production & management 3

TAPN 722 Swine production & management (E) 2

TAPM 732 Meat technology 2

TAPN 732 Monogastric animals nutrition and feeding 3

TAPN 742 Seminar II (Current topics in non-ruminant animal) 1

TAPM 762 Muscle physiology and biochemistry (E) 2

TAP 772 Livestock products value chain analysis (E) 2

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***Total 9/15***

**Year II; Semester I up to Year III; Semester II**­­­\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_***Course Code Course Title Credit Hours***

***TAP 812 PhD Thesis Research 30***

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**Total Course Work**

1. **Dairy Animal production stream 22/33**
2. **Meat Animal production stream 22/31**
3. **Non-ruminant Animal Production stream 22/31**

**2. Course description**

**TAP 711: Adaptation Physiology of farm animal in the tropics (2)**

**Course objectives**

To teach students about livestock adaptation to tropical climates and related stress factors that limit animals’ productivity and strategies to ameliorate environmental stress and increase livestock productivity.

**Course description**

Modern theories of adaptation; physiological and genetic adaptation; adaptation in relation to environment, management and physiology; an overview of factors acting as stress, quantifying factors of stress, physiological responses to stress in relation to genetic makeup, effect of stress on production, reproduction and adaptation; modification/control of factors of stress; pharmacological, management and physiological basis of alleviating stress.

**Delivery methods:**

Lecture, video, term papers and presentations, case study

**TAP 721: Tropical Livestock Production System (2)(E)**

**Course objectives**

To equip the students with knowledge, skill and attitude about tropical livestock productions systems in relation to changing global trends and how different development interventions could be designed and executed in different livestock production systems.

**Course description**

Classic concept of livestock production systems, methods/tools of classification of production systems, characterization of major livestock production system in the tropics and in Ethiopia based on objectively verifiable variables with a view to identify constraints and develop viable opportunities for sustainable agricultural and natural resource management, constraints of livestock production in Ethiopia. Understand their evolution and show future livestock production system pathways in relation to driving forces (population, urbanization, and climate change)

**Delivery methods:**

* Lecture, video, term papers and presentations, case study

**TAP 731: Animal Science Research and Biometrics (3)**

**Course objectives**

To equip students with knowledge and skill of research methods in the field of Animal Sciences and about different biometrical analysis in the field. This especially designed to enable the students to exercise different statistical packages and methods to undertake dissertation research.

**Course description**

Problems arising in formulating Animal Science research; application of experimental techniques to animal science research; planning, animal consideration, method of error control, starting experiment, recording, processing, interpretation and critical appraisal of experimental data; selection, designing and management of animal nutrition, breeding, reproduction, physiology, and survey research; missing data and methods of handling missing data in the analysis; confounding; methods of data transformation; analysis of results of series of experiments; experimental design considerations and application of current procedures associated with large scale research projects; principles and steps of writing scientific papers.

**Delivery methods:**

* Lecture, assignment, data analysis using different statistical soft wares, term papers, presentations, and case study

**TAP 741: Tropical farm animal reproduction and fertility (2)**

**Course objectives**

To enable students to understand and perceive deeply the various reproduction systems notably, anatomic, and physiology aspects including the various indigenous and exogenous hormonal systems related to reproduction and fertility of ruminants and factors affecting their expression under different management and environmental conditions.

**Course description**

The reproductive physiology and fertility course is designed to enable students to understand and perceive deeply the various reproduction systems (the male and female) notably, anatomic, and physiology aspects including the various endogenous and exogenous hormonal systems related to reproduction and fertility of ruminants and factors affecting their expression under different management and environmental conditions. The course also assess the major problems related to reproduction and fertility problems and constraints, critically analyze and evaluate the available reproduction technologies in domestic animals, such as AI, MOET, etc. that suits various production systems and improve the reproduction and fertility functions of farm animals. Aspects of fertilization, pregnancy, birth and puerperium, regulation of gonadal activities will be dealt by the course.

**Delivery methods:**

* Lecture, video, term papers and presentations, case study

**ABG 731: Animal genetic resources conservation and management (2)**

**Refer to ABG**

**TAP 761: Seminar I (1)**

**Objective**

To strengthen students ability to search for new and current ideas in their field of study

**Course description**

The PhD candidate is expected to review and analyze literature on current issues of tropical animal production and present his observations in a form of departmental seminar in the presence of senior scientists and postgraduate students. The title of the seminar shall be related to his field of specialization, but not same as or similar to his dissertation research topic.

**Delivery methods:**

* Presentation and defence of their topic of presentation under supervisor’s guidance.

**SWEN 672: Geographical Information Systems (GIS) Technology (2)**

**Course objectives**

To equip students with knowledge, skill and attitude of topographic and thematic databases, terminologies in GIS

**Course description**

Ground rules; topographic and thematic databases; terminology in GIS; map projection and scales; traditional cartography, vector map and raster map representation; digital mapping, processing, and analysis; relational database; GIS components, networks, and types; GIS selection and testing, land resource planning- surveys, capability evaluation, and modelling; environmental monitoring-water quality, pollution, soil erosion, and impact assessment; landscape monitoring-mapping, change analysis and impact assessment; remote sensing-input to GIS, need for data from GIS, use of GIS in livestock population and feed resources monitoring.

**Delivery methods:**

* Lecture, video, term papers and presentations, case study

**TAP 781: Livestock resource Economics and Marketing (2) (E)**

**Course objectives**

* To equip students with the prevailing knowledge and skill about the interaction between livestock and economy, and the role of market chain in the livestock sector.

**Course description**

The supply, demand, and allocation of livestock resources with the main objective to better understand the role of livestock in the economy in order to develop more sustainable methods of managing the livestock resources to ensure their efficient utilization. Interactions between economic and livestock production systems, with the goal of developing a sustainable and efficient economy will be covered. Livestock market and value chain with emphasis to development of efficient transparent trade off between producers and other parties involved in livestock marketing.

**Delivery methods:**

* Lecture, group discussions, term papers and presentations, case study

**TAPD 712: Tropical dairy animals’ production and management (3)**

**Course objectives**

* To equip students with the prevailing dairy production in Ethiopia and how dairy production could be managed for maximum productivity of dairy sector in the country.

**Course description**

Tropical dairy animals’ production and Management is designed to assess and understand the present condition of dairy cattle production systems in Ethiopia in terms of various resources available, particularly feeds and feeding systems, how these resources are combined to produce milk and various milk derivatives under different production systems. In addition, various problems and constraints associated with dairy production will be analyzed and appropriate technologies would be sorted out for various dairy production systems prevailing in various regions of Ethiopia in particular. These technologies would be such that it would substantially help increase dairy production and improve supplies for both domestic and export markets. Topics such as individual cow/bull and herd management, calf rearing, heifer rearing, selection, and production constraints in dairy will be addressed by the course.

**Delivery methods:**

* Lecture, video, term papers and presentations, case study

**TAPD 722: Lactation physiology of dairy animals (2) (E)**

**Course objectives**

To assess anatomy, physiology and endocrinology of mammary gland and its functional development and mechanisms of milk biosynthesis and metabolism

**Course description**

Anatomy, physiology and endocrinology of mammary gland and its functional development with emphasis to factors affecting milk yield and composition; mechanisms of milk component secretion or biosynthesis, including protein, lactose and fat metabolism; biochemical properties of mammary secretion, management and nutritional impacts on mammary development and lactation performance; manipulation of mammary development and milk production; disorders of the mammary gland (mastitis) and control strategies and milking management.

**Delivery methods:**

* Lecture, video, term papers and presentations, case study

**TAPD 732: Advances in dairy animals’ nutrition and feeding (3)**

**Course objectives**

Nutritional requirement of dairy animals at different age, physiology and lactation stage will be covered

**Course description**

Body condition, milk yield and reproduction in dairy animals in relation to nutrition; nutrient requirements and feeding for different physiological stages of dairy animals; feed input-milk output relationship in dairy animals; the nutritive value of silages in dairy cattle; application of non-protein nitrogen, protected protein and rumen fermentation control in cattle; complete diet feeding system for dairy cows; calcium requirement in relation to milk fever of dairy animals; feed processing and feed utilization in dairy animals; anti-nutritive factors in animal feed stuffs and their detoxification; bioavailability of minerals from feeds and feed ingredients for dairy animals; metabolic profile tests for dairy animals; least cost feed formulation for different stages of dairy animals; relationship between ration composition and milk components and quality.

**Delivery methods:**

* Lecture, video, term papers and presentations, case study

**TAPD 742: Dairy product processing and technology (2)**

**Course objectives**

Composition, properties, chemistry, microbiology of milk will be covered with the physical and chemical properties of milk and milk products during processing. Different dairy products and their processing methods will be covered.

**Course description**

Composition, structure and properties of milk and milk products; Chemistry of milk and its components; Microbiology of milk and milk products; Physical and chemical changes that occur during processing and storage of dairy products; Analytical methods in dairy technology; Dairy ingredients and equipments; Manufacture of various processed dairy products such as cheese, butter, ice-cream, yogurt, etc.

**TAP 722: Camel production and management (2) (E)**

**Course objectives**

To equip students with method of camel production and management in the world as well as in Ethiopia with emphasis to the role of camel in Ethiopian pastoral life and national economy as a whole

**Course description**

The camel production and management is designed to assess and understand the present condition of camel production systems in Ethiopia in terms of genetic resource, various feed resources and nutrients available particularly water, Proteins and critical minerals under pastoral and agro pastoral systems. How these resources are combined to produce main products of camel like milk, meat and other many products by products under different production systems. In addition, various problems and constraints associated with camel production will be analyzed and appropriate technologies would be sorted out for various camel production systems prevailing in various regions of Ethiopia. These technologies would be such that it would substantially help increase camel production and improve supplies for both domestic and export demand of camel products markets in various countries.

**TAPD 752: Seminar II (Current topics in dairy animal production) (1)**

**Course objectives**

Students will search for current topics in dairy animal production and gather up to date data and information and write a paper which will be presented and discussed.

**Course description**

A PhD candidate is expected to do survey and analysis of literature and make observations on the subject concerned for making presentation in a form of departmental seminar in the presence of senior scientists and graduate students. Seminar presentation should be on the topic related to the specific area of the study, other than the candidate’s research topic.

**Delivery methods:**

* Paper write up and presentation and defend

**TAPD 762: Dairy development policy and trade (2) (E)**

**Course objectives**

To equip students with the knowledge and skill of the current global dairy policy and trade as well as Ethiopian dairy policy and trade

**Course description**

Dairy development policy and trade will cover global and national dairy policies that make the country to participate in international dairy trade and what are the barriers and obstacles that made the country lag behind; ways to fit to international dairy policies; requirement for international trade of dairy products; livestock policy and trade, milk and milk products trade and policy; quality assurance of dairy and dairy products to meet international requirements

**Delivery methods:**

* Lecture, group work, term papers and presentations, case study

**TAP 772: Livestock products value chain analysis (2) (E)**

**Course objectives**

To equip students with the knowledge and skill of the current global market chain of livestock and its value chain analysis in view of the changing livestock production scenario with particular emphasis to Ethiopian livestock sector

**Course description**

This course is designed to understand livestock products value chain analysis and value addition along with analysis of market opportunities. Moreover, the way producers can establish link with market which cover full range of activities required to bring a product (e.g. live animals, meat, milk, eggs, leather, fibre, manure) to final consumers passing through the different phases of production, processing and delivery. Market-focused collaboration among different stakeholders who produce and market value-added products; access to markets and distribution of risks and gains along different steps of livestock value chains

**Delivery methods:**

* Lecture, group discussion, term papers and presentations, case study

**TAPM 712: Tropical meat animals production and management (3)**

**Course objectives**

To equip students with the knowledge and skill of the current global meat animals production and Ethiopian meat animals production condition in particular. This will helps students to understand what is lacking in Ethiopian meat animals production and enable them to come up with the way forward in line with the changing food habit and sanitary regulations for export and import of meat and meat products.

**Course description**

The meat animal production and nutrition is designed to assess and understand the present condition of meat animal production systems in Ethiopia in terms of various resources available particularly feeds and feeding systems, how these resources are combined to produce meat and meat by products under different production systems. In addition, various problems and constraints associated with meat production will be analyzed and appropriate technologies would be sorted out for various meat production systems prevailing in various regions of Ethiopia. The topics to be covered will include meat production systems in Ethiopia-the cow-calf possibility, meat and meat animal export status and potential, growth and development of meat animals, carcass measurement techniques, methodologies and quality standards, slaughtering and carcass processing, selection and management of meat animals at different stage of development, meat animal transport and handling.

**TAPM 722: Advances in meat animals’ nutrition and feeding (3)**

**Course objectives**

To cover topics on feeds and feeding systems of meat animals in terms of various feed resources available, their chemical composition, feeding values and how these feed resources are used across the seasons in different production systems.

**Course description**

This is designed to assess and understands the feeds and feeding systems of meat animals in terms of various feed resources available, their chemical composition, feeding values and how these feed resources are used across the seasons in different production systems. In addition, understanding the relationship of feeding various nutrients like energy, proteins and minerals to the growth of animals and the extent these nutrients influence meat yield and quality under different production systems. Effects of nutrient content of animal diet on meat composition, muscle and fat in the course of animal development. Effect of feed intake, feed restriction on weight loss, recovering and compensatory growth of animals.

**Delivery methods:**

* Lecture, video, term papers and presentations, case study

**TAPM 732: Meat Technology (2)**

**Course objectives**

To cover topics on muscle structure, effect of pre-slaughter And post-slaughter changes that the muscle undergo and precautions needs to be taken to maintain meat quality and quantity; meat processing equipments and meat products

**Course description**

This course is designed to cover the following areas: Carcass fabrication and dressing; muscle structure, composition and post-mortem changes; pre-slaughter and postmortem factors affecting meat quality; influence of species breed, age and sex on meat quality, effect of animal handling and associated stress on meat quality; meat quality attributes; meat processing and preservation technologies including Ethiopian conventional methods; meat safety and eating quality; meat processing equipment; hazard analysis and critical control points in meat industry; sensory evaluation and functional properties; bio-processing of meat; animal slaughter practices.

**Delivery methods:**

* Lecture, video, term papers and presentations, case study

**TAPM 752: Seminar II (Current topics in tropical meat animal production) (1)**

**Course objectives**

Students will search for current topics in tropical meat animals’ production and gather up to date data and information and write a paper which will be presented and discussed.

**Course description**

A PhD candidate is expected to do survey and analysis of literature and make observations on the subject concerned for making presentation in a form of departmental seminar in the presence of senior scientists and graduate students. Seminar presentation should be on the topic related to the specific area of the study, other than the candidate’s research topic.

**Delivery methods:**

* Paper write up and presentation and defend

**TAPM 762: Muscle physiology and biochemistry (2) (E)**

**Course objectives**

To equip students with the knowledge of physiology of muscle and muscle contraction; role of calcium and different enzymes in muscle contraction; role of myoglobin; glycogen, glycolysis, lactic acid; double muscling

**Course description**

Muscle physiology and biochemistry is proposed to cover topics about muscle development, maturity, contraction and its conversion to muscle after slaughtering. The role of growth hormones, calcium, different enzymes, and biochemical processes and cycles like glycolysis will be covered. Source of energy for life as well post-mortem muscle, chemical and physical stresses effect on muscle as well as post-mortem aging of meat and its products

**Delivery methods:**

* Lecture, video, term papers and presentations, case study

**TAPN 712: Poultry production & management (3)**

**Course objectives**

To equip students with physiology of egg formation and oviposition; Hatching eggs and hatchability. Hatchery equipment, operation, incubation and hatchery management. Commercial scale management of chicks, replacement pullets, layers and broilers. Environment, housing, equipment and waste management

**Course description**

Current issues and prospects of commercial layer and broiler poultry farms in the tropics; Different poultry breeds, ducks, quils, guinea fowl etc management; Physiology of egg formation and oviposition. Hatching eggs and hatchability; Hatchery equipment, operation, incubation and hatchery management; Commercial scale management of chicks, replacement pullets, layers and broilers; Environment, housing, equipment and waste management; Feed resource, components of poultry feed, nutrient requirement and monitoring of feed ingredient evaluation and diet formulation for different classes of poultry. Health management-control of poultry diseases and parasites; Worldwide breeding technology, biotechnology, record keeping, production of parental stock and hybrids, Chick sexing and grading. Egg as a product- quality, grading processing and marketing; Broiler birds - marketing live and processed birds; and Economics of egg and broiler meat production.

**Delivery methods:**

* Lecture, video, term papers and presentations, case study

**TAPN 722: Swine Production and Management (2)**

**Course objectives**

To equip students with the knowledge and skill of swine feeding, breeding and management and role of swine in meat production

**Course description**

Current production and management principles and practice of swine; nutrition, breeding and management of swine; application of science and basic principles of nutrition, physiology, genetics, health; economics, meat, and housing in integrated management systems for modern swine production; contribution of swine to meat production sectors; pork production, processing, preservation; role of swine in human health. Application of biotechnology in swine production and reproduction will also be covered.

**Delivery methods:**

* Lecture, video, term papers and presentations, case study

**TAPN 732: Monogastric animals nutrition and feeding (3)**

**Course objectives**

To equip students with the knowledge and skill of gastro-intestinal digestion and metabolism of nutrients in poultry, pig, equines, and rabbit; measurement of energy value; energy requirement; role of protein quality and requirements

**Course description**

Comparative gastro-intestinal digestion and metabolism of nutrients in poultry, pig, equines, and rabbit; measurement of energy value; energy requirement; role of protein quality and requirements; role of vitamins, minerals, enzymes, feed additives for monogastrics; feed resources and formulation of rations for monogastric animals; feeding methods for the different classes of poultry, pig, horse and rabbit. Feed Preparation, formulation, storage. Feed biosecurity, cost benefit analysis.

**Delivery methods:**

* Lecture, video, term papers and presentations, case study

**TAPN 742: Seminar II (Current topics in tropical non-ruminant animal production) (1)**

**Course objectives**

Students will search for current topics in tropical non-ruminant production and gather up to date data and information and write a paper which will be presented and discussed.

**Course description**

A PhD candidate is expected to do survey and analysis of literature and make observations on the subject concerned for making presentation in a form of departmental seminar in the presence of senior scientists and graduate students. Seminar presentation should be on the topic related to the specific area of the study, other than the candidate’s research topic.

**TAP 812: PhD Thesis Research (30)**

**Objectives**

To enable students to carry out research in their field of specialization and may produce technologies, new practices and innovation of new ideas, and produce publishable papers

**Description**

A PhD candidate is required to identify a research problem relevant to the subject concerned and on national priority. Formulation of the research proposal should be according to the standard research methodology developed by the school of graduate studies of HU and in consultation with the advisory committee. The problem should reflect the current advances in the field and should have objectives intended for new findings and/or for confirmation of known facts for the Ethiopian conditions. The candidate is also required to identify a research problem relevant to the subject concerned and national priority consistent with the mission and mandate of the School/University. The experiment should be planned in such a way that at least 3 manuscripts of publishable quality papers could be extracted. After the approval, the candidate is expected to execute the proposal and come up with the findings in the form of a dissertation according to the SGS guideline and the norm of the School of Animal and Range Sciences.

**School of Natural Resource Management and Environmental Sciences**

**Syllabi for PhD Program in Soil Science**

**1. Program Name: PhD in Soil Science**

**Distribution of Courses and Research Work by Year and Semester**

The course work will be conducted in the first two semesters of study.

|  |  |  |  |
| --- | --- | --- | --- |
| **Course code** | **Course title\*** | | **Credit hours** |
|  | **Year I, Semester I** | |  |
| SoSc 701 | Geomorphology (E) | | 2 |
| SoSc 711 | Advanced Soil Physics | | 3 |
| SoSc 721 | Advanced Soil Genesis | | 3 |
| SoSc 731 | Advanced Soil Chemistry | | 3 |
| SoSc 751 | PhD Seminar I (Current Topics in Soil Science) | | 1 |
| **Subtotal** |  | | **10/12** |
|  | **Year I, Semester II** | |  |
| SoSc 702 | Soil Health and Climate Change | | 2 |
| SoSc 712 | Irrigation Principles and Management (E) | | 2 |
| SoSc 722 | Land Use Planning and Watershed Management | | 3 |
| SoSc 762 | Soil Biology and Nutrient Cycling | | 3 |
| SoSc 782 | PhD Seminar II (Current Topics in Soil Science) | | 1 |
| **Subtotal** |  | | **9/11** |
|  | **Year II, Semester I up to Year III, Semester II** | |  |
| SoSc 891 | PhD Dissertation Research | | 30 |
| **Total course work** | | | **19/23** |
| **Overall total** | |  | **49/53** |

\*E = Elective course

**Course Description**

**SOSC 701: Geomorphology (2) (Elective)**

**Objectives:** this course intends primarily to equip students with basic knowledge about relationship between land form development, environment and soil forming processes

**Learning outcome**: after successful completion of this course, students will be able to relate soil, land form and environmental processes

**Course contents:** Principles of landform evolution; landforms and landscapes, their relationship with pedons and polypedons; climate and denudational processes; nature and types of drainage basins; sediment load; geometry of channel forms and processes; flood plain and hill slope characteristics; their development and relationship with lithology and soils

**SOSC 711: Advanced Soil Physics (3)**

**Objectives:** to equip students with detailed knowledge of the field-water balance and its management, and expression of spatial variability of soil physical properties using spatial statistics

**Learning outcomes:** After successful completion of the course, students will be able to:

* Comprehend and explain the major components and processes of field-water balance
* Explain infiltration and surface runoff processes,
* Comprehend the post-infiltration movement of water and its effect on plant available soil moisture and solute transport,
* Describe groundwater drainage and its effects on sustainable use of groundwater resources,
* Understand the evaporation process from bare-soil surfaces under different conditions of water table depth and its effect on soil desiccation and soil moisture availability, and
* Describe the spatial variability of soil physical properties and use it for designing sampling strategy.

**Course contents:** The field-water cycle and its management: Infiltration and surface runoff, profile moisture distribution during infiltration, infiltrability equations, the Green and Ampt Approach, modern approaches to infiltration theory, infiltration into layered profiles, infiltration into crust-topped soils, instability of wetting fronts during infiltration, rain infiltration, surface runoff, runoff inducement, some topics of current research on infiltration; Internal drainage and redistribution following infiltration: Internal drainage in thoroughly wetted profiles, redistribution of soil moisture in partially wetted profiles, hysteresis phenomena in redistribution, Analysis of redistribution process; Groundwater drainage: some basic concepts of groundwater hydrology, flow of confined groundwater, flow of unconfined groundwater, analysis of falling water table, review of equations pertaining to flow of unconfined groundwater, Flow nets, models and analogs, groundwater drainage, factors influencing drainage, drainage design equations; Evaporation from bare-surface soils: Steady evaporation in the presence of a water table, hazard of salinization due to high water table, evaporation in the absence of a water table, Diurnal fluctuations of surface-zone moisture and hysteresis effects, evaporation from irregular surfaces and shrinkage cracks, reduction of evaporation from bare soils; spatial variability of soil physical properties in the field: expressing variability, sample numbers, autocorrelation and spatial analysis.

**SOSC 721: Advanced Soil Genesis (3)**

**Objectives:** this course tries to equip students with basic knowledge on soil forming factors and processes, clay mineralogy and its properties, classification and nomenclature of soils

**Learning Outcomes:** upon completion of this course, students will be able to discuss soil forming factors and processes, weathering processes, clay minerals and their properties and classification of soils.

**Course contents:** Genetic factors of soil forming processes and reactions; Physical and chemical (geochemistry) processes and mineralogy of weathering and soil formation; quantitative pedology; the soil as part of the ecosystem; physical and chemical properties of primary, secondary and accessory clay minerals.

**SOSC 731: Advanced Soil Chemistry (3)**

**Objectives:** To help students understand elements of soil chemistry, particularly the relation of the soil solution to the solid and colloidal phases, and the soil’s interaction with the atmosphere, hydrosphere, and biosphere systems, discuss soil’s capacity to retain (dsorb), exchange, release and transform chemical elements of concern to life and soil development, explain soil’s role in the production of food and fiber for the sustainability of life and the world’s industrial economy, and to explain the soil’s role and significance in biogeochemical cycles, in environmental problems, and in mitigating these and other problems. It explores how molecular-scale solution-phase and surface reactions influence macroscopic chemical processes such as sorption-desorption, precipitation-dissolution, oxidation-reduction and particle interactions.

**Course contents:** Fundamentals of aqueous surface and colloid chemistry of inorganic and organic constituents; ion exchange and equilibrium relations; absorption chemistry; thermodynamic approach to nutrient availability; physical and chemical processes influencing the behavior of ions and contaminants in the subsurface environment; transport and behavior of chemicals/ heavy metals in soil environment; equilibrium and kinetic theory of solubilization-dissolution, volatilization, sorption, hydrolysis, photolysis, surface catalysts and radioactive decay; ecotoxicity; Properties, and principles and practices of acid soils management and reclamation; Properties, and principles and practices of salt affected soil management and reclamation; Current research in the field will be explored through independent literature research and the preparation & presentation of a term paper.

**SOSC 751: PhD Seminar I (Current Topics in Soil Science) (1)**

**Course contents:** The PhD candidate is expected to review and analyze the literature and present his observations in the seminar on the selected topic related to his field of specialization other than his dissertation research topic.

**SOSC 702: Soil Health and Climate Change (2)**

**Objectives**: to equip students with basic knowledge on the impacts of climate change on soil properties, processes and soil health under different ecosystems and management practices, possible effects of soil processes and properties on climate change, and research methodologies in assessing the possible impacts of climate change on soil health.

**Learning outcomes:** Upon successful completion of the course, students will be able to:

* Identify and comprehend soil health indicators for climate change,
* Understand soil attributes and soil processes affected by climate change and their management,
* Comprehend the impacts of conventional land use systems on soil health under climate change, and
* Conceptualize the pros and cons of organic farming, biochar and bio-energy systems on soil health and clim2ate change

**Contents:** Soil health and climate change; soil health indicators under climate change: climate change and soil physical, chemical and biological properties, and soil health; Genetic and functional biodiversity of soils, soil health and climate change; Soil attributes and soil processes in response to the climate change; Tillage and Crop Stubble Management and Soil Health in a Changing Climate; Intensification in Pastoral Farming: Impacts on Soil Attributes and Gaseous Emissions; Climate Change Impacts on Soil Processes in Rangelands; Possible Impacts of Climate Change on Forest Soil Health; Rehabilitated Mine-Site Management, Soil Health and Climate Change: Organic Farming: Pros and Cons for Soil Health and Climate Change; Biochar in Soil for Climate Change Mitigation and Adaptation; Bio-energy Systems, Soil Health and Climate Change

**SOSC 712: Irrigation Principles and Management (3) (Elective)**

**Objectives:** to equip students with basic knowledge on water resources development and utilization for irrigation, assessment of impacts of large-scale irrigation projects on the environment, water measurement devices and distribution structures, evapotranspiration, and crop and irrigation water requirement determination, methods of irrigation, irrigation scheduling, salinity management, land suitability evaluation for irrigation and management of excess water in irrigated agriculture (agricultural drainage).

**Learning outcomes:** after successful completion of the course, students will be able to:

* Develop water resources development strategies for irrigation,
* Identify appropriate water harvesting and storage structures for irrigation,
* Foresee the possible impacts of large-scale irrigation projects on the environment,
* Know the different water measurement devices and water distribution structures for irrigation,
* Understand the concepts of evapotranspiration,
* Determine irrigation and crop water requirement for an area and a given crop,
* Understand the basics of the different irrigation methods and their pros and cons,
* Identify appropriate management salinity management scenarios in irrigated agriculture, and
* Recommend and design appropriate drainage systems for irrigated agriculture.

**Contents:** Utilization of water resources and Irrigation development: Need for sustainable water management, Irrigation development in the world, Extent of utilization of irrigation potential in Africa and Ethiopia, participatory irrigation management, floods and droughts, Environmental impact assessment of irrigation projects; Sources and storage of irrigation water: Measurement of irrigation water: methods of water measurement, weirs and flumes, orifices and meter gates, tracer methods; open channel distribution in command areas: on-farm structures for water conveyance, control and distribution, on-farm water conveyance and distribution systems in irrigation command areas; Underground pipeline system: Underground pipeline structures, underground pipeline water distribution systems in community irrigation projects; Water requirement of crops and irrigation management: Evaporation, transpiration, evapotranspiration, estimating evapotranspiration based on climatological approach, FAO Penma-Montieth based combination formula for estimating Reference Evapotranspiration, crop evapotranspiration, Crop water requirement and irrigation, Irrigation scheduling, Irrigation efficiency, Planning cropping systems and water management in irrigation project areas, irrigation requirement of common crops, Evaluating lands for irrigation command areas: Methods of irrigation water application: surface irrigation, sprinkler irrigation, drip irrigation; Salinity management in irrigated agriculture: Application of soil amendments, irrigation with poor quality water; Drainage of irrigated lands: Surface and subsurface drainage systems and their design, bio-drainage; Performance evaluation of irrigation projects: Internal and external indicators of performance

**SOSC 722: Land Use Planning and Watershed Management (3)**

**Objectives:** thiscourseis initiated to upgrade students’ ability of appraising and evaluating land and preparing a land use plan that ultimately contributes to sustainable land use and also to better understand and practices which ensure the most adoptable watershed management options.

**Course contents:** The structure and function of watershed ecosystems with emphasis on the ecosystem and geomorphic processes shaping watersheds, measuring ecosystem function in watersheds, and measurement of positive and/or negative changes in ecosystems; processes shaping the structure and functioning of ecosystems and watersheds, their responses to natural and anthropogenic change and recovery to these disturbances; comparison of different ecosystems to watershed responses to anthropogenic changes and collect data from selected field sites to explore the relationship among ecosystem processes and changing climate (or other disturbances); the importance of proper ecologic functioning to the maintenance of healthy watershed systems; Land classification systems for agriculture, forestry and environmental planning; selected land uses; land resources data; approaches for managing soils and landscapes judiciously in ecosystem frame-work; controls in land use planning; modern trends in controlling land uses; soil potential rating; soil degradation and reclamation; concept and planning of watershed management, characteristics of watershed, methods of watershed management.

**SOSC 762: Soil Biology and Nutrient Cycling(3)**

**Course objectives:** The course gives an understanding about micro organisms living in soil, their habitat and interrelationships. The importance of nutrient cycling in soil and role of micro organisms in it. Application of microbes in agriculture and utilization of biofertilisers and organic farming. Developing knowledge on soil biotechnology and its application in degradation processes. Bioconversion of different wastes by various technologies.

**Learning outcomes:**The course will enable the students to learn basic principles of various soil management techniques related to soil micro organisms and maintaining the biological characters of soil in relation to improving the quality of soil. The students will be able to give guidance and solve problems associated with soil fertility in an eco friendly way. The knowledge will be used to recommend an organic method of farming involving utilization and production of biofertilisers. The practical knowledge gained will help them to establish microbial based techniques for improvement of crop production and abatement of pollution.

**Course contents:** Plant soil relationships; biogeochemistry-microbial activity; Nutrient cycling; Biological Nitrogen Fixation **-**Recent trends in nitrogen fixation –molecular and genetic aspects of nodulation and nitrogen fixation. Soil microbial ecology;Rhizospheric and phyllospheric microbes and their ecophysiology;Soil plant microbe interactions in rhizosphere in relation to nutrients and xenobiotics;Symbiotic and pathogenic relations with plants. Biofertilisers; Fate of inoculants in soil; Mycorrhiza plant relationship. Soil biotechnology- Biodegradation of pollutants; Biopesticides; Aerobic and anaerobic decomposition in soils ; Integrated recycling of wastes; Organic waste recycling and sustainable agriculture. Sewage sludge and effluents –treatment processes; Biodegradation of hazardous and toxic compounds.

**SOSC 782: PhD Seminar II (Current Topics in Soil Science) (1)**

**Course contents:** The PhD candidate is expected to review and analyze current literature and present his/her observations, in a seminar, on the selected topic related to his/her field of specialization other than his/her dissertation research topic.

**SOSC 891: PhD Thesis Research (30)**

**Course contents**: A PhD candidate is required to identify and undertake dissertation research work on a topic of national priority related to soil and water resources under the supervision of a major advisor from the major field. Formulation of the dissertation research proposal should be according to the standard research methodology and framed in consultation with the advisory board. The topic and planning of the study is to be determined jointly by the student and his advisor(s). After the approval the candidate is expected to execute the proposal and come up with the findings in the form of a dissertation. The PhD dissertation research, as a partial requirement for the fulfillment of degree program, includes its presentation and successful open defense.

**Department of Rural Development and Agricultural Extension**

**Syllabi for PhD Program in** **Rural Development and Agricultural Extension**

*(Streams: Knowledge Management and Capacity Development; Commercial and Rural Institutions*)

**1. Program Name: PhD in Rural Development and Agricultural Extension**

1. **Course Profile**

Course profile entails List of courses, Course coding, Course breakdown. Course description, Course objectives, Mode of delivery and Mode of assessment

* 1. **Course Work and Research**

The course work and dissertation research of each candidate should address the thematic areas listed. The course work will follow two general guiding principles. First, the cross-cutting issues like gender, natural resource management and climate change are to be mainstreamed. Second, the courses should address theoretical, conceptual, policy/institutional, analytical, empirical, and practical issues of the topic.

The two streams of this doctoral program will have separate compulsory thematic areas and elective courses relevant to the dissertation research. The stream of Knowledge Management and Capacity Development will have courses related to knowledge management and innovation as well as capacity development thematic areas. The stream of Commercialization and Rural Institutions will have to cover courses related to rural institutions and collective action, commercialization and rural livelihoods, and rural and agricultural service delivery.

* 1. **Course Breakdown**

**Semester I**

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Course Code** | **Course Title** | **Credit Hours** |
|  | RDAE 711 | Advanced Methods in Social Research\* | 3 |
|  | RDAE 712 | Knowledge Management for Development1 | 4 |
|  | RDAE 713 | Agricultural and Rural Innovation Systems1 | 3 |
|  | RDAE 714 | Agricultural Commercialization and Rural Livelihoods2 | 4 |
|  | RDAE 715 | Rural Institutions and Collective Action2 | 3 |
|  | RDAE 716 | Doctoral Seminar-1 | 1 |
| **Total** | | | **11+3/4= 14/15** |

**Semester II**

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Course code** | **Course title** | **Credit Hours** |
|  | RDAE 721 | Rural Capacity Development1 | 3 |
|  | RDAE 722 | Local Development Planning1 | 4 |
|  | RDAE 723 | Rural Policies and Governance2 | 4 |
|  | RDAE 724 | Agricultural Inputs and Service Delivery Systems2 | 3 |
| 6 | RDAE 725 | Doctoral Seminar-2 | 1 |
| **Total** | | | **8+3/4 =11/12** |

\*stands for common compulsory course; 1 and 2 stands for compulsory courses in the first and second streams respectively. Choice of elective either in first or second semester, which makes the total credit hour requirement 22 or 23

**Doctoral Dissertation**

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Course code** | **Course title** | **Credit Hours** |
| 1 | RDAE 761 | Doctoral Dissertation Research | 30 |

* 1. **Course Descriptions**

The following are the descriptions of the courses proposed.

**Course Title: Advanced Research Methods**

**Course Code: RDAE 711**

**Credit Hours: 3 credits**

**Course Objectives**

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

* Identify the appropriate research methods and tools in each context of socio-economic research
* Apply the research methods and techniques appropriately and accurately
* Interpret the empirical findings in a critical way
* Conduct in-depth analytical methods of qualitative research

**Course Description**

Research designs; sampling design; types of errors in measurements; establishing validity and reliability; scaling techniques; principles and techniques of scale construction; paired comparison, equal appearing intervals, successive intervals, summated ratings, scalogram analysis, scale discrimination technique, sociometry, content analysis, case study methods, Q-sort techniques, semantic differential technique; critical incident methods; participatory tools and techniques in social research; impact analysis; qualitative research tools and methods; qualitative data analysis and interpretation; quantitative data analysis; regression estimations and interpretations; principal component analysis – econometric models - projective techniques and semi-projective techniques in behavioral research

**Teaching Learning Methods**

Introductory lectures, group discussions, case studies, individual reading and field based assignments and presentations

**Assessment Methods**

Performance in written examination, reading and field based assignments, presentations and reports of case studies. Presentations- 30%, Individual assignments- 30%, Exam- 40%

**Course Title: Knowledge Management for Development1**

**Course Code: RDAE 712**

**Credit Hours: 4**

**Course Objectives**

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

* Understand the concepts, theories and applications of knowledge management
* Realize its importance in the context of rural development
* Familiarize with different knowledge management tools

**Course Description**

Historical and sociological foundations for knowledge; Theories/definitions of knowledge; Introduction to the field of knowledge management; Concepts, principles, and theories of knowledge management; Information management vs. knowledge management; Applications of knowledge management in agriculture; Agricultural knowledge systems; Knowledge and information; Identification and effective management of agricultural knowledge assets; Utilization of knowledge assets by communities and enterprises; Agricultural knowledge acquisition, generation, formalization, organization, sharing, utilization, measurement and evaluation; Identification of agricultural knowledge needs of end-users; Management of indigenous knowledge in rural development context; Key technologies for agricultural knowledge management; Application of ICTs in knowledge management; Issues in selecting agricultural knowledge systems; Concept of knowledge engineering; Design and operation of agricultural knowledge systems and technologies; Knowledge management frameworks; Techniques of knowledge management: SWOT, Balanced Score Cards, IDEF, Role Activity Diagrams; Knowledge management roadmaps; Knowledge networks of rural communities; Trends in agricultural knowledge management.

**Teaching Learning Methods**

Introductory lectures, group discussions, case studies, individual reading and field based assignments and presentations

**Assessment Methods**

Performance in written examination, reading and field based assignments, presentations and reports of case studies. Presentations- 30%, Individual assignments- 30%, Exam- 40%

**Course Title: Agricultural and Rural Innovation Systems (ARIS)**

**Course Code: RDAE 713**

**Credit Hours: 3**

**Course Objectives**

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

* Clearly understand the concepts of system thinking, and different types of innovations
* Comprehend the application of innovation systems in rural development
* Apply innovation system tools in analytical procedures

**Course Description**

Innovation systems thinking: evolution, concepts and principles; types of innovation systems; managing Innovation Systems; viable innovation systems; leadership and direction functions; innovation capacity; diagnostic assessments of agricultural innovation capacity; innovation systems in Ethiopian context; institutionalization of innovation system perspective; partnerships and networks in innovation systems; efficiency and effectiveness of public-private partnerships in national and international context; phases of partnership and networking; monitoring and evaluation of innovation systems; market-led extension and value chain analysis in sub- Saharan Africa and Ethiopia; outcome mapping for tracking behavioral changes; dimensions of impact assessment; SWOT analysis of innovation systems; stakeholder analysis; actor linkage mapping and matrix; goal setting and project cycle in innovation systems; application of log frame analysis; participatory assessment and planning; participatory learning and action; tools of PRCA and their application in innovation systems’ analysi

**Teaching Learning Methods**

Introductory lectures, group discussions, visits to resource centers in the country, case studies, individual reading and field based assignments and presentations

**Assessment Methods**

Performance in examination, reading and field based assignments and presentations. Presentations- 30%, Individual assignments- 30%, Exam- 40%

**Course Title: Agricultural Commercialization and Rural Livelihoods**

**Course Code: RDAE 714**

**Credit Hours: 4**

**Course Objectives**

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

* Understand the concepts, issues and possibilities of commercialization of small holder farming
* Realize its importance in the context of rural development
* Analyze the elements and constraints in agricultural commercialization in Ethiopi

**Course Description**

Policy and institutional issues: conceptual, analytical and methodology approaches for understanding and analysis of agricultural commercialization for increasing farming households’ incomes, creating rural employment, improving livelihoods, and economic growth, with especial emphasis on smallholder market participation, sustainable intensification and rural non-farm for employment creation. Gender and environment are crosscutting issues that should be systematically mainstreamed in both theoretical and analytical discussions.

The role of well functioning market for rural growth and poverty alleviation; transformation of agricultural out put markets (scale, nature of demand, governance); the concept of smallholder market participation, commercialization and commercialization process and drivers; opportunities and challenges for smallholder participation in traditional, moderns, domestic and global markets; agricultural value chain approach, risks and transaction costs along value chains, collective action, infrastructural investment and contracts for reducing risks and transaction costs and the role of government, NGOs, CSO and donors; agricultural value chain as a means of creating demand for labor and services for rural poor and youth.

Conventional approaches to agricultural intensification, environmental externalities, energy scarcity and climate change; systemic approaches to sustainably managing natural resource base from agro-ecological perspective, context adaptation, and building on local practices and integrating scientific knowledge; incentive and risk mitigation measures such as secure land tenure, market for environmental services, and strengthening agricultural education and training system, research and advisory services, multi-stakeholder collaboration and coordination.

Rural non-farm economy as risk management strategy and routes out of poverty as source of rural growth and employment; agricultural growth as a key driver of rural non-farm, and other non-agricultural drivers, including urbanization and rural-urban linkages, liberalization and globalization, improving ICT and increasing investment in renewable-based energy systems; incentives and risk reduction for rural non-farm economy growth such as investment in rural infrastructure and services, improving business climate and provision of business development and financial services to small enterprises/entrepreneurs.

Analytical frameworks for assessing market participation, commercialization, and rural livelihoods; value chain approach; methods for empirical assessment; experience and lessons from Ethiopia and other countries in sub-Saharan Africa in smallholder commercialization and improvement of rural livelihoods – policies and interventions by governments and donors.

**Teaching Learning Methods**

Introductory lectures, group discussions, visits to resource centers in the country, case studies, individual reading and field based assignments and presentations

**Assessment Methods**

Performance in examination, reading and field based assignments and presentations. Presentations- 30%, Individual assignments- 30%, Exam- 40%

**Course Title: Rural Institutions and Collective Action2**

**Course Code: RDAE 715**

**Credit Hours: 3**

**Course Objectives**

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

* Clearly understand the role of rural institutions in community mobilization
* Realize the applications of collective action in all spheres of rural welfare
* Undertake research on collective action, particularly in the context of common property and group mobilization contexts

**Course Description**

The concepts of institutions; old versus new institutional economics; institutions and agricultural development; institutions and perverse incentives; institutions and market; the concepts of collective action; institutions for collective action; social dilemma in collective action; determinants of collective action; collective action in commons management; core relationships and structural factors; public goods and collective action; collective action in provision of services, cooperatives

**Mode of delivery and assessment**:

In addition to lecture and classroom discussion, students will be exposed to various case studies on collective action to relate the theoretical aspects with empirical studies in managing irrigation systems, cooperatives, service delivery, access to markets, soil and water conservation, watershed management, etc. This will be achieved through writing a term paper (30%), individual assignments (30%) and the final exam (40%).

**Course Title: Doctoral Seminar-1**

**Course Code: RDAE 716**

**Credit Hours: 1**

**Course Objective**

The objective of this course is to make the students updated and familiar with issues of contemporary importance in the country and the world. It will enable them to learn how to gather all possible information from primary and secondary sources to have a comprehensive knowledge of the topic under focus, and how to make interpretations with analysis of its implications. Seminar will also help to improve technical presentation skills and report writing abilities.

**Course Description**

This seminar will address selected topics of contemporary importance as suggested by the Department Graduate Council ensuring their relevance importance. Examples of such topics are Climate and Adaptation, Rural Energy Crisis, Consequences of Rural-Urban Migration and so on. The students have to make exhaustive information gathering from primary and secondary sources and prepare elaborate concept notes on the themes suggested. Each student will have separate topic for the seminar. Preferably, experts on the topics from inside or outside the university will be invited to have a discourse on the topic at least a week before the date of seminar by the student and the deliberations of that event will also be incorporated in the students’ seminar. The seminar report will include detail discussions of the topic content, contextual interpretations and brief recommendations. The seminar report will also include the tools of presentation.

**Assessment Methods**

This course will be assessed based on depth of topic coverage, style of presentation, presentation aids used, and quality of report. The assessment will be done by team of experts assigned for this purpose based on fixed evaluation criteria.

**Course Title: Rural Capacity Development1**

**Course Code: RDAE 721**

**Credit Hours: 3**

**Course Objectives**

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

* Understand the concepts, theories and applications of rural capacity development
* Realize its importance and means in the context of rural development
* Familiarize with different capacity development techniques

**Course Description**

Concept of capacity development; Capacity assessment; Levels and dimensions of capacity development: broader system or societal level, Entity or organizational level, Group of people or individual level; Human resource development, Organizational and institutional capacity development, Policy and legal frameworks; Antecedents of institutional change; Historical antecedents in capacity development; McKinsey’s framework for capacity development; Theories of social change in the context of rural capacity development; Multi-layered, non-linear, multi-stakeholder change inducement; Education and micro enterprises development, Modernizing agricultural and vocational education, Farmers’ Training Centers in rural capacity development; Women empowerment through micro finance, Elements of capacity development: Knowledge building, Leadership development, Network Building, Valuing community and the capacity of the community, Supporting information; Theories of community capacity development: Human capital theory, New public management theory, Social exclusion theory, Need for research in rural capacity development, Natural resources and rural capacity, Community based organizations enhancing community capacity; Role of ICT in strengthening rural community life

**Teaching Learning Methods**

Introductory lectures, group discussions, library and field based information gathering, individual assignments, case studies and presentations

**Assessment Methods**

Performance in examination, reading and field based assignments and presentations. Presentations- 30%, Individual assignments- 30%, Exam- 40%

**Course Title: Local Development Planning1**

**Course Code: RDAE 722**

**Credit Hours: 4**

**Course Objectives**

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

* Understand the concepts, theories and applications of local development planning
* Learn the strategies and methods of local development planning
* Familiarize with different dimensions of successful planning and execution

**Course Description**

The need for planning local development; development planning perspectives in the contemporary world; multi-sectoral and integrated development; recent theoretical insights pertaining to regional development including issues of institutions, learning, innovation, and competitiveness; rural land use planning – housing and settlement, landscape, environment and conservation and eco-tourism, transportation; rural-urban relationships- migration, employment, and trade; planning for services; local development planning and management; community empowerment and participation in planning; facilitating community-based planning; situation analysis in development planning; gender dimension in local development planning; sensitivity in planning – scenario analysis; the role of donors in development planning- pros and cons analysis; the influence of globalization in local development

**Mode of Delivery**- Introductory Lectures, discussions, case study analysis and presentations

**Mode of Assessment**:

Performance in examination, reading and field based assignments and presentations. Presentations- 30%, Individual assignments- 30%, Exam- 40%

**Course Title: Rural Policies and Governance2**

**Course Code: RDAE 723**

**Credit Hours: 4**

**Course Objectives**

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

* Learn the concepts, theories and applications of policies in the context of good governance
* Understand its importance in the context of rural development
* Acquaint with different policies and practices in Ethiopia

**Course Description**

Paradigm shift in rural development policies; agricultural sector and economic growth; linear process Vs participatory stakeholder in policy process; issues on democratization governance strategies and policy frameworks; tolls for institutional, political and social analysis of policy; policy analysis and institutional analysis; governance reforms; institutional innovations and reforms for rural development; globalization; replacing economic globalization with democratic localization; Africa’s regional reactions to globalization, IGAD, COMESA, SADIC, ECOWAS; Fiscal expenditure and subsidies, principal aspects of the legal framework; policies that influence farmers/producer incentives; fiscal policy and agricultural prices; land reforms and land tenure policies; issues and trends in land tenure in Ethiopia; communal, collective and individual rights land; experiences with land reforms of Zimbabwe, Kenya and other African countries; policies for agriculture and rural finance; regulatory framework and structural considerations for rural finance institutions; macroeconomic policy to support rural finance institutions; policies for agricultural technologies; new approaches in agricultural research and extension; water management policies in agriculture; institutional and process issues; participatory process, structure and consistency; substantive orientations. The concepts of governance; governance structures; public participation in governance; governance reforms; decentralization, de-concentration and centralization in governance; relationship between governance and rural development; challenges in governance; opportunism, corruption and development; policies in preventing corruption; political and economic institutions in governance; equity, growth and political stability; approaches in governing of rural land resources – devolution, co-management and privatization;

**Mode of delivery and assessment:**

In addition to lectures and classroom discussions, students must read relevant articles and/or case studies to digest the concepts and apply these concepts while writing a term paper for the course. Assessment will be based on performance in examination, reading and field based assignments and presentations. Presentations- 30%, Individual assignments- 30%, Exam- 40%

**Course Title: Agricultural Input and Service Delivery Systems2**

**Course Code: RDAE 724**

**Credit Hours: 4**

**Course Objectives**

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

* Understand the concepts and theories of service delivery systems
* Realize the importance of input and other service delivery in the context of rural development in Ethiopia
* Develop a clear understanding about the constraints and opportunities in having an effective service delivery system in the country

**Course Description**

Policy and institutional issues as well as conceptual, analytical and methodology approaches for better understanding and analysis of input and service systems for sustainable intensification of smallholder crop and livestock systems, with special emphasis on fertilizers, seeds and agro-chemicals, and livestock production inputs, breeding and animal health services. Gender and environment are crosscutting issues that should be systematically mainstreamed in both theoretical and analytical discussions. The roles of efficient input supply and service systems for sustainable intensification of smallholder crop and livestock systems; major challenges facing smallholder crop and livestock sectors relating to accessing inputs and services; organization, financing and delivery of agricultural input and services with special reference to Ethiopia; macro-economic policy and regulatory framework influencing input/service market; efficiency, equity/gender, quality, human health and environmental concerns; trends and drivers of changes in agricultural input and service systems; analytical frameworks for input and service systems assessment such as political-economic, transaction costs framework, etc; approaches and methods for empirical assessment; policy and institutional options to improve input and service systems and access by smallholder; experience and lessons from Ethiopia and other countries in sub-Saharan Africa in input supply and service systems improvement interventions by governments and donors.

**Delivery Methods:**

Classroom lecture and discussions, Literature review on Ethiopia and term paper on specific inputs/services- fertilizer, seeds, agro-chemical, animal health and breeding services, etc, Journal articles (empirical research) reading assignment, accompanied by sharing of knowledge gained with fellow students as well as instructors to help the students to internalize the main analytical frameworks, and research approach and methods.

**Methods of Assessment**

Performance in examination, reading and field based assignments and presentations. Presentations- 30%, Individual assignments- 30%, Exam- 40%

**Course Title: Doctoral Seminar II**

**Course Code: RDAE 725**

**Credit Hour: 1**

**Course Objective and Mode:**

This will cover a theme related to the Doctoral thesis research, and concepts, theories and issues of realities on the ground will form the basis of presentation. Students have to make an exploratory survey using PRA tools in the proposed study location using basic research questions. Adequate time should be taken for field work and review of literature. This seminar will help to write the full research proposal later, incorporating the feedback obtained in the presentation.

**Course Assessment**

The report should be in detail and bound hard copy and soft copy will have to be submitted to the department after presentation. Assessment of the seminar will be based on depth of information gathered using primary and secondary sources and field work, style of presentation, clarity in responses to questions from the audience, quality of presentation slides, and the final report.

**Course Title: Doctoral Dissertation Research**

**Course Code: RDAE 761**

**Credit Hour: 30**

The Doctoral dissertation will be based on an original research work, which is problem oriented and innovative in nature. It will have a credit load of 30 hours per week. A pre-proposal should be developed based on a reconnaissance survey using rapid appraisal tools carried out in the study area and should be defended in an open forum created for the purpose. Taking the feedback of this presentation and collecting additional information, the research proposal has to be developed taking a maximum period of two months. The proposal has to be finalized after the Doctoral Seminar II, which also will provide ideas for improvement. The proposal defense will be in an open forum for the university community. In the course of research process, semester-wise periodical progress reports are to be submitted to the DGC with the approval of the research supervisor.

**SCHOOL OF PLANT SCIENCES**

**Syllabi for PhD Program in Agronomy**

**Syllabi for PhD Program in Horticulture**

**Syllabi for PhD Program in Plant Breeding**

**Syllabi for PhD Program in Plant Pathology**

**Syllabi for PhD Program in Agricultural Entomology**

**1. PhD Program in Agronomy**

**Course Profile**

Course profile includes Course coding, Course breakdown and Course description

**Course Breakdown**

**Year I; Semester I**

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Course Code** | **Course Title\*** | **Instructor** |
| 1. | PLAG 711 | Mineral Nutrition of Crop Plants (R) | 2 |
| 2. | PLAG 721 | Physiology of Crop Yield and Quality (R) | 3 |
| 3. | PLAG 731 | Soil-Plant-Water Relations (R) | 2 |
| 4. | PLAG 741 | Advances in Weed Management (E) | 2 |
| 5. | PLAG 751 | Soil & Water Conservation and Watershed Management  (E) | 3 |
| **Total** | | | **7/12** |

**Year I; Semester II**

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Course Code** | **Course Title\*** | **Instructor** |
| 1. | PLAG 712 | Irrigation Agronomy (E) | 2 |
| 2. | PLAG 722 | Stress Physiology and Management in Crop Plants (R) | 3 |
| 3. | PLAG 732 | Advanced Crop Ecology and Cropping System (R) | 3 |
| 4. | PLAG 742 | Crop-Climate Modelling (R) | 3 |
| 5. | PLPB 572 | Seed Technology (E) | 2 |
| 7. | PLAG 762 | PhD Seminar in Agronomy (R) | 1 |
| **Total** | | | **9/14** |

\* (R) stands for required courses and (E) stands for elective courses, students are required to take

at least one elective course from any of the semesters

**Year II; Semester I up to Year III; Semester II**

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course Title** | **Credit Hours** |
| PLAG 771 | PhD Comprehensive Examination | P/F |
| PLAG 772 | PhD Dissertation Research | 30 |

|  |  |
| --- | --- |
| **Total course work (CrHr)** | **16/26** |
| **Overall total (CrHr)** | **46/56** |

**Course Descriptions**

**Course title:** Mineral Nutrition of Crop Plants (R)

**Course code:** PLAG 711

**Credit hours:** 2

**Course objective**

• To understand the principles of mineral uptake, transport, partitioning and its role in crop production

**Course Description**

Nutrient availability in the soil; nutrient uptake and distribution in plants; nutrient functions in the plant and contributions to growth and yield; mineral composition of crop plants; time course, kinetics and mechanism of ion uptake by roots; ion transport and distribution to shoots; physiological and biochemical roles of essential plant nutrients in crop growth and yield build-up; concepts of critical nutrient concentration, critical nutrient range and diagnosis and recommendation of integrated systems (DRIS); diagnosis of nutrient deficiencies and their correction; efficiency of nutrient utilization and assessment of nutritional needs of various crops; soil fertility & fertilizers, soil nutrient mining, organic vs inorganic fertilizers

**Delivery:**

Introductory lectures, group discussions, assignment presentation and individual reading

**Assessment Methods** Performance in written examination and assignment presentation. Presentations- 50% and Exam-50%

**Course Title:** Physiology of Crop Yield and Quality (R)

**Course Code:** PLAG 721

**Credit Hours:** 3 (2+1)

**Course Objective**

The general objective of the course is to enable the students understand the basic physiological processes in plant growth and development. At the end of the course, the students will be able to know:

• the mechanisms of the processes and how they are regulated by the environment;

• the inter-relationships between the processes and how they jointly influence plant productivity and quality; and

• the importance of different physiological processes in crop productivity and quality.

**Course Description**

**Theory**

Crop growth, yield and quality in relation to environmental factors; strategies for maximizing solar energy utilization; leaf area; interception of solar radiation and crop growth; differences in photosynthetic rates among and within species; physiological limitations to crop yield and quality; solar radiation concept and agro-techniques for harvesting solar radiation; yield potential, yield limiting factors; crop product quality and productivity; growth analysis: concept, validity and limitations in interpreting crop growth and development; growth curves; root systems; root-shoot relationship; concept and types of heat units; concept of plant ideotypes: crop physiology and new ideotypes; characteristics of ideotype for wheat, rice, maize, sorghum, teff, major pulse and oilseed crops of Ethiopia; concept and types of plant growth hormones and their role in field crop production.

**Practical**

Field measurement of root-shoot relationship in crops at different growth stages; estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., at different stages of crop growth; computation of harvest index of various crops; assessment of crop yield on the basis of yield attributing characters; construction of crop growth curves based on growth analysis data, computation of senescence and abscission indices; analysis of productivity trends.

**Delivery:**

Introductory lectures, group discussions, laboratory and field practicals, assignment presentation and individual reading

**Assessment Methods**

Performance in written examination, laboratory and field practical report and assignment presentation. Laboratory and field practical and reports -30%, assignment presentations - 30% and Exam- 40%.

**Course Title:** Soil-Plant-Water Relations (R)

**Course Code:** PLAG 731

**Credit Hours:** 2

**Course Objective**

The aim of this course is to give essential understanding of the factors affecting, and the techniques of measuring, the entry, retention, and movement of water into and through the soil- plant system. It considers the accessibility and significance of water to plants, atmospheric water and the transport of water through plants.

**Course Description**

This course focuses on the ecological importance of water, thermal water properties, solution physical laws, such as vapor pressure, solution potential and latent heat. It tackles the plants relation with the soil’s physical properties, as in apparent specific gravity, soil compactness, soil water and soil temperature regimes, soil water replenishment of the roots and the mechanisms of water transport within the soil-plant system. The course discusses the factors affecting ET and the technology employed in ET reduction, the direct measuring of ET’s depletion, lysimeter and panevaporation. This major topics will include Functions and Properties of Water; Fundamental Concepts of Soil-Water System; Plant Water Status and Potential; Absorption of Water and Root and Stem Pressures; Soil-Plant-Atmosphere Continuum (SPAC); Transpiration; Movement of Soil- Water to Roots and Extraction by Roots; Effects of Drought Stress on Plant Productivity.

**Delivery:**

Introductory lectures, group discussions, assignment presentation and individual reading

**Assessment Methods**

Performance in written examination and assignment presentation. Presentations- 50% and Exam-

50%

**Course title:** Advances in Weed Management (E)

**Course Code:** PLAG 741

**Credit hours:** 2

**Course objective**

• To understand current advances in weed management in relation to the changing weed flora, new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

**Course Description**

Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects; structural, physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action, selectivity of herbicides and factors affecting them; climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, residue management of herbicides, adjuvants; advances in herbicide application techniques; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides; development of transgenic herbicide resistant crops; relationship of herbicides with tillage, fertilizer and irrigation; bioherbicides, allelochemicals and herbicide bioassays; advances in physical, cultural, biological and integrated weed managements.

**Delivery:**

Introductory lectures, group discussions, assignment presentation and individual reading

**Assessment Methods**

Performance in written examination and assignment presentation. Presentations- 50% and Exam-

50%

**Course title:** Soil & Water Conservation and Watershed Management (E)

**Course Code:** PLAG 751

**Credit hours:** 3 (2+1)

**Course objectives**

• To understand the principles of soil erosion processes and management practices to decrease erosion in cropland and rangeland systems;

• To understand the principles of the soil water cycle to improve water use efficiency of drylands; and

• To understand the different soil and moisture conservation technologies for enhancing the agricultural productivity through holistic approach to watershed management.

**Course Description**

**Theory**

Importance, quality and quantity of soil and water as natural resources for ecosystems and societies; soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion; soil conservation: definition, methods of soil conservation; agronomic measures: contour cultivation, strip cropping, cover crops; vegetative barriers; improved dry farming practices; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts; soil quality; restoration of degraded soils; dryland soil water management; watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas; land use capability classification, alternate land use systems; agro-forestry;

ley farming.

**Practical**

Study of different types of erosion; field studies of different soil conservation measures and

watershed management practices; run-off and soil loss measurements, laying out run-off plot and deciding treatments, identification of different grasses and trees for soil conservation.

**Delivery:**

Introductory lectures, group discussions, laboratory and field practicals, assignment presentation and individual reading

**Assessment Methods**

Performance in written examination, laboratory and field practical report and assignment presentation. Laboratory and field practical and reports -30%, assignment presentations - 30% and Exam- 40%.

**Course title:** Irrigation Agronomy (E)

**Course Code:** PLAG 712

**Credit hours: 2**

**Course objectives**

• To understand principles, practices and about optimization of irrigation in different crops under variable agro-climatic conditions.

**Course Description**

**Theory**

Irrigation needs: atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth; transpiration**,** evapo-transpiration (ET) and their significance; infiltration; water movement under saturated and unsaturated conditions; evapo-transpiration and water requirement of crop; use of climatic data in assessing irrigation needs, irrigation water quality, irrigation scheduling, concept of critical growth stages, irrigation methods, measurement of water flow, water management of principal crops, consequences and removal of excess water; management practices for improving water use efficiency of crops; methods of application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; strategies of using limited water supply; factors affecting ET, control of ET; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies; land suitability for irrigation, land irrigability classification; agronomic evaluation and choice of irrigation methods, economics and costing of irrigation; scheduling and practices of irrigation for different agricultural crop; Water resources and irrigation projects of Ethiopia;

**Practical**

Determination of water infiltration characteristics and water holding capacity of soil profiles;

moisture extraction pattern of crops, consumptive use and water requirement of a given cropping pattern for optimum/variable productivity; crop planning at the farm and project level; agronomic evaluation of irrigation projects, case studies; water flow measurement by using different devices; calculation of irrigation efficiency; moisture test based irrigation scheduling.

**Delivery:**

Introductory lectures, group discussions, laboratory and field practicals, assignment presentation and individual reading

**Assessment Methods**

Performance in written examination, laboratory and field practical report and assignment presentation. Laboratory and field practical and reports -30%, assignment presentations - 30% and Exam- 40%.

**Course title:** Stress Physiology and Management in Crop Plants (R)

**Course Code:** PLAG 722

**Credit hours:** 3 (2+1)

**Course objectives**

The genera objective of this course is to examine the impact of various abiotic stresses on plant growth and development, yield and productivity including acclimation and adaptation techniques. Emphasis will be given on plant diagnosis. In addition, a basic understanding of stress physiology, acclimation and adaptation and management techniques will be acquired.

**Course Description**

**Theory**

Mechanism of physiological and biochemical processes affected by various stresses: moisture stress, water logging/ flooding, high and cold temperature, radiation, salinity, and acidity stresses in crop plants with a special emphasis on cell growth, cell wall synthesis, protein metabolism, osmotic adjustment, proline accumulation; photosynthesis and respiration; primary and secondary characters for assessing stress tolerance in major crops, practical ways of overcoming or managing stresses; air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution; agricultural greenhouse gases and their effect on growth, development, physiological processes and productivity of crops.

**Practical**

Determination of electrical conductivity of plant cell sap; determination of osmotic potential and

tissue water potential; measurement of transpiration rate; measurement of water balance in soil; measurement of stomatal frequency; growing of plants in sand culture under salt stress for biochemical and physiological studies; studies on effect of osmotic and ionic stress on seed germination and seedling growth; measurement of low temperature injury under field conditions

**Delivery:**

Introductory lectures, group discussions, laboratory and field practicals, assignment presentation and individual reading

**Assessment Methods**

Performance in written examination, laboratory and field practical report and assignment presentation. Laboratory and field practical and reports -30%, assignment presentations - 30% and Exam- 40%.

**Course title:** Advanced Crop Ecology and Cropping System (R)

**Course Code:** PLAG 732

**Credit hours:** 3

**Course objective**

• To understand and describe how plant adaptations to environment affect crop selection, growth and yield;

• To understand the agro-ecosystems and their optimization in crop production;

• To describe crop responses to radiation quality, quantity and photoperiod;

• To describe plant adaptation and acclimation to temperature and to precipitation;

• To understand and quantify services provided by agroecosystems including food, fiber and fuel production, water quantity and quality, and nutrient cycling;

• To enable students use tools of crop ecology to come up with new ways to address the ever-changing challenges of crop production.

**Course Description**

Concept of crop ecology, agricultural systems, ecology of cropping systems; principles of plant distribution and adaptation; ecosystem characteristics, types and functions, flow of energy in ecosystem, ecosystem productivity, biomass, and succession and climax concept; effect of global climate change on crop production;; competition in crop plants; environmental pollution, ecological basis of environmental management and environment manipulation through agronomic practices; current perspectives in tropical crop ecology; properties of agro- ecosystems; quantitative analysis and modelling of energy flow and nutrient cycling in crop production; crop plant population models and regulations; interaction in mixture of species: competition models and indices in mixtures of species with emphasis on interactions between and/or among crop/crop and crop/weed species; competition between plants; concept of coexistence and niche in agro-ecosystems; crop suitability mapping; agriculture and the environment: case studies on the impacts of agriculture on the environment resulting from rapid escalation in the amount of chemical fertilizers, organic waste materials and pesticides; issues related to environmental impact on agro-ecosystems and implications of environmental (climate/soil) change on sustainability of agro-ecosystems. Farming systems: definition and importance; classification of farming systems according to type of rotation, cropping intensity, degree of commercialization, water supply, enterprises; concept of sustainability in farming systems; efficient farming systems; natural resources - identification and management; production potential of different components of farming systems; interaction and mechanism of different production factors; stability in different systems through research; eco-physiological approaches to intercropping; preparation of different farming system models; evaluation of different farming systems; new concepts and approaches of farming systems and cropping systems and organic farming; case studies on different farming systems.

**Delivery:**

Introductory lectures, group discussions, assignment presentation and individual reading

**Assessment Methods**

Performance in written examination and assignment presentation. Presentations- 50% and Exam-

50%

**Course title:** Crop-climate Modelling (R)

**Course Code:** PLAG 742

**Credit hours:** 3 (2+1)

**Course objective**

Students will learn how crop simulation models are developed, operate these models for model validation and application to various issues, including climate variability, water management, yield gap analysis, and site-specific management.

**Course Description**

**Theory**

Fundamentals of crop modelling: eco-physiological aspects; model components; types of models; development of simulation models including relationships used to model processes in soil, plant and atmosphere; checking the quality of models and application for crop production; models for crop growth on the bases of methods of classical growth analysis, crop modeling methods for crop- weather interaction, climate change and variability components.

**Practical**

Acquaintance with various crop growth and yield simulation models, simulation of elementary models for crop growth, simulation of potential production, simulation of production with limitation of water, nutrient and their management options, sensitivity analysis using different climate years and crop management practices; model validation and application to various issues, including climate variability, water management, yield gap analysis, and site-specific management.

**Delivery:**

Introductory lectures, worked examples, group discussions, home take–exercises and assignments, assignment presentation and individual reading.

**Assessment Methods**

Performance in written examination, home take-exercises and assignments, assignment presentation. Home take-exercises and assignments -30%, software applications- 30% and Exam- 40%.

**Course title:** Seed Technology (E)

**Course Code:** PLPB 572

**Credit hours:** 2 (1+1)

**Course objectives**

• to understand seed as a basic input for agricultural production

• to understand procedures of quality seed production

**Course Description**

**Theory**

Seed as a basic input for Agricultural production; procedures of quality seed production of crops; factors determining ideal areas of seed production; determination of varieties; pollination and reproduction in relation to seed production and varietal maintenance; release and notifications of varieties; concept and procedures of seed certification; seed moisture; seed sampling, physical and genetic purity; seed germination; seed viability; seed vigour tests, seed priming; seed health; seed dormancy; procedures for breaking seed dormancy; field and seed standards.

**Practical**

Seed and seedling morphology; methods and procedures of seed sampling; seed moisture determination; physical and genetic purity analysis; seed germination test; seed viability and seed vigour test; seed health test; seed dormancy breaking; seed certification procedures; seed priming, visit of seed processing plant.

**Delivery:** Introductory lectures, group discussions, laboratory and field practicals, assignment presentation and individual reading

**Assessment Methods**

Performance in written examination, laboratory and field practical report and assignment presentation. Laboratory and field practical and reports -30%, assignment presentations - 30% and Exam- 40%.

**Course title:** PhD Seminar in Agronomy (R)

**Course Code:** PLAG 762

**Credit hours:** 1

**Course Objective:**

To introduce candidates to simple techniques of presentation and communication

To help them learn the methods of reviewing, analyzing, compiling and presenting most recent research works and findings

**Description:** A Ph.D candidate will select relevant scientific topic in consultation with the seminar advisor; sets the structural contents of the work; make exhaustive literature review on the selected seminar topic and analyze scientifically; summarize the review and present the relevant data in tables and figures; the candidate presents his/her observations and review facts (related to his/her field of specialization but not from his/her dissertation) to the audience within the registered time frame or semester.

**Delivery:** Ph.D. seminar presentation will be announced to all interested participants and the candidate is expected to present his/her observations in the seminar on the selected topic related to his field of specialization other than his dissertation research topic. Presentation will be conducted using audio-visual aids like Power-point in a meeting hall for one hour (20 to 25 minutes presentation by the student and 20 to 30 minutes for discussion (questions and answers).

**Assessment:** Evaluation of the content and presentation by professionals and peers. School Graduate Council members and graduate students will evaluate the course based on the organization of the compiled review paper; manner of presentation and response of the candidate to questions. An evaluation form prepared for this purpose will be used.

**PLAG 771: PhD Comprehensive Examination (P/F)**

It is aimed to tests the general knowledge of the student's subject area and used to determine a candidate's eligibility to continue his or her PhD study. It consists of written or oral examination set by a group of professional designated by the DGC.

**Course Title: PhD Dissertation Research (30 cr. hr.) Course Code: PLAG 772**

**Credit Hour: 30**

A Ph.D. candidate is required to identify a research problem relevant to the subject concerned and on national priority. Formulation of the research proposal should be according to the standard research methodology and in consultation with the advisory committee. The problem should reflect the current advances in the field and should have objectives intended for new findings and/or for confirmation of known facts for the Ethiopian conditions or on issues of global importance. After the approval the candidate is expected to execute the proposal and come up with the findings in the form of a dissertation.

**2. Program Name: PhD Program in Horticulture**

**Distribution of courses by Year and Semester**

**Year I, Semester I**

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course Title** | **Instructor** |
| ***HORT 711*** | Mineral Nutrition of Horticultural Crops | 2 |
| ***PLAG 511*** | Biometry (E) | 3 |
| ***HORT 731*** | Advanced Physiology of Horticultural Crops | 3 |
| PLAG 731 | *Soil-Water-Plant Relations* | *2* |
| ***HORT 741*** | Seminars in Horticulture I | 1 |
| ***HORT 751*** | Protected Horticulture (E) | 2 |
| ***HORT 761*** | Plant Biochemistry (E) | 3 |
| ***Semester Total*** |  | 10/18 |

\* Students are required to add at least one elective course.

**Year I, Semester II**

|  |  |  |
| --- | --- | --- |
| ***Course Code*** | ***Course Title*** | ***Credit hours*** |
| HORT 712 | *Advances in Plant Growth Regulators* | *2* |
| PLBR 732 | *Advances in Plant Cell & Tissue Culture (E)* | *2+1* |
| *HORT 722* | Seminars in Horticulture II | 1 |
| HORT 752 | *Post-harvest Physiology and Technology of Horticultural*  *Crops* | *3* |
| SSTC 532 | *Seed Production of Horticultural Crops* | *3* |
| HORT742 | Horticultural Crops Breeding (E) | 2 |
| *HORT 762* | PhD Dissertation Research | 30 |
| ***Semester Total*** |  | 9/13 |

\* Students are required to add at least one elective course

Each candidate must take at least two elective courses. Candidates are free to take more elective courses to strengthen their knowledge, but must first meet the compulsory requirements for graduation. Moreover, the students should be able to take deficient courses from lower study levels (either bachelor or master courses) that deemed necessary to assist their research as determined by the student and supervisor with approval of the School Graduate Committee, but the total credit hour must not be greater than 28.

**Course objectives and description**

**HORT 711: Mineral Nutrition of Horticultural Crops (2 cr.hr.) Course Objectives:**

• Understand the underlying principles governing plant mineral nutrition,

• Understand the basis and methods used to evaluate soil fertility status, including nutrient deficiency symptoms, soil analysis and plant analysis,

• Recognize the characteristic nutrient deficiency and toxicity symptoms displayed by typical horticultural crops,

• Understand the factors affecting nutrient availability and uptake and know appropriate soil and plant management techniques to control them,

• Understand the basics of crop physiology and particularly the effects of plant nutrition on yield responses and crop quality,

• Understand the specific nutritional and crop physiological aspects of each nutrient and know individual and balanced nutrient applications to enhance yield and quality of horticultural crops.

**Course Description:** Mineral composition of horticultural crop plants; time course, kinetics and mechanism of ion uptake by roots; ion transport and distribution to shoots; physiological and biochemical roles of essential plant nutrients in crop growth and yield build-up; concepts of critical nutrient concentration, critical nutrient range and diagnosis and recommendation integrated systems (DRIS); diagnosis of nutrient deficiencies and their correction; efficiency of nutrient utilization and assessment of nutritional needs of various crops.

**PLAG 731: Soil-Water-Plant Relationships (2 cr.hr.) Course Objectives:**

• Understand the properties and significance of water in the environment,

• Elucidate soil-water relationship

• Understand mechanism of water transport through soil-plant-atmosphere continuum,

• Understand factors affecting water availability to plants,

• Understand how soil water requirements is assessed,

• Understand how water expressions are modeled in terms of the solar energy and photosynthesis,

**Course Description:** Soil mass-volume relationships; energy concept of soil water; water structure and its properties in relation to plant cells; mechanism of water transport through soil-plant-atmosphere continuum; water availability to plants; internal water relations of plants; evapo-transpiration and water requirement of crops; soil water stress and plant response, canopy temperature and water stress; crop water production functions.

**HORT 751: Protected Horticulture (E) (2 cr. hr.) Course Objectives:**

• Introduce the candidates with the general purpose and need for the protected horticulture,

• Understand techniques and apparatus used to regulate climate in protected horticulture,

• Introduces candidates with the different types of structures in protected horticulture,

• Analyze and understand the environmental and safety aspects of projected horticulture.

**Course Description:** environmental variables for protected Horticultures; purposes of protected horticulture; basic structures in protected Horticulture; types and functions of lath houses, plastic tunnels, plastic houses, green houses; environmental and safety aspects in protected horticulture.

**PLAG 511: Biometry (E) (3 cr. hr.) Course Objectives:**

• Understand basic features of experimentation,

• Understand experimental designs and their selection principles,

• Understand the various experimental data analysis techniques

• Understand trend and relationship quantifications techniques

• Understand assumption and analysis of non-parametric statistics.

**Course Description:** Analysis of variance models; assumptions and their tests, alternatives in case of failures of assumptions; principles of designs of experiments; detail discussion on the applicability, layout and randomization, analysis of variance, mean separation, interpretation of results and missing plot techniques with respect to completely randomized design, randomized completely block design, Latin squares design, factorial experiments with confounding and fractional factorial design concepts; split plot design and strip plot design with two or more factors; compact family block design; incomplete block designs-simple and balanced lattice design, augmented randomized block designs; combined analysis of variance and its interpretation; analysis of covariance with randomized block design for adjustment; simple and multiple correlation and regression analysis; application of chi- square and non-parametrics statistics

**HORT 731: Advanced Physiology of Horticultural Crops (3 cr. hr.) Course Objectives:**

• Understand the physiology of growth and development in major horticultural crops,

• Understand physiological role and biochemistry of plant hormones,

• Teach metabolic pathways, their regulation and engineering and methods used in their elucidation.

• Acquaint with importance of light in plant development,

• Understand movement of water in plants,

• Plant stress factors will be elaborated.

**Course Description:** Growth and development physiology; plant hormones and growth regulators, their biosynthesis, bioassay and mode of action. Metabolic pathways- photosynthesis, photorespiration, respiration, and lipid metabolism. Plant nutrition- assimilation of nitrogen including biological nitrogen fixation and sulfate assimilation. Photo-morphogenesis, physiology of diseases and post harvest physiology; plant-water relations including stress physiology, biotechniques in plant physiology.

**HORT 761: Plant Biochemistry (3 cr. hr.)**

**Course Objectives:**

• Learn the structure, function and biosynthetic pathways of essential biochemical molecules including their key chemical and physical properties,

• Understand plant cell structure and organization and apply specific biochemical functions to all components of plant cell structure.

• Learn how membranes form and function and how the building blocks of membranes are made.

• Learn amino acid structures and relate their chemical properties to the synthesis and function of proteins and enzymes.

• Understand protein structural hierarchy and relate structure to function. The principles of enzyme kinetics will learned and applied through hands on problem sets. Students will be shown how enzyme properties contribute to metabolic processes.

• Understand how light energy is captured and used to provide chemical forms of energy to power the functions of cells and whole plants. The importance of CO2 fixation and carbohydrate metabolism will be presented. The nature and composition of plant cell walls will be explored.

• Learn about the rich diversity of secondary compounds and metabolism in plants and how such compounds contribute to human health.

**Course Description:** Plant cell, cell membrane, structure and function of bimolecules (protein- hemoglobin, lipid- membranes, carbohydrate-peptidoglycans etc.). Metabolism (carbohydrate, protein and lipid), including photosynthesis and organ specialization. Integration of carbohydrate, protein and lipid metabolism and regulation. Vitamins, enzymes, coenzymes and mineral metabolism. Biosynthesis of macromolecules.

**HORT 752: Post-harvest Physiology and Technology of Horticultural Crops (3 cr. hr.) Course Objectives:**

• Understand the major biochemical reaction occurring after harvest and devise mechanisms to reduce the rate of produce quality deterioration after harvest.

• Familiarize students with the commercial practices used in post-harvest handling of horticultural crops and their effect on specific physicochemical changes which occur in harvested products.

• Knowledge in identification of appropriate harvesting stages of different horticultural crops, prevention of post-harvest deterioration and design of storage containers from locally available material.

• Familiarize students with the current commercial methods used to harvest, pack, transport and market fresh horticultural crops, with emphasis on maintaining product quality.

• To prepare students to systematically evaluate and critically analyze these operations based on field trip experiences and course assignments.

• Familiarize students with techniques of preserving horticultural produces.

**Course Description:** Importance of post harvest physiology and technology, present status, biochemical changes after harvesting of fresh fruits, vegetables and flowers; pre-treatment and post harvest treatments to check losses. Dehydration, drying, freezing and cold storage techniques of chemical, biological and thermal preservation. Preservation and storage of fruits and vegetables products like jams, jellies, marmalades and preserves. Processing of pickles, sauce and ketchups. Raw materials: principal spoilages, microorganisms and their control measures. Containers and equipments for processing quality controls

**HORT 731: Seminars in Horticulture I (1 cr. hr.) Course Objectives:**

• Introduce candidates to simple techniques of presentation and communication,

• Learn the methods of reviewing, analyzing, compiling and presenting most recent research works and findings,

**Course Description:** Students are expected to present a seminar on current and advanced topics in the field of horticulture. Topics can be drawn from post-harvest biology, technology and marketing, fruit science, vegetable science, ornamental and landscape horticulture, and plant biotechnology. Each candidate should present at least one oral and written paper based on independent reading and/or experimentation related to the chosen topic.

**HORT 712: Advances in Plant Growth Regulators (2 cr. hr.) Course Objectives:**

• Introduce students with recent advances in plant hormones metabolisms

• Familiarize students with quantitative analysis and bioassays of plant ormones

• Familiarize students with the physiological roles of growth regulators,

• Understand students Growth regulators as herbicides and as yield and quality of horticultural crop enhancers ,

**Course Description:** Recent advances in biosynthetic pathways, transport, metabolism, mode of action; physiological and biochemical actions and quantitative analysis and bioassays of growth regulators – cytokinins, auxins, gebberellins, ethylene and abscisic acid and other inhibitory growth regulators such as batasins and jasmonic acid and other synthetic growth regulators, their effect on growth and development; seasonal and tissue profiles, and their usage in arable and horticultural crop production.

**HORT 722: Seminars in Horticulture II (1 cr. hr.)**

**Course Objectives:** the course will help students to learn methods of reviewing, critically analyzing, compiling and presenting most recent research works and findings,

**Course Description:** A PhD candidate is expected to review and critically analyze literature related to their area of investigation for PhD study. Based on the survey each candidate should present at least one oral and written paper based on independent reading related to the chosen topic.

**SSTC 532: Seed Production of Horticultural Crops (3 cr. hr.) Course Objectives:**

• Introduce the candidates state of seed production in tropics and factors limiting it,

• Introduce the candidates the basic features of seeds of horticultural crops,

• Develop an understanding of seed development, germination, vigor, deterioration and the relationship between laboratory tests and field performance.

• Acquaint the students with the principles of seed production for horticultural crops within and outside of the region of adaptation and the techniques used in seed conditioning.

• Understand seed increase systems, seed testing and the laws and regulations related to marketing high quality seed

**Course Description:** Seed as a basic input for agricultural production; procedures of seed production and testing of horticultural crops; standards for maintaining seed quality; deterioration of varieties; factors determining ideal areas of seed production; pollination and reproduction in relation to seed production and varietal maintenance; release and notification of varieties; concepts in seed physiology and health; principles, procedures and rules of sampling, purity tests germination and viability tests; concepts and objectives of seed certification; seed dormancy, its causes and breakage; yield and yield attributes in major horticultural crops

**HORT742: Horticultural Crops Breeding (E) (2 cr. hr.) Course Objectives:**

• Develop general familiarity with the overall science of plant breeding, especially as it relates to the improvement of horticultural crops.

• Understand how directed selection for crop improvement is affected by plant mating systems, available genetic variation, environmental influences, selection strategies, and the social context,

• Gain an appreciation and understanding of the processes involved in natural evolution and directed selection and manipulation by humans,

• Familiar with prominent techniques for directed plant improvement.

• Develop critical thinking, and to improve skills in written and oral analysis of specific topics related to crop breeding.

• Lay the foundation for the study of more advanced plant breeding methodology and quantitative genetics e.g. molecular—marker assisted determination of quantitative trait locus variation.

**Course Description:** Horticultural crops improvement through conventional breeding and biotechnology which includes, reproduction and pollination control mechanisms, breeding methods, biometrical approaches, breeding for abiotic and biotic stresses and use of biotechnology techniques for the improvement of major vegetable and fruit crops.

**PLBR *732:* Advances in Plant Cell & Tissue Culture (E) (2 cr. hr.) Course Objectives:**

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

• Acquaint the students with the various components of plant tissue culture media, e.g. minerals, growth factors, hormones, and what governs the choice of components,

• Familiarize the students with the various steps taken to establish and optimize media for particular purposes in particular species,

• Enable the students to perform some of the more advanced techniques, e.g. embryo rescue, and protoplasting,

• Enable students to establish and maintain plants in tissue culture and micropropagation, including morphogenesis, • Investigate and define a protocol to establish an unknown species and test its response,

• Acquaint the students with the various cell lines used in tissue culture and their origins and uses.

**Course Description:** Recent advancements in plant cell and tissue culture techniques and their scope in crop improvement; establishing of somatic cell cultures; micro-propagation; soma- clonal variation and *in vitro* selection at cellular level; advances in protoplast technology; production of hybrids and organelle recombinants; production of secondary metabolites in plant cell culture; advances in transformation of crop plants using plasmids; transposable elements and other vectorless systems

**HORT 762: PhD Dissertation Research (30 cr. hr.)**

**Course Objectives:** to enable candidate identify original researchable topics in his/her area of specialization, develop proposal, conduct research, analyze data, write articles for publication and compile dissertation.

A PhD candidate is required to identify a research problem on national priority and relevant to expand knowledge in the candidate’s area of specialization. Candidates shall be required to conduct original independent research on a specific topic related to horticulture. Formulation of the research proposal should be according to the standard research methodology and in consultation with the advisory committee. The problem should reflect the current advances in the field and should have objectives intended for new findings and/or for confirmation of known facts for the Ethiopian conditions. After the approval the candidate is expected to execute the proposal and come up with the findings in the form of a dissertation. The thesis shall form part of the fulfilment of the requirements for the conferment of the Doctor of Philosophy degree in Horticulture.

# 3. Program Name: PhD in Plant Breeding

**Distribution of Courses by Year and Semester**

|  |
| --- |
| **Year I; Semester I** |
| **Course Code Course Title Credit Hours** |
| PLBR 711 Molecular Genetics 2 |
| PLBR 721 Breeding for Abiotic Stresses 2 |
| PLBR 731 Advanced Quantitative Genetics 3 |
| PLBR 741 Breeding for Biotic Stresses 1+1 |
| PLBR 751 Crop Evolutions and Plant Genetic Resources (E) 2 |
| PLCP 521 Advanced Plant Pathology (E) 3 |
| PLBR 751 Seminar I 1 |
| **Total 9/14** |

E = Elective courses

**Year I; Semester II**

|  |  |  |
| --- | --- | --- |
| **Course Code**  **Hours** | **Course Title** | **Credit** |
| PLBR 712 | Advanced Plant Breeding | 3 |
| PLBR 722 | Molecular Plant Breeding | 1+1 |
| PLBR 732 | Advances in Plant Cell and Tissue Culture | 1+1 |
| PLPB 582 | Breeding for Quality Traits (E) | 1+1 |
| PLPB 572 | Seed Technology (E) | 2 |

PLBR 752 Seminar II 1

Total **8/12**

*E = Elective courses and students must register and complete at least one elective course*

*Successfully.Students are required to take at least one elective course.*

***Total Course Work Credit: 18/26***

***Overall Total Credit: 48/56***

**Course Descriptions**

**PLBR 711 Molecular Genetics (2) Objectives:**

Study Genomes in prokaryotes and eukaryotes

Understand structure and nature of DNA

Study the structural and functional genomics, proteomics and protein-protein interaction

Study nature of mutations and mode of induction

Understand screening techniques and selection procedures of induced mutations

**Description:** Genomes in prokaryotes and eukaryotes; genome organization euchromatin and heterochromatin; DNA content variation; Types of DNA sequences - unique and repetitive sequences, VNTRs, minisatellites and microsatellites; DNA organization in eukaryotic chromosomes; organelle genomes; gene amplification and its significance; mechanisms of DNA replication and recombination in prokaryotes and eukaryotes; structure and nature of DNA; DNA sequencing; gene fine structure in prokaryotes and eukaryotes; Split genes, alternative splicing, trans-splicing, pseudogenes, overlapping genes, nested genes (case studies); Transcription and its regulation mechanisms in prokaryotes and eukaryotes, enhancers, suppressors, transcriptomes, transcription factors and their role; Post-transcriptional regulation - mRNA processing, SnRNAs, ribozymes and RNA editing; Regulation of protein synthesis in prokaryotes and eukaryotes ribosomes, tRANs and translational factors; post-translational modifications; structural and functional genomics; proteomics and protein-protein interaction; signal transduction; genes in development; mechanisms and regulation of cell division, cancer and cell ageing. Nature of mutations; induced and spontaneous mutations; mode of induction (physical and chemical mutagens); transposons as mutagens; somaclonal variation) and screening techniques and selection procedures of induced mutations

**PLBR 721 Breeding for Abiotic Stresses (2) Objectives:**

Understand importance of abiotic stresses and characteristics of abiotic stresses Study genetics and breeding for abiotic stress (drought resistance/tolerance, salinity stress, mineral efficiency, heat and cold tolerance etc.)

**Description:** Importance of abiotic stresses; characteristics of abiotic stresses; minimizing losses due to abiotic stresses. Breeding for drought resistance/tolerance: Effects of drought on plant growth and development; types of drought environments; morphological, physiological and biochemical basis of drought resistance/tolerance in plants. Drought resistance/tolerance mechanisms: Drought escape; dehydration avoidance; dehydration tolerance. Genetics of drought resistance/tolerance; sources of drought resistance genes; relationship between drought resistance/tolerance and yield; selection criteria; creation of drought environment; combined selection for drought resistance/tolerance traits and high yield; difficulties in breeding for drought resistance/tolerance ; marker assisted selection. Breeding for mineral stress (Salt affected

- Saline and alkali soils); management of salt affected soils; effects of salinity stress; morphological, physiological and biochemical symptoms under saline conditions; genetics of salinity resistance; measurement of salinity resistance; sources of salinity resistance genes; breeding approaches for salinity resistance; problems in breeding for salinity resistance. Mineral stress resistance: resistance to mineral deficiency stress/nutrient use efficiency; mechanisms of mineral deficiency stress; genetics of mineral deficiency stress; sources of mineral deficiency stress resistance genes; selection criteria; marker assisted selection in breeding for mineral stress nutrient use efficiency. Mineral toxicity resistance: aluminium toxicity resistance; manganese toxicity resistance; genetics of mineral toxicity resistance; sources of mineral toxicity resistance genes; creation of mineral toxicity environment; selection criteria; problems in breeding for mineral deficiency/toxicity resistance. Breeding for heat and cold stress resistance: importance; genetics of heat and cold tolerance; sources of genes for heat and cold tolerance in plants; mechanisms of heat and cold tolerance; breeding approaches for heat and cold resistance/tolerance.

**PLBR 731: Advanced Quantitative Genetics (3)**

(Prerequisite PLPB 532 – Quantitative genetics or equivalent)

**Objectives:**

Understand mating designs and exercise analyses for genetic components

Study detection and estimation of linked interaction effects and influence of linkage on genetic effects estimation

Study genetic divergence, estimation of effective factors, QTL and QTL mapping

Understand; population genetics and factors affecting gene frequency in relation to response to selection

Understand and exercise softwares for genetic analysis of quantitative variation

**Description:** Non-allelic interactions and their scale dependability; detection and estimation of linked interaction effects; influence of linkage on genetic effects estimation; components of heterosis in the presence of epitasis; unweighted and weighted analysis for the estimation of additive, dominance and epistatic variances; implication of epistasis and linkage on the magnitude of variability in successive generations; genetic analysis of mutagenic induced polygenic variation; mating designs and analyses for genetic components; genetic divergence; triallel and quadrellel along with their utility; cross prediction for response to selection based on genetic components; estimation of effective factors and QTL; QTL mapping; co-heritability and its implications; genetic analysis of polysomes; population genetics; factors affecting gene frequency in relation to response to selection; introduction to softwares for genetic analysis of quantitative variation..

**PLBR 741**: **Breeding for Biotic Stresses (1+1) Objectives:**

Understand nature and importance of viral, bacterial, fungal and other diseases,

insect pests and weeds

Study types and characteristics, genetic, physiological and molecular mechanisms of disease, weeds and insect pest resistance

Study host-parasite interaction, factors affecting host reactions and implications and significance in plant breeding

Study methods of breeding for disease, weeds and insect pest resistance resistance

**Description:** Nature and importance of viral, bacterial, fungal and other diseases; insect pests and weeds. Types and characteristics, genetic, physiological and molecular mechanisms of disease, weeds and insect pest resistance. Host-parasite interaction, variation in pathogen and host, factors affecting host reactions, gene-for-gene concept, implications and significance in plant breeding. Disease epidemics and measures for prevention of epidemics. Methods of breeding for disease, weeds and insect pest resistance resistance commonly used in traditional breeding methods and biotechnological tools (selection, introduction, mutation, hybridization, MAS, tissue culture methods: somaclonal variation, somatic hybridization (Protoplast fusion), meristem-tip culture (for virus free planting material) and genetic engineering (Transgenics).

**PLBR 751 Crop Evolution and Plant Genetic Resources (2) (E)**

**Objectives:**

Study the genetic mechanism associated with plant/crop evolution Understand natural and crop evolution in reorganizing genetic variability

Study overall framework of species change and the domestication process and the origin of crop species (when and where crops were domesticated and types of change associated with their domestication)

Study the emergence and diffusion of agriculture and the ways species were changed during domestication

Identify natural and human processes creating and eroding biodiversity and genetic resources

Overview methods to characterise, use, conserve, and manage biodiversity and genetic resources

Understand cconventions and treaties in plant genetic resources.

**Description:** Chromosome structure and genetic variability; assortment of genetic variability; multifactorial genomes; polyploidy and gene duplication; speciation; origin of agriculture; the dynamics of plant domestication; evolution of cultivated crops (cereals, protein plants, starchy and sugar crops, fruits, vegetables and fibers).Evolution and

dynamics of biodiversity; causes of genetic erosion; genetic resources and their use; management and conservation of biodiversity and genetic resources and cconventions and treaties in plant genetic resources.

**PLCP 521: Advanced Plant Pathology (3) (E)**

The physiology of host–parasite relationship; the genetics of plant-pathogen interaction;

epidemiology of plant disease and their management.

**PLBR 751: Seminar I (1) Objectives:**

To introduce candidates to simple techniques of presentation and communication,

To help them learn the methods of reviewing, analyzing, compiling and presenting most recent research works and findings

**Description:** The PhD candidate is expected to review and analyze the literature and present his observations in the seminar on the selected topic related to his field of specialization other than his dissertation research topic.

**PLBR 712 Advanced Plant Breeding (3)**

**Objectives:**

Understand principles and breeding methods of self-pollinated, cross-pollinated and asexually propagated crops

Study population structure and mechanism for maintenance of genetic variability in populations

Study ideal plant type and selection and breeding strategies for sustainability

Understand concept, genetic; physiological and molecular basis of heterosis

Study hybrid breeding methodology, development and improvement of heterotic pool,

Study application of biotechnology in selection and heterosis breeding

**Description:** Breeding and principles of self-pollinated, cross-pollinated and asexually propagated crops. Ideal plant type and selection; population structure, mechanism for maintenance of genetic variability in populations; gene action and selection methods; population improvement in autogamous crops; multi-trait selection index; modified convergent improvement method; combined selection criteria for productivity and stability; selection techniques for improvement of negatively correlated traits; crop breeding strategies for sustainability; concept of designer crops and future strategies; marker assisted selection methods; farmers selection criteria and participatory plant breeding method; selection criteria for cropping system. Historical and development of heterosis concept, genetic; physiological and molecular basis of heterosis; hybrid breeding methodology-development and improvement of heterotic pool, and inbred lines, evaluation of inbred lines and hybrids, nature and number of testers, combining ability and performance per se, prediction of hybrid performance, genetic diversity and heterosis, genotype & environment interaction and heterosis. Male sterility systems (cytoplasmic, genetic, cytoplasmic-genetic, EGMS, gametocide induced and genetically engineered male sterility) -origin, development, maintenance and exploitation in hybrid breeding. Application of biotechnology in heterosis breeding (molecular markers, doubled haploids, somatic hybridization). Current status and future prospects of hybrid breeding in selected crops (rice, wheat, mustard, sunflower, cotton, pearlmillet, sorghum, maize, and vegetable crops).

**PLBR 722: Molecular Plant Breeding (1+1) Objectives:**

Study genetic systems and restriction patterns; cloning vectors, construction of

cDNA and genomic libraries;

Study molecular marker technology and their use in precise alien gene transfer;

construction of high density maps and genetic analysis

Understand recent developments in production of transgenic plants

Study another specific gene expression for production of ms lines

**Description:** Genetic systems; restriction patterns; cloning vectors, construction of cDNA and genomic libraries; molecular marker technology; construction of high density maps and their use in genetic analysis; chromosome walking, gene tagging and gene cloning; molecular characterization of germplasm and interspecific derivatives; recent developments in production of transgenic plants; use of molecular markers in precise alien gene transfer; control of plant gene expression (terminator genes): anther specific gene expression for production of ms lines; Bt cotton (bolgard), Tomato (Flavr savr), Dolly and Jefferson clones; vitamin rich transgenics (Golden rice), etc; biosafety and environmental issues in biotechnology.

**PLBR 732: Advances in Plant Cell and Tissue Culture (1+1) Objectives:**

Study recent advancements in plant cell and tissue culture techniques and their scope in crop improvement

Understand and exercise somatic cell cultures; micro-propagation; somaclonal variation and in vitro selection at cellular level

Understand advances in protoplast technology, production of hybrids and organelle recombinants

Understand advances in transformation of crop plants using plasmids, transposable elements and other vectorless systems

**Description:** Recent advancements in plant cell and tissue culture techniques and their scope in crop improvement; establishment of somatic cell cultures; micro-propagation; somaclonal variation and in vitro selection at cellular level; advances in protoplast technology, production of hybrids and organelle recombinants; production of secondary metabolites in plant cell culture; advances in transformation of crop plants using plasmids, transposable elements and other vectorless systems.

**PLPB 582: Breeding for Quality Traits (2) (E) Objectives:**

Understand the importance of quality traits in crops

Study analytical and selection techniques for quality traits

Understand genetics of quality traits and their association with yield and other traits

Understand objectives, breeding approaches, achievements and prospects for the improvement of quality traits of important field and horticultural crops

**Description:** Importance of quality traits; analytical and selection techniques for quality traits; screening sequences; role of physico-chemical, histo-chemical and components of protein synthesis for improving protein quality and quantity; genetics of quality traits and their association with yield and other traits; biochemical and genetic aspects of the known quality mutants like opaque-2, fluory-2; anti-nutritional factors in different crops and their genetic removal; objectives, breeding approaches, achievements and prospects for the improvement of quality traits of important field and horticultural crops.

**PLPB 572: Seed Technology (2) (E) Objectives:**

Understand seed as a basic input for agricultural production

Understand procedures of quality seed production of crops; deterioration of varieties and factors determining ideal areas of seed production

Study pollination and reproduction in relation to seed production and varietal maintenance

Study and exercise procedures and rules of seed moisture sampling, physical and chemical purity tests; germination, viability tests and seed vigor tests

Understand concepts, objectives and procedures of seed certification

**Description:** Seed as a basic input for agricultural production; procedures of quality seed production of crops ; deterioration of varieties; factors determining ideal areas of seed production; pollination and reproduction in relation to seed production and varietal maintenance; release and notification of varieties; principles, procedures and rules of seed moisture sampling, physical and critical purity tests; germination and viability tests; seed vigor tests and seed priming, seed health; concepts, objectives and procedures of seed certification; seed dormancy, its causes and breakage; field and seed standards for maintaining seed quality.

**Practical:** Seed and seedling morphology; methods and procedures of seed sampling, seed moisture determination,; physical and genetic purity analysis; seed germination testing; seed viability; seed vigour tests; seed health tests; seed dormancy breaking; seed certification procedures; seed priming and seed processing plant visit.

**PLBR 752: Seminar II (1) Objectives:**

To introduce candidates to simple techniques of presentation and communication,

To help them learn the methods of reviewing, analyzing, compiling and presenting most recent research works and findings

**Description:** A PhD candidate is expected to do survey and analysis of literature and make observations on the subject concerned for making presentation. Seminar presentation should be on the topic related to the specific area of the study, other than the candidate’s research topic.

**PLBR 762: PhD Dissertation Research (30)**

A PhD candidate is required to identify a research problem relevant to the subject concerned with national priority. Formulation of the research proposal should be according to the standard research methodology and in consultation with the advisory committee. The problem should reflect the current advances in the field and should have objectives intended for new findings and /or for confirmation of known facts for the Ethiopian conditions. After the approval, the candidate is expected to execute the proposal and come with the findings in the form of a **dissertation**

***4. Program Name: PhD in Plant Pathology***

***Distribution of Courses by Year and Semester***

**Year I; Semester I**

**Course Code Course Title Credit Hours**

|  |  |  |
| --- | --- | --- |
| PLPA 711 | Biology of Pathogens and Emerging Plant Diseases | 4 |
| PLPA 731 | Physiology and Genetics of Host-Pathogen Interaction | 3 |
| PLPA 751 | Special Topics in Plant Pathology | 1 |
| PLPA 741 | Scientific Paper Writings (E) | 1 |
| PLPA 551 | Disease Diagnosis and Techniques in Plant Pathology (E) | 2 |
| **Total** |  | **8/11** |

**Year I; Semester II**

**Course Code Course Title Credit Hours**

|  |  |  |
| --- | --- | --- |
| PLPA 722 | Molecular Concepts and Methods in Plant Pathology | 2 |
| PLPA 762 | Plant Disease Epidemiology and Management | 3 |
| PLPA 752 | Ph.D Seminar in Plant Pathology | 1 |
| PLPA 732 | Biological Control of Plant Diseases (E) | 2 |
| PLPA 742 | Biochemistry of Plant Diseases (E) | 2 |
| PLAG 512 | Crop Ecology and Cropping Systems (E) | 2 |
| **Total** |  | **6/12** |

*E = Elective courses; a minimum of one course of 2 credit hours among five elective courses is required.*

**Year II; Semester I up to Year III; Semester II**

**Course Code Course Title Credit Hours**

PLPA 772 Ph.D Dissertation Research 30

***Total Course Work Credit: 14/23***

***Overall Total Credit: 44/53***

**Course Descriptions**

**PLPA 711: Biology of Pathogens and Emerging Plant Diseases (4 cr.hr.) Objectives:**

Study the biology of fungal plant pathogens, plant pathogenic bacteria, viruses and nematodes;

Understand the metabolism of phytopathogenic fungi, bacteria, viruses and nematodes;

Familiarize students with methods of identification of plant pathogenic fungi, bacteria, viruses and nematodes;

Understand the systematics or taxonomic classification of the major phytopathogenic organisms;

Study the host-pathogen relationships in disease development and transmission mechanisms; and

Know the principles and practices of management of plant pathogens.

**Description:** Fungal systematics; detailed studies of different families and orders of various phyla of fungi; use of keys for species level identification; chemistry of fungal cell and growth; digestion and transport of nutrients; fungal metabolism; physiology of development, dormancy and germination of fungal spores.

Biology of fungi, bacteria, plant viruses, and nematodes; metabolic processes of the plant pathogens; emerging plant diseases and their significance; methods of identification of major plant pathogens and use of keys; detailed taxonomy of plant pathogenic fungi, bacteria, viruses and nematodes and criteria for pathogen classification; active and passive mechanisms of pathogen transmission; preservation techniques in plant pathogens/ diseases specimens; pathogenicity and host-pathogen relationships in disease development; principles and practices of plant disease management options.

**Delivery:** Classroom lectures based on two-way teaching/learning reciprocal approach; group discussion in the class room; use of audio-visual teaching aids to depict models, formulas, figures, tables and summaries; presentations on selected relevant current topics; assignments (term-papers, practical exercises, etc); reviewing selected articles and book chapters on relevant topics; field demonstrations and laboratory practices; visits to places and organizations of advanced technologies.

**Assessment:** Participation in presentation; questions and answers from the term-papers by students (15%); various individual and group assignments (10%); final written examination (75%).

**PLPA 722:** Molecular Methods in Plant Pathology (2 cr. hr.)

**Objectives:**

To introduce the theoretical concepts, underlying principles and techniques in molecular plant pathology

To introduce the rationale in the selection and implementation of certain molecular procedures

develop critical thinking and scientific inquiry skills

**Description:** Basic molecular, molecular genetics and genomic concepts; molecular genetics techniques; functional genomics techniques; proteomics; bioinformatics.

**Delivery:** The course will be delivered in the form of lecture, reading assignments, student presentations, and laboratory practical. Students will be familiarized with selected techniques molecular techniques.

**Assessment:** Performance of students on the course will be assessed through reviewing, presenting and discussing research articles individually or in groups; reports on laboratory exercises; final written examination.

**PLPA 731: Physiology and Genetics of Host-Pathogen Interaction (3 cr.hr.) Objectives:**

Develop critical thinking skills through discussions and reading of journal articles.

To help students to make in-depth exploration of the interactions between plants and pathogens driven by the current research literature.

Appreciate how interactions with pathogens influence plant health and disease. Students will learn to research the literature on specific topics in plant-pathogen interactions, and to critically evaluate — orally and in writing — key hypotheses, experimental tests, and conclusions pertaining to the assigned topics.

To introduce basic skills for searching literature databases, reading scientific papers efficiently to identify key points, and writing in appropriate scientific style while employing scientific conventions.

**Description**: The course will explore the interactions between pathogens and plants. Topics include: the physiology and genetics of host-pathogen interactions, in-depth exploration of the interactions between plants and pathogens driven by the current research literature. Emphasis is on the molecular mechanisms of disease resistance and signaling that drive broader host/pathogen/environment interaction

**Delivery:** The course will be delivered in the form of lecture, reading assignments and discussions on the assigned research papers, term paper that will be presented in class. **Assessment:** Performance of students on the course will be assessed through reviewing, presenting and discussing research articles individually or in groups (20%), one term paper (20%) and final written examination (60%).

**PLPA 732: Biological Control of Plant Pathogens (E) (2 cr.hr.) Objectives**

To introduce the principles and applications of biological control method;

To introduce to challenges and future trends of biological control method.

**Description:** Principles, and mechanisms; types (natural, introduction of antagonists, modification of the environment); description and methods for identification of biocontrol agents; approaches to implement biological control; mass culturing techniques; storage and application technology; comprehensive testing of bioagents; formulation of bioagents; shelf life and ecological relationship of important biological control agents; compatibility of bio-control agents with chemicals; and challenges and future trends in biocontrol.

**Delivery:** The course will be delivered through lecturing, laboratory work on some biological control agents, presenting cases, group work, presentation and discussion.

**Assessment:** Performance of students on the course will be assessed through three research articles reviewing and presentation and discussion individually or in groups; reports on laboratory exercises and final written examination.

**PLPA 741: Scientific Paper writing (1 cr.hr) Objectives:**

To understand whys and how of science communication and strengthen scientific communication capabilities;

To introduce basic knowledge on research proposal writing and research process;

To understand components (sections) and contents of a proposal, a scientific article and other publications;

To develop critical and analytical skills to prepare a research proposal and undertake scientific research; and

To recognize the different avenues of communication within the scientific research.

**Description:** Why research; the research process; research proposal development; research proposal components and contents; the ABC of science communication; scientific versus popular science writings; sections and contents of a scientific paper and other writings.

**Delivery:** The course will be delivered intensively in a form of short term training. Group exercise and discussion will be utilized.

**Assessment:** Performance of students on the course will be assessed through assignments after course completion to prepare research proposals in groups and presentation.

**PLPA 742: Biochemistry of Plant Diseases (E) (2 cr.hr.) Objectives:**

Understand the effects of plant pathogens on the chemical properties of infected plants;

Recognize the role of pathogen enzymes on respiration of diseased plants;

Examine the effects of plant pathogens on the various metabolisms of host plants;

Identify the chemical compounds that induce host plant resistance; and

Assess the pathogen and plant toxins secreted during pathogenesis and their effects on plants.

**Description:** Introduction to plant infection processes and factors that facilitate the infection processes; photosynthesis and chlorophyll content as affected by plant pathogens; pathological respiration as influenced by fungi, bacteria, viruses and nematodes; pathogen enzymes involved in the plant cell wall degradation; effect of pathogen infection on nitrogen, protein, lipid and starch (carbohydrates) metabolism; phenol metabolism in infected plants and phenol oxidizing pathogen enzymes; phenolics and phytoalexins induced by pathogens; pathogenesis and growth regulators; role of pathogenesis-related proteins (PR-proteins) or antimicrobial proteins induced in plant defense mechanisms or host resistance; various toxins induced by plant pathogens and their impacts; comparative studies of biochemistry of healthy versus infected plants.

Effect of various pathogens on photosynthesis, absorption, translocation, respiration, permeability, transcription and translation; molecular and genetic perspective of resistant and susceptible interaction between plants and fungal, bacterial and viral pathogens; current hypothesis on the nature of disease resistance will also be discussed; applications of biotechnology in plant pathology.

**Delivery:** The course will be delivered in the form of classroom lectures assisted by audio-visual aids and group discussion on selected topics; term-paper writing and presenting on current topics of interest; laboratory and field demonstrations of diseased plants and diseased tissue chemical analyses; and literature reviews and critical analyses.

**Assessment:** Performance of students will be assessed through evaluation of the compilation of review paper and presentation on related topics (15%); assessment of assignments and laboratory exercises (15%); and final written examination (70%).

**PLPA 751: Special Topics in Plant Pathology (1 cr.hr.)**

**Objectives:** To acquaint students with emerging issues and possible solutions to plant pathology problems of national as well as international interest.

**Description:** Discussions and lectures on important areas and contributions in the field of plant pathology; reviews of current topics in plant pathology of interest to graduate students. Students will select topics of interest on emerging issues in the field of plant pathology in cooperation with the course instructor. Students will form groups of two or three, get prepared on the topic and present in class. Gust lecturers may also be invited to give talks on topics of special interest to plant pathology.

**Delivery:** There will be group preparations, presentation and discussion in class.

**Assessment:** Students will be evaluated through written questions and answers to trigger further thinking after each presentation.

**PLPA 752: Ph.D Seminar in Plant Pathology (1 cr.hr.) Objectives:**

To introduce candidates to simple techniques of presentation and communication,

To help them learn the methods of reviewing, analyzing, compiling and presenting most recent research works and findings, and

**Description:** A Ph.D candidate will select relevant scientific topic in consultation with the seminar advisor; sets the structural contents of the work; make exhaustive literature review on the selected seminar topic and analyze scientifically; summarize the review and present the relevant data in tables and figures; the candidate presents his observations and review facts (obviously related to his specialization but not from his dissertation) to the audience within the registered time frame or semester.

**Delivery:** Ph.D. seminar presentation will be announced to all interested participants and

the candidate is expected to present his observations in the seminar on the selected topic related to his field of specialization other than his dissertation research topic. Presentation will be conducted using audio-visual aids like Power-point in a meeting hall for one hour (20 to 25 minutes presentation by the student and 20 to 30 minutes for discussion

(questions and answers).

**Assessment:** Evaluation of the content and presentation by professionals and peers.

School Graduate Council members and graduate students will evaluate the course based on the organization of the compiled review paper; manner of presentation and response of the candidate to questions. An evaluation form prepared for this purpose will be used.

**PLPA 762: Epidemiology and Management of Plant Pathogens (3 cr.hr.)**

**Objectives:**

To introduce subject matter of plant disease epidemiology and factors affecting it and how;

To introduce models and analysis of temporal and spatial epidemic; yield loss, disease surveys and experimentations and disease forecasting;

To discuss the need for disease management and its perspective;

To discuss environment, public and food safety and economics issues of disease management; and to discuss on recent advances of plant disease management.

**Description:** Plant disease epidemiology and its importance; factors of epidemics and their monitoring; modeling, temporal and spatial analysis of epidemics; crop loss assessment and modeling; experiments and surveys in plant disease epidemiology; advances in plant disease forecasting systems; need for plant disease management; disease management in perspective; disease management in crop production systems; ecologically based management of plant diseases; biological control of plant diseases; role of biotechnological advances in plant disease management; and disease management in practice.

**Delivery:** The course will be delivered through lecturing, group work, presentation and discussion.

**Assessment:** Performance of students on the course will be assessed through three research articles reviewing and presentation and discussion individually or in groups; reports on exercises and final written examination.

**PLPA 772: Ph.D. Dissertation Research (30 cr. hr.)**

A Ph.D. candidate is required to identify a research problem relevant to the subject concerned and on national priority. Formulation of the research proposal should be according to the standard research methodology and in consultation with the advisory committee. The problem should reflect the current advances in the field and should have objectives intended for new findings and/or for confirmation of known facts for the Ethiopian conditions. After the approval the candidate is expected to execute the proposal and come up with the findings in the form of a dissertation.

**PLAG 512: Crop Ecology and Cropping Systems (E) (2 cr.hr.)**

(Course objectives, description, delivery methods and assessment from M.Sc Agronomy program will be used).

**PLPA 551: Disease Diagnosis and Techniques in Plant Pathology (E) (2 cr.hr.)**

(Course objectives, description, delivery methods and assessment from M.Sc Plant Pathology

Program will be used).

***5. Program Name: PhD in Agricultural Entomology***

***Course Breakdown***

**YEAR I SEMESTER I**

**Course Title Credit hrs**

PLEN 711 Advanced Insect systematics (R) 3

PLEN 721 Insect Plant Interactions (R) 3

PLEN 731 Methods in Agricultural Entomology (R) 3

PLEN 741 Molecular Approaches in Agric. Entomology (E) 3

**Total 9/14**

**YEAR I SEMESTER II**

**Course Title Credit hours**

PLEN 712 Insect Population Ecology (R) 3

PLEN 722 Special Topics in Agricultural Entomology (R) 2

PLEN 522 Biological Control (E) 2

PLEN 732 PhD Seminar in Agricultural Entomology (R) 1

PLEN 742 Insect Pathology (R) 2

**Total 10/13**

**(R)** stands for required courses and **(E)** stands for elective courses, Students are advised to take at least one elective course from any of the semesters.

**YEAR II Semester I up to Year III:**

**Course Code Title Credit hours**

**PLEN 752** PhD Thesis Research 30

Students are required to take at least two elective (E) courses

**Total course work = 19/27**

**Overall Total = 49/ 57**

***Courses***

**PLEN 711- Insect Taxonomy and Systematic - 3 Cr. Hrs**

**Objectives of the course**

• Shall equip them with knowledge of insect classification and nomenclature

• Shall give them idea of insect identification and use of taxonomic keys

• Shall provide knowledge of taxonomic descriptions of new taxa

**Course Description**

Principals and application of zoological nomenclature ,international code of zoological nomenclature; zoological nomenclature and classification; current classification; taxonomy of insect pests of agricultural importance; concept of species, sub species, kinds of species and taxonomic categories; intraspecific categories and biotypes; procedures in identification and kinds of taxonomic keys; concepts of supraspecific and infraspecific categories; taxonomic characters-morphological, cytological, biochemical, parasitological, geographical, numerical; hybridization and speciation; evolution and phylogeny; taxonomic publications; identification of taxonomic descriptions of new taxa; numerical taxonomy, cladistics and dendrograms.

**Practical**: Preparations for insects for making illustrations of taxonomic characters; identification of insects with the help of taxonomic keys; Writing of taxonomic papers; Visit to insect museum. Repository of insect collections.

**Mode of Delivery**

• Classroom lectures

• Insect characeterization assignment

• Laboratory practices

• Demonstration

**Assessment Methods**

• Article review on insect taxonomical characterization

• Written and oral examinations (mid-term and final)

• Laboratory records and assignments

**PLEN 721 Insect-Plant Interactions 3 Cr. Hrs**

**Objectives of the Course**

• Equip them with knowledge of insect host relationship

• Provide knowledge of insect multiplication in tropical areas

• Would give them information on important plant products to manage insect pests

**Course Description**

Relationship between insect and plants; herbivores insects; Insect damage in natural and disturbed ecosystems; plant chemistry and resistance; Host plant selection; Endocrine system of herbivores to host plant signals; Interactions in plant–insect communities; the theory of co- evolution; pollination ecology; Role of natural plant products in insect pest control and special features of insects in tropics and subtropics. Insecticide resistance, Insect diseases, Parasitoids and plant interaction.

**Practical**: Measurement of plant characters and their correlations with plant resistance;

bioassays of plant extracts of susceptible and resistant varieties.

**Mode of Delivery**

• Classroom lectures

• Laboratory practices

• Demonstration

• Glasshouse experiments on insect-plant interactions

**Assessment Methods**

• Article review on insect-plant interactions puplished on national and international journals

• Written and oral examinations (mid-term and final)

• Laboratory records and assignments

• Reports of the glasshouse experiments

**PLEN 731 Methods in Agricultural Entomology 3 Cr. Hrs.**

**Objectives of the Course**

• Knowledge of insect behavior

• Techniques to evaluate insecticides and efficacy of natural enemies

• Knowledge of mass culturing of insects

**Course Description**

Methods in studying insect behaviours; quantifying insect populations; techniques for

quantifying insect migration; evaluation of factors affecting host plant selection; statistical aspects of field experiments; injury ,damage and threshold concepts; techniques in studying insect pollination; techniques to evaluate insecticide efficacy; techniques to evaluate the efficacy of natural enemies; Methods of mass culturing and utilization of microbial agents in insect pest control; host pathogen relationships.

**Practical**: Preparing of different insect cultures in laboratory. Life table study of seasonal pests. Insect sampling and crop loss assessment.

**Mode of Delivery**

• Classroom lectures

• Laboratory practices

• Demonstration

• Field visits and trips

• Bioassay tests

**Assessment Methods**

• Article review on related topics

• Written and oral examinations (mid-term and final)

• Laboratory records and assignments

• Reports of the visit and trips

**PLEN 741 Molecular approaches in Agricultural Entomology 3 Cr. Hrs.**

**Objectives of the course**

• Shall provide information on techniques used in molecular biology

• Provide knowledge of genes of interest in entomological research

• Give knowledge of DNA based diagnostics and DNA fingerprinting

• Provide basis for insect management approach

**Course Description**

Introduction to molecular biology; techniques used in molecular biology; DNA and RNA analyses in insect transcription and translation mechanisms, recombinant DNA technology; genes of interest in entomological research- marker genes for sex determination, neuropeptides, JH esterases, BT toxins and venoms, chitinase, lectins and proteases; insect gene transformation; DNA finger printing for taxonomy and phylogeny; DNA based diagnostics; molecular basis of metamorphosis.

**Practical**: Visit to national laboratories to understand techniques used for DNA based diagnostics and molecular basis of metamorphosis

**Mode of Delivery**

• Classroom lectures

• Laboratory practices

• Demonstration

• Field visits and trips

• DNA and RNA extraction and PCR practices

**Assessment Methods**

• Article review on related topics

• Written and oral examinations (mid-term and final)

• Laboratory records and assignments

**PLEN 712 Insect Population Ecology 3 Cr. Hrs**

**Objectives of the course**

• Will give understanding of the insect ecosystem and prey parasite interaction

• Give information on effect of various environment factors on insect development

• Provide knowledge on insect food chain and food pyramids

**Course Description**

Major components and process in ecosystems; plant- insect -prey -predator interactions; predator and prey population dynamics; parasite and host interaction; mutualistic associations; demography; behavioral ecology; the niche concept and division of resources; intra and interspecific competitions; community development, structure and organization, diversity and stability; paleoecology and biogeography; effect of constant and variable environmental factors on development of insects and their population build up; Numeral changes influencing birth death rate; food chain and food pyramids and modern trends in insect ecology.

**Practical**: Environmental factors and population dynamics of some major insect pests of crops; methods of measuring insect population; study of life tables; determination of effect of constant and variable temperatures and humidity on growth and development of insects.

**Mode of Delivery**

• Classroom lectures

• Laboratory practices

• Field visits and trips

• Assignments

**Assessment Methods**

• Article review on related topics

• Written and oral examinations (mid-term and final)

• Laboratory records and assignments

**PLEN 722 Independent study Entomology 2 Cr. Hrs**

**Objectives of the course**

• Will develop skills of scientific writing

• Will bring confidence to write papers and reports

• Give idea to plan and present scientific papers

**Course Description**

Independent assignment to candidates on topic related to insect sciences; assignment could be laboratory or field work such as mini project, data compilation, independently or in partnership with other staff and students within the department on a topic which is not part of the PhD Dissertation.

**Mode of Delivery**

• Classroom lectures

• Laboratory practices

• Field visits and trips

• Sample article writing practices

• Reviewee of different journal writing styles

• Assignments

**Assessment Methods**

• Article review on related topics

• Written and oral examinations (mid-term and final)

• Laboratory records and assignments

• Presentations of sample articles

• Assignmnts

**PLEN 742 Seminar 1 Cr. Hrs**.

A PhD candidate is expected to do survey and analysis of literature and make observations on the subject concerned for making presentation. Seminar presentation should be on the topics related to the specific area of the study, other than the candidate’s research topic.

**Mode of Delivery**

• Literature reviews

• Discussion

**Assessment Methods**

• Article review on related topics

• Presentation of the reviews

• Assignments

• Manuscripts of the seminar

**PLEN 522 Biological Control (E) - 2 Cr. Hrs.**

**Objectives of the course**

• Shall equip them with knowledge of various insect predators and parasites

• Shall be able to utilize principles of biological control

• Give idea of insect pathogens and microbial pesticides

**Course Description**

Philosophy, scope, history and importance of biological control; theoretical and empirical basis of biological control; parasitism and predatism, phases of parasitism; important parasitic and predatory groups of insects and insect pathogens; ecological principles of biological control; methods of colonization, recovery and evaluation; introduction, culture, establishment and management of natural enemy population; biological control of weeds; role of natural enemies in integrated pest management with special reference to agriculture; microbial insecticides; examples of successful studies on bio-control.

**Practical**

Identification of common natural enemies (parasitoids, predators, pathogens and phytophagous

insects) of crop pests and weeds; rearing of eggs, egg larval, larval and pupal parasitoids and their laboratory hosts; rearing of common predators and phytophagous natural enemies of weeds; field recovery of parasitoids; culturing and identification of common insect pathogens.

**Mode of Delivery**

• Classroom lectures

• Laboratory practices

• Demonstration

• Assignments

**Assessment Methods**

• Article review on related topics

• Written and oral examinations (mid-term and final)

• Laboratory records and assignments

**PLEN 742 Insect Pathology (E) 2 Cr. Hrs**

**Objectives of the course**

• To have an understanding of various pathogenic agents(bacteria, fungi, nematodes, Viruses…) on economically important insects

• To learn how these agents can be utilized for managing economically important insect- pests in the field

• To learn how these agents can successfully be multiplied in laboratories

**Course Description**

History and development of insect pathology; the underlying principals in insect pathology, common and unique features/characteristics and association; entomopathogenic bacteria, viruses, fungi, nematode , protozoa and insects. Pathogenecity and performance enhancing mechanisms in entomopathogens. The challenges and opportunities in the development and application of microbial pesticides. The role of microbial pesticides in IPM and organic farming. To explore the common and specific procedures by entomopathogenic microrganisms in collection, screening, formulation, mass production, storage, shipment application and post application monitoring and evaluation methods, current status and prospects of microbial biopesticides.

**Practical**: Identification of different entomopathogenic bacteria, fungi, virus and nematodes. Familiarization with various techniques of culturing of microbial pesticides. Microbial formulations and their application for insect control.

.

**Mode of Delivery**

• Classroom lectures

• Laboratory practices

• Assignments

• Demonstration

**Assessment Methods**

• Article review on related topics

• Written and oral examinations (mid-term and final)

• Laboratory records and assignments

**PLEN 762 Ph D Thesis Research 30 Cr. Hrs.**

A Ph D. candidate is required to identify a research problem relevant to the subject concerned and on national priority. Formulation of the research proposal should be according to the standard research methodology and in consultation with the advisory committee. The problem should reflect the current advances in the field and should have objectives intended for new findings and /or for confirmation of known facts for the Ethiopian conditions. After the approval, the candidate is expected to execute the proposal and come up with the findings in the form of a thesis. Dissertation would be presented and defended in an open defense ceremony and candidate examined by a board of examiners designated by DGC and approved by CGS. The dissertation proposal would be defended at the DGC.

**Mode of Delivery**

• Continous suprvision of the research work

• Laboratory and field expirments

**Assessment Methods**

• At least one article published

• Public Defense

**Merits of the Proposal**

• Will become a part of important specialist forces in the country

• Farmers smile would bring sense of satisfaction

• Shall bring honor to Alma meter in the longer run

• Would be able to participate in important projects in the future

**African Center of Excellence for Climate Smart and Biodiversity Conservation**

**Syllabi for PhD Program in Climate Smart Agriculture and Biodiversity Conservation (*Sub-specialization: Crops; Livestock; Soil and water; Policy, institutions & Innovation; and Biodiversity conservation*)**

# 1. Program Name: PhD in Climate Smart Agriculture and Biodiversity Conservation

**Course Breakdown**

**Table 1:** Core common courses

|  |  |  |  |
| --- | --- | --- | --- |
| **R.N.** | **Course code** | **Core courses** | **Credit hours** |
| 1 | CSAg-5111 | Theories, Principles and Practices of Climate-Smart Agriculture | 3 |
| 2 | BdEM5112 | Ecosystems & Ecosystem Services | 2 |
| 3 | CSAg-5332 | GIS and Remote Sensing | 3 |
| 4 | BdEM5111 | Biodiversity Conservation and Management | 2 |
| 5 | CABC 712 | Models and Modeling for CSA | 3 |
| 6 | CABC761 | PhD Seminar in CSA and BDC I | 1 |
| 7 | CABC731 | Advanced Biostatistics\* | 3 |
| 8 | AgEc 732 | Econometrics\* | 3 |
| 9 | CABC732 | PhD Seminar in CSA and BDC II | 1 |
|  | **Total** | | **18** |
|  | CABC 811 | PhD Dissertation | **30** |

**Note**: Students choosing ‘policy, institutions and innovation’ sub-specialization will take **econometrics** while others will take **advanced biostatistics**.

**Table 2:** Sub-specialization courses

|  |  |  |  |
| --- | --- | --- | --- |
| **Sub-specializations** | **Course code** | **Course** | **Credit hours** |
| **Crops** | CACI 742 | Improvement of Crops for Resiliency | **3** |
| CACI 752 | Climate resilient crop production systems | **2** |
| **Livestock** | CALI 742 | Improvement of Livestock for Resiliency | **3** |
| CALI 752 | Climate Resilient Animal Production Systems | **2** |
| **Soil and water** | CASW 742 | Climate Smart Soil &Water Management | **2** |
| CASW 752 | Soil, Water, Plant and Atmosphere Relations | **3** |
| **Policy, institutions and**  **Innovation** | CAPI 742 | Economics of Climate Change | **3** |
| CAPI 752 | Institutions and Innovations for Climate Resilience | **2** |
| **Biodiversity conservation** | CABC 742 | Genomics and Proteomics | **2** |
| CABC 752 | Climate Change, Biodiversity and Ecosystem Management | **3** |

**Distribution of courses by semesters**

**Table 3:** Semester I

|  |  |  |  |
| --- | --- | --- | --- |
| **R.N.** | **Course code** | **Core course** | **Credit hours** |
| 1 | CSAg-5111 | Theories, Principles and Practices of Climate-Smart Agriculture | 3 |
| 2 | BdEM5111 | Biodiversity Conservation and Management | 2 |
| 3 | BdEM5112 | Ecosystems & Ecosystem Services | 2 |
| 4 | CABC 731 | Advanced Biostatistics\* | 3 |
| 5 | AgEc 741 | Econometrics\* | 3 |
|  |  |  |  |
| 6 | CABC 761 | PhD Seminar in CSA I | 1 |
|  | Total | | 11 |

**Note**: Students choosing ‘policy, institutions and innovation’sub-specialization will take **Econometrics** while others will take A**dvanced Biostatistics**.

**Table 4:** Semester II

|  |  |  |  |
| --- | --- | --- | --- |
| **R.N.** | **Course code** | **Course** | **Credit hours** |
| 1 | CABC 712 | Models and Modeling for CSA | 3 |
| 2 | CABC 751 | GIS and Remote Sensing | 3 |
| 3 | CABC 732 | PhD Seminar in CSA II | 1 |
| 4 | CACI 742 | Improvement of Crops for Resiliency1 | **3** |
| 5 | CACI 752 | Climate resilient crop production systems1 | **2** |
| 6 | CALI742 | Improvement of Livestock for Resiliency2 | **3** |
| 7 | CALI 752 | Climate resilient animal production systems2 | **2** |
| 8 | CASW742 | Climate-smart soil & water management3 | **2** |
| 9 | CASW 752 | Soil, water, plant and atmosphere relations3 | **3** |
| 10 | CAPI 742 | Economics of climate change4 | **3** |
| 11 | CAPI 752 | Institutions and innovations for climate resilience4 | **2** |
| 12 | CABC 742 | Genomics and Proteomics5 | **2** |
| 13 | CABC 752 | Climate Change, Biodiversity and Ecosystem Management5 | **3** |
|  | **Total** | | **12** |
|  | CABC 811 | PhD Dissertation | 30 |

**Notes:**

1)Sub-specialization: 1=crop, 2=livestock, 3= soil and water, 4= policy, institutions and innovation, 5= biodiversity conservation and management

2) The total credit hour for the second semester sums up to 12 where a student takes 5 credit hours from a chosen sub-specialization.

3) At the end of the coursework, students should pass a comprehensive examination as a requirement for eligibility to develop a dissertation research proposal.

1. **Course Descriptions**

* **Core courses**

**CSAg-5111: Theories, Principles, and Practices of Climate Smart Agriculture (3)**

**Course Description**

Agriculture in developing countries must undergo significant transformation if it is to meet the growing and interconnected challenges of food insecurity and climate change. A proposed means of achieving such improvements is increased use of a ‘climate-smart agriculture’ approaches through the courses like **Theories, Principles and Practices of Climate Smart Agriculture.** This course contains seven major sections: Introduction; Agriculture, Climate Change and Food Security; Background to CSA; Climate Change Adaptation, mitigation and disaster risk reduction; Perspectives of Climate Change and Energy; Capacity building and policy innovation; and future research on CSA. Thecourse will provide students with an insight into the theories, principles and practices of Climate Smart Agriculture. It will also deal with climate change during the past, present and in the future; major causes and effects of climate change; issues related to Greenhouse Gases and their emissions, Agriculture, Climate Change, Food Security. Climate change mitigation, adaptation and resilience, Farming Systems, Concepts and principles of Climate Smart Agriculture, Climate Smart Agricultural Technologies, Indigenous Knowledge for CSA, Policy perspectives to CSA, Climate Change Adaptation, Mitigation and Disaster Risk management, the concept of carbon sequestration; Carbon Trading and REDD+, Organizations working on Climate Change and Agriculture, energy perspectives of CSA, Capacity Building and Policy Innovation, issues of Clean Development Mechanism (CDM) and development of modalities and procedure of Future research on CSA.

The course is supported with practical activities on climate change impacts on crops and on soils; Sources and sinks of GHGs; Estimating GHG emissions; Carbon monitoring and sequestration; Analysis and interpretation of climate data; modeling climate impact on crops; Farming system field analysis; soil, plant and water analysis; Animal waste management practice; Field trip and case studies.

**General Objectives of the course**:

To impart theoretical and practical knowledge and skills on challenges of Agriculture due to Climate change and explore ways to enhance food security while contributing to Adaptation and mitigation to Climate Change.

**Specific Objectives of the course:**

After successful completion of the course, the students will be able to:

* discuss about the theories, principles and practices of Climate Smart Agriculture:
* identify the major causes of climate change and its effects on Agriculture;
* assess issues related to climate change mitigation, adaptation and resilience;
* explain the concept of food security, sustainable Agriculture, Conservation Agriculture, Farming systems;
* explain the concepts and components of CSA;
* discuss the synergies and Tradeoff s between CSA objectives;
* assess Indigenous Knowledge and technologies related to Climate Smart Agriculture;
* assess the policy perspectives of Climate Smart Agriculture;
* discuss on the energy perspectives of climate change and CSA;
* discuss about Carbon sequestration, Carbon Trading, REDD+, Clean Development Mechanism (CDM);
* Identify the major definitions and concepts of climate change, mitigation and adaptation;
* Identify the major barriers to adopt Climate Smart Agricultural Practices;
* Analyze national and global policies related to CSA and disaster risk management;
* Identify the major renewable energy sources in line with CSA;
* To assess the capacity building and policy innovations, national and international initiatives for Climate Smart Agriculture;
* Identify and analyze the different adaptations and mitigation options for monitoring CSA
* assess Greenhouse Gas emissions and prioritizing coping mechanisms for climate change;
* climate change adaptation: adaptation and technological needs; adaptation and coping mechanisms; national and local
* Discuss the models and procedures of climate change impacts on Crops.

**Course contents:**

1. **Introduction**
   1. Climate: Past, present and future
   2. Causes and Evidences of Climate Change
   3. Major Green House Gases and their Emissions
   4. Climate Change Scenarios in Africa and Global context
2. **Agriculture, Climate Change and Food Security**
   1. Food Security
   2. Sustainable Agriculture and Food Security
   3. Climate Change; Impacts, Vulnerability and Resilience in Agriculture
   4. Climate Change, Development and Farming systems in Africa
   5. Impacts of Climate variability and change on Soil Health, Environment, and Plant -Water interactions
   6. Agricultural Impacts on Climate change
3. **Background to Climate-Smart Agriculture**

3.1 Concept and Principles of Climate-Smart Agriculture (CSA)

* 1. Components of CSA and their Assessment
  2. Synergies and Trade-offs between CSA Objectives
  3. Climate-Smart Agriculture for future food production, Food Security and Resilience
  4. Approaches and practices of CSA
  5. Climate-Smart Agriculture Technologies
  6. Integrated farming system and Conservation Agriculture for Climate Resilience
  7. Indigenous knowledge for CSA
  8. Gender, Climate-Smart Agriculture and Climate change
  9. Development of Climate- Resilient Green Economy strategies in Ethiopia and other African countries
  10. Integrated National Policy Approaches, Strategies and Institutions related CSA

3.12 Barriers to Adoption of Climate Smart Agriculture practices

1. **Climate Change Adaptation, Mitigation, and Disaster Risk Reduction**
   1. Mitigating greenhouse gas emissions from Agriculture
   2. Building Adaptation and Resilience to Climate Change in Agriculture
   3. Climate-smart agriculture: integrating adaptation and mitigation
   4. Impacts and Response of Agriculture to Climate Change
   5. Managing Climate Risks with development of CSA
   6. Community-Based approaches for CSA
   7. Over view of Climate-smart management of livestock, forestry, agro-forestry,
   8. Fisheries and aquaculture
   9. Clean Development Mechanism, Carbon Trading, Carbon Sequestration and REDD+
   10. Organizations working on Climate Change and Agriculture
2. **Perspectives of Climate Change and Energy**
   1. Management of Energy for CSA
   2. Opportunities for synergies between CSA, REDD+ and Energy
   3. Energy Efficiency and Renewable Energy
   4. Moving forward-possible Energy Solutions for CSA
3. **Capacity Building and Policy Innovation in Ethiopia and other African Countries**
   1. Capacity Development for CSA
   2. Assessment, monitoring and Evaluation for CSA
   3. National and International Initiatives on CSA
   4. Mainstreaming CSA into National Policies and Programmes
4. **Future Research on Climate-Smart Agriculture**
   1. Improving Access to Knowledge and Monitoring of CSA
   2. Prioritizing the Climate Change Adaptation and Mitigation Options
   3. Quantifying Greenhouse Gas Emission from Crops and cropping systems
   4. Modeling Climate Change Impacts on Crops

**Mode of Delivery:** Lecture, assignments, practical field trips, term papers, presentation, climate change video and case study.

**Methods of Assessment**

The assessment will be made mainly through Assignments and Examination.Students are also expected to review articles and present.

* Assignments (15%)
* Review articles on cases of Theories and Principles of Climate Smart Agriculture and presenation (15%)
* Reports on field visit and practical activities (20%)
* Final examination (50%)

**References:**

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FAO (Food and Agriculture Organization of the United Nations). 2010a. Climate change implications for food security and natural resources management in Africa. Background paper prepared for the Twenty-sixth Regional Conference for Africa. Luanda, Angola.

FAO. 2012. Identifying opportunities for climate-smart agriculture investments in Africa. http://www.fao.org/docrep/015/an112e/an112e00.pdf

FAO 2014a. Climate-Smart Agriculture: What is it? Why is it needed?

http://www.fao.org/3/a-i4226e.pdf

FAO. 2014b. FAO Success stories on climate smart agriculture. Food and Agriculture Organization of the United Nations. http://www.fao.org/3/a-i3817e.pdf.

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Henderson-Sellers, A. & K. McGuffie (2012). The future of the world’s climate.Other relevant IPCC reports available at [www.ipcc.ch](http://www.ipcc.ch)

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.

FAO. 2010. Climate-smart agriculture: policies, practices and financing for food security, adaptation, and mitigation. Rome.

FAO. 2013. Community for Climate Change Mitigation in Agriculture. Mitigation of climate change in agriculture (MICCA) programme.

McCarthy, N., Lipper, L. &Branca, G. 2011. Climate-smart agriculture: smallholder adoption and implications for climate change adaptation and mitigation. FAO, MICCA Series No. 4. Rome, FAO.

FAO, 2010. Climate-Smart” Agriculture Policies, Practices and Financing for Food Security, Adaptation and Mitigation

World Bank 2010. The Hague Conference on Agriculture, Food Security and Climate Change: Opportunities and Challenges for a Converging Agenda: Country Examples. Washington, DC: World Bank.

**CSAg 5332: GIS and Remote Sensing for Climate Change (3)**

**Course Description**

Through lectures and laboratory exercises, this course illustrates the fundamental concepts of GPS, GIS and remote sensing technologies in the context of Climate Smart Agriculture and Biodiversity conservation. Topics include the physical basis for remote sensing, remote sensing systems, digital image processing, data structures, database design, and spatial data analysis. The course is intended to provide students with extensive training in particular image processing or GIS package and, hands-on computer laboratory sessions re-enforce critical concepts. Working knowledge of personal computers and completion of a term project are required.

**Learning objectives**

* Master the principles and concepts of GIS and RS
* Acquire, manipulate, save the data sources in a GIS
* Understand how GIS database works and how to update
* Learn how to edit data in GIS
* Learn digital image processing techniques
* Become familiar with specific functionality to the GIS: "Spatial Analysis"
* Learn map design, symbolization and   publishing
* Mastering the output and dissemination of results of a GIS project.
* Develop and implement a GIS project
* Present the software and data sources available on the current GIS market
* Discover and use the internet for publishing maps

**Mode of Delivery**: Lecture, critical Review and Presentation, Practical Session

**Course Outline:**

**Chapter 1.** **Introduction to Principles of GPS, GIS and Remote Sensing**

* 1. Principles of GIS and Remote Sensing
  2. Components of GIS Systems
  3. GIS Capabilities and Functions
  4. Spatial Data Infrastructure
  5. Introduction to GPS and Global Navigation Satellite

**Chapter 2. Data Acquisition: Using GPS/Mobile based GPS (ODK)**

* 1. Principles and concepts of GPS
  2. Introduction to Mobile Data gathering
  3. Survey Authoring
  4. GIS Mapping using open data kit (ODK) collected data
  5. Online web mapping with Google maps
  6. Exporting to GIS /RS environment for further analysis
  7. Hosting the data online

**Chapter 3. Data Acquisition: Extraction of Feature from Other Sources**

* 1. Extracting data from Satellite images,
  2. Extracting data from online GIS data sources
  3. Importing data to GIS
  4. Obtaining Data from topographic sheets
  5. Downloading Data from open street maps

**Chapter 4. Database Design and development**

* 1. Working with spreadsheets data in GIS
  2. Conceptual and logical database design
  3. Building and coding the attributes
  4. Digitizing and scanning of maps
  5. Relating spatial and attribute data

**Chapter 5. Editing and management of GIS**

* 1. Adding feature to GIS data
  2. Reducing GIS data
  3. cutting points of interest in image datasets
  4. Transforming GIS data

**Chapter 6. Integrating Imagery and Remote Sensing into GIS**

* 1. Radiometric and atmospheric correction
  2. Temporal normalization
  3. Geo-coding and geo-referencing
  4. Transformation
  5. Signature development
  6. Supervised Classification
  7. Unsupervised Classification
  8. Change detection
  9. Accuracy assessment

**Chapter 7.Geo-Spatial Analysis**

* 1. Geo-processing
  2. Creating views and themes
  3. Working with themes
  4. Working with attribute tables
  5. Spatial query and analysis
  6. Working with charts
  7. Creating a map layout
  8. Digital Cartography and Visualization

**Chapter 8. Introduction to cartographic visualization and the mapping process**

* 1. Components of a map
  2. Map design
  3. Symbol design
  4. Name design and placement
  5. Concept of scale
  6. Map projections
  7. Data pre-processing techniques
  8. Thematic mapping;
  9. Digital mapping

**Chapter 9. Online Publishing of Maps and GIS Outputs**

* 1. Working with Google Maps and Fusion Tables
  2. Publishing into other web based platforms

**Chapter 10. Case Study and Short Project**

* 1. Case study of a related programme use of GIS and RS technology

**Assessment**: Midterm Exam= 20%, critical paper review and presentation =15%, Practical Session =25% and Final Exam 40%

**References**

* Rolf A. de, 2001. Principles of Geographical information System: an introductory text book
* Lucas L., F. Janssen and Gerrit C., 2001. Principles of Remote Sensing: an introductory text book
* Remote Sensing and GIS Integration Theories, Methods and Applications. 2010 by the McGraw-Hill Companies, Inc. (Author?)

**BdEM5011:** Biodiversity Conservation and Management (2)

**Course Description:**

Basic concepts of biodiversity, characterization of biodiversity at genetic, species and ecosystem level, importance/values/benefits of biodiversity, threats and loss of biodiversity and its impact; the climate system and greenhouse effect vs. biodiversity; climate changes and its impacts on ecosystems and species distributions; biodiversity conservation tools and techniques (such as in-situ and ex-situ); qualitative and quantitative biodiversity resource assessment techniques, management plan for biodiversity conservation, the role of local people in biodiversity conservation (local/indigenous knowledge and its importance in biodiversity conservation), conservation incentives and incentive provision approaches; hotspots and mega-diverse countries, bioprospecting, biopirecy, and benefit sharing. Ethiopia centre of origin for some major crops. National and global conventions, policies and institutional aspect in biodiversity conservation and ecosystem management.The course is supported with field practical activities on qualitative and quantitative measurement of biodiversity.In addition, software programs in biodiversity informatics, national, regional and global biodiversity information databases and sources of thematic biodiversity information should be covered.

**Course Objectives:**

After completing this course, students will be able to:

* Explain the key concepts and definition of biodiversity.
* Characterize the biodiversity at any level in a systematic approach.
* Describe the major threats and challenges faced on the biodiversity.
* Understand the impacts of climate change on the biodiversity and develop knowledge on mitigation and adaptation strategies.
* Develop skill on the quantitative and qualitative measurement of biodiversity and carbon stock analysis of the various carbon pools.
* Develop knowledge on various techniques of management plan and conservation tools.
* Describe the global and national conventions, policies, and institutions of biodiversity conservation.

**Course Contents**

**1. Basics of Biodiversity**

1.1. Concepts and definitions of biodiversity

1.2. Characterization of biodiversity at genetic, species, ecosystem and cultural levels

1.3. Spatial and Temporal Patterns of Biodiversity

1.4. Structural and functional biodiversity

1.5. Importance/values/benefits of biodiversity

**2. Climate change and challenges on biodiversity**

2.1. The greenhouse gases effect vs. biodiversity

2.2. Climate changes and its impacts on ecosystems and species distributions

2.3.Threats and loss of biodiversity and its impact

**3. Biodiversity measurement and conservation methods**

3.1. Qualitative and quantitative biodiversity assessment/measurement methods

3.2. Conservation priorities

* hotspots and mega-diverse countries

3.3. Biodiversity conservation tools and techniques

* in-situ and ex-situ conservations

3.4. Management plan for biodiversity conservation

**4. Biodiversity and society**

4.1. The role of local community in biodiversity conservation

4.2. Indigenous communities and biodiversity

4.3. Indigenous knowledge in the use and conservation of biodiversity

4.4. Gender and biodiversity

4.5. Bioprospecting, bio-piracy, and benefit sharing

4.6. Conservation incentives and incentive provision approaches

**5. Overview of African biodiversity**

5.1.An overview of African biodiversity (Flora, fauna, microorganisms, and endemism)

5.2. Biodiversity hotspots and Mega-diverse countries in Africa

5.3. Overview of Ethiopian biodiversity

5.4. Ethiopia centre of origin for some major crops and wild relatives

5.5. Major biodiversity conservation challenges and opportunities

**6. Conventions, policies and institutions**

6.1. Conventions/protocols and policy instruments,

**6.2. Institutional arrangements,**

**6.3. Regional and international cooperation to manage genetic resources**

**Method of Delivery**: Lecture, assignments, term papers/independent studies, presentation, field works on quantitative measurement of biodiversity and work on Sourcesof Biodiversity information (Local to global databases,Global, regional and thematic information centres and databases and On-line sources of information).

**Assessment Methods:**

Group and individual assignments and presentations, field work reports, mid and final examinations.

**References:**

1. Richard B. Primack, 2006. Essential of Conservation Biology. 4th edition. HU Library: QH bstr. 57)

2. Van Dyke, F. (2003). Conservation Biology: Foundations, Concepts, Applications. McGraw-Hill, New York.

**BdEM5012. Ecosystems and Ecosystem Services (2)**

**Course Description**

The course will focus on integrated management of land, water and living resources and place human needs at the centre of ecosystems and ecosystem services, interlinked with the functioning and resilience of the ecosystems and the ecosystem services. The course links theories, principles and practices in the science of ecosystem ecology. It begins within the fundamentals of ecology that leads to the concept of ecosystems, and sub-divisions of ecosystems including agro-ecosystems.Highlight on thestructural aspects of ecosystem like,biotic and abiotic components, and detail on the functional processes of ecosystems like, energy and organic matter flow, hydrologic and biogeochemical cycles; trophic levels, ecological pyramids; and ecosystem stability are all covered. The factors that influence ecosystem structure and function,mechanisms by which climate affects ecosystems; projections of future climate change and potential impacts on ecosystems, ecosystem services.

The second part of this course deals with ecosystem restoration, and principles and methods to repair ecosystems that have been degraded, damaged, or destroyed. Procedures to restore the structure of biological communities, the ecosystem functions and ecosystems services they provide as well as technologies and models for ecosystem restoration.

Ecosystems provide a variety of valuable services that improve human well-being. Therefore, the third part of this course deals with values of ecosystem services. The four major categories of ecosystem services are provisioning services; regulating services; supporting services and cultural services. Methods used to value ecosystem services(including economic valuation); policy instruments and social institutions (including property rights, social norms and regulation) used to protect ecosystem services; the natural and human drivers of change in the provision of ecosystem services; and challenges exist in defining, measuring, valuing, and protecting ecosystem services.

**Course Objective**

The general objective of this course is to provide students with fundamental structures, functions and processes in the ecosystems. It enables students to identify the various ecosystems of the world, the structural and functional aspects of all kinds of ecosystems, values of ecosystems, the natural and human drivers of change in the provision of ecosystem services; and challenges exist in defining, measuring, valuing, and protecting ecosystem services.After completing this course, students will be able to:

* To understand the physical, chemical, and biological factors controlling the dynamics of aquatic and terrestrial ecosystems.
* Explain how ecosystem structures, functions, and processes are controlled by factors such as climate, parent material, topography and potential biota, and how human management and activities, including climate change, affect them.
* Learn the practical elements of restoration planning, include site assessment, implementation, monitoring and adaptive management.
* Gain an understanding of the linkages between natural and human systems and how these affect the production of ecosystem services.
* Obtain a skill on the processes of identifying, measuring, valuing, and protecting ecosystem services.
* Describe the global and national policy instruments that could be organized to facilitate valuation of ecosystem services including payment for ecosystem services as a tool in the mitigation of climate change at all levels.

**Course Content**

**1. The Ecosystems**

1.1. Fundamentals of ecology

1.2. The Ecosystem Concept

1.2. Components of Ecological Systems

1.3. Ecological Productivity and Energetics

1.4. Trophic chains and webs, ecological pyramids, and Energy Flow diagrams

1.5. Ecosystem Stability and Sustanability

1.6. Biogeochemistry: Nutrient Cycling in Ecosystem; Carbon inputs to ecosystem; Carbon Budgets – Ecosystems

1.7. The Millennium Ecosystem Assessment framework

**2. Ecosystem restoration**

2.1. Concepts of ecosystem restoration

2.2. Restoration planning**;**

2.2.1 Prioritizing sites for restoration;

2.2.2 Project design and management;

2.2.3 Regulations and policy;

2.2.4 Aesthetics and design;

2.2.5 Use of volunteers in restoration;

2.2.6 Project monitoring and evaluation

2.3. Procedures in restoration practice:

2.3.1. Assessment of the ecosystem/habitat problem,

2.3.2. Statement of restoration goals/targets,

2.3.3. Restoration plan describing what should be done,

2.3.4. A description of the monitoring plan.

**3. Ecosystem Services**

3.1. The history and rise of the ecosystem services concept

3.2. Typology/classification of ecosystem service

3.2.1.Provisioning services

3.2.2. Regulating services

3.2.3. Supporting services

3.2.4. Aesthetic and cultural services

**4. Valuation of Ecosystem Services**

4.1. Economic perspectives: Accounting & valuation of ecosystem services

4.2. Prices, Value and Importance

4.3. Methods for Valuation of Ecosystem Services: Non-monetary techniques

4.4. The Value of the World’s Ecosystem Services

**5. Ecosystem service indicators and resilience**

5.1. Ecosystem service indicators development framework

5.2. Ecosystem services and resilience

**6. Laws and Policies of Ecosystem Services**

6.1. The global and national laws and policies

6.2. Payments and markets for Ecosystem Services

6.3. Stakeholder involvement in ecosystem service decision-making

**7. Software Programs for ecosystem services and their evaluation**

**Mode of Delivery/Learning strategies**

* Lecture
* Theoretical and practical exercises
* Independent study and team work. practical fieldwork

For example, Practical exercise on a systematic analysis/investigation on the nearby terrestrial and aquatic ecosystem in a synergistic approach from the four perspectives of ecosystem services. The analysis/investigation report must include integration of natural science (e.g., ecology, hydrology, nutrient cycle, or climatology) and social science approaches (e.g., economics, sociology, anthropology, policy or political perspectives). Existing natural and anthropogenic challenges encountered and mitigation opportunities and options for ecosystem stability and sustainability. Teamwork with peer presentation.

**Assessment Methods**

Assignments, individual and teamwork and reporting, field work reports, quiz, final exam

**References**

Textbook “[Ecosystem Services: From Concept to Practice](http://www.cambridge.org/us/academic/subjects/life-sciences/natural-resource-management-agriculture-horticulture-and/ecosystem-services-concept-practice)” published by Cambridge University Press (2015). ISBN: 9781107062887.

Chapin, F.S. III, P.A. Matson, P.M.Vitousek. 2011. Principles of Terrestrial Ecosystem Ecology. Springer-Verlag, NY.

**HU Blog Site:** Instructors should upload on the blog site. Students will be expected to check.

National Research Council (NRC). 2005. Valuing Ecosystem Services: Toward Better Environmental Decision-Making. National Academies Press (Washington, DC).

**Further reference materials/Supplemental Readings**

MEA, The Millennium Ecosystem Assessment, Ecosystems and human well‐being: Synthesis.

2005, World Resources Institute: Washington D.C. p. 86.

Kareiva, P., et al., eds. Natural Capital: Theory & Practice of Mapping Ecosystem Services. 2011, Oxford University Press.

Kareiva, P., *et al*., eds. Natural Capital: Theory & Practice of Mapping Ecosystem Services. 2011, Oxford University Press.

Howell, E.A., J.A. Harrington, and S.B. Glass,Introduction to restoration ecology.2012,Washington, DC: Island Press. xv, 418 p.

**CABC712: Models and Modeling for CSA (3)**

**Course description:**

This course covers general topics of climate models and modelling that give an insight into basics of theoretical principles and their applications in agriculture and biodiversity conservation.The course give an overview of the climate system and greenhouse effect and examine evidence of climate changes. It also present models and recent methods for projecting future climate change at global and regional scales, and uncertainties in climate change projections, observed and projected climate changes. The major components of the climate system (atmosphere, ocean, land and cryosphere) and interactions among the components (Earth’s energy balance, surface energy balance, hydrologic cycle, atmospheric circulation, ocean circulation) that determine the state of the climate examine in the course using model and modelling. Moreover, approaches of downscaling global model projections and finer spatial scales will be discussed.

**Aims of the course:** Climate change and climate variability have become important topics in Agriculture and biodiversity conservation. Recent developments in understanding, modeling and prediction of climate change have brought seasonal to inter-annual predictions into everyday life. Projections of global warming as a consequence of human activity have been in the public consciousness for some time, even if the understanding of the scientific issues may not be as deep as would be desirable. There is a need to prepare science students for participation in climate change decision making by teaching the physics of the phenomena and the physical basis of computational climate models. Therefore this course aims to teach students current scientific understanding of global warming and of important natural climate variations, while laying out the essentials of how climate models are constructed and used for climate smart agriculture and biodiversity conservation in the context of climate change.

**Objective of the course:** At the end of the course students will:

* Understand what climate models do and the main sources of uncertainties in climate change projections;
* Know the changes in climate and sea level that are expected based on projections from global climate models;
* Know the main approaches for downscaling global projections to regional scales and their uncertainties; and
* Know the ranges of projected climate changes for the region

**Mode of delivery:** The course will include a combination of lectures, hands-on model development, and hands-on evaluation and use of existing models. Lectures and exercises will cover all steps in the modelling process: qualitative and quantitative model formulation, parameter estimation, and model validation and analysis. Each practical exercise will result in a short exercise report from each student. These reports will make up the students personal course portfolio.

**Chapter 1. Overview of Climate Variability and the Science of Climate Dynamics Model**

* 1. Climate dynamics, climate change and climate prediction
  2. The chemical and physical climate system
     1. Chemical and physical aspects of the climate system
     2. El Niño and global warming
  3. Climate models - a brief overview
  4. Global nature of the climate system

**Chapter 2. Basics of Global Climate**

* 1. Components and phenomena in the climate system
     1. Time and space scales
     2. Interactions among scales and the parameterization problem
  2. Basics of radiative forcing
     1. Blackbody Radiation
     2. Solar energy input
  3. Globally averaged energy budget—first glance
  4. Gradients of radiative forcing and energy transports by atmosphere and ocean
  5. Atmospheric circulation
     1. Latitude structure of the circulation
     2. Latitude-longitude dependence of climate features
  6. Ocean circulation
     1. Latitude-longitude dependence of climate features
     2. The ocean vertical structure
     3. The ocean thermohaline circulation
  7. Land surface processes
  8. Carbon cycle

**Chapter 3. Physical Processes in the Climate System**

* 1. Conservation of momentum
     1. Coriolis force
     2. Pressure gradient force
     3. Velocity equations
     4. Application: geostrophic wind
     5. Application: pressure coordinates
  2. Equation of state
     1. Equation of state for the atmosphere: Ideal gas law
     2. Equation of state for the ocean
     3. Application: thermal circulations
     4. Application: sea level rise and oceanic thermal expansion
  3. Temperature equation
     1. Ocean temperature equation
     2. Temperature equation for air
     3. Time derivative following the parcel
  4. Continuity equation
     1. Oceanic continuity equation
     2. Atmospheric continuity equation
  5. Moisture equation and salinity equation
     1. Conservation of mass and moisture
     2. Sources and sinks of moisture, and latent heat
  6. Moist processes
     1. Saturation
     2. Saturation in convection; Lifting condensation level
     3. The moist adiabat and lapse rate

**Chapter 4. El Niño and Climate Prediction**

* 1. Recap of El Niño basics
     1. The Bjerknes Hypothesis
  2. Tropical Pacific climatology
  3. El Niño-Southern Oscillation mechanisms
  4. Pressure gradients in an idealized upper layer
     1. Subsurface temperature anomalies
  5. Transition into the El Niño
     1. Subsurface temperature measurements
     2. Subsurface temperature anomalies and El Niño
     3. Subsurface temperature anomalies and La Niña
  6. El Niño mechanisms: Dynamics of transition phases
     1. Equatorial jets and the Kelvin wave
     2. Response of the ocean to a wind anomaly
  7. El Niño prediction
     1. El Niño-Southern Oscillation forecasts
  8. El Niño remote impacts: teleconnections
  9. Other inter-annual climate phenomena and prospects for seasonal-to- inter-annual climate prediction
     1. Hurricane season forecasts
     2. Sahel drought
     3. North Atlantic oscillation and annular modes

**Chapter 5. Climate Models**

* 1. Constructing a Climate Model
     1. An Atmospheric model
     2. Treatment of sub-grid scale processes
     3. Resolution and computational cost
     4. An ocean model and ocean-atmosphere coupling
     5. Land surface, snow, ice and vegetation
     6. Summary of principal climate model equations
     7. Climate system modeling
  2. The hierarchy of climate models
  3. Climate simulations and climate drift
  4. Evaluation of climate model simulations for present day climate
     1. Atmospheric model climatology
     2. Climate model simulation of climatology
     3. Simulation of El Niño-Southern Oscillation response

**Chapter 6.The Greenhouse Effect and Climate Feedbacks**

* 1. The greenhouse effect in Earth’s current climate
     1. Global energy balance
     2. A global-average energy balance model and a one-layer atmosphere
     3. Infrared emissions from a layer
     4. The greenhouse effect
     5. The greenhouse effect in a one-layer atmosphere, global average model
     6. Temperatures from the one-layer energy balance model
     7. Global-average energy balance model
     8. Increases in the basic greenhouse effect
     9. Climate feedback parameter in the one-layer global average model
  2. Climate feedbacks
     1. Climate feedback parameter
     2. Global average temperature response
     3. Climate sensitivity
  3. The water vapor feedback
  4. Snow/ice feedback
  5. Cloud feedbacks
     1. Stratospheric cooling
  6. Climate response time in transient climate change
     1. Transient climate change versus equilibrium response experiments
     2. A doubled-CO2 equilibrium response experiment
     3. The role of the oceans in slowing warming
     4. Climate sensitivity in transient climate change

**Chapter 7.Climate Model Scenarios for Global Warming**

* 1. Greenhouse gases, aerosols and other climate forcings
     1. Scenarios, forcings and feedbacks
     2. Forcing by sulfate aerosols
     3. Commonly used scenarios
  2. Global-average response to greenhouse warming scenarios
  3. Spatial patterns of warming for time-dependent scenarios
     1. Comparing projections of different climate models
     2. Multi-model ensemble averages
     3. Poleward amplification of warming
     4. Summary of spatial patterns of the response
  4. Climate response time in transient climate change
     1. Transient climate change versus equilibrium response experiments
     2. A doubled-CO2 equilibrium response experiment
     3. The role of the oceans in slowing warming
     4. Climate sensitivity in transient climate change
  5. Ice, sea level, extreme events
     1. Sea ice and snow
     2. Land ice
     3. Extreme events
  6. Climate change observed to date
     1. Temperature trends & natural variability: scale dependence
     2. Sea ice, land ice, ocean heat storage and sea level rise
  7. Emissions paths and their impacts

**Assessment:** Individual writing assignments**,** group writing assignments, presentation, quizzes, projects and practical works, final exam

**References**

Raper, S., and F. Giorgi (2005). Climate change projections and models. In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 199-210.

Hewitson, B., R. Crane, and M. Tadross (2007). Regional climate scenarios for impact assessment. In L. Otter, D. Olago, and I. Niang, eds., *Global Change Processes and Impacts in Africa: A Synthesis*. East African Educational Publishers, Nairobi, pp. 56-71.

Hulme, M., R. Doherty, T. Ngara, and M. New (2005). Global warming and African climate change: a reassessment. In P. Low, ed., *Climate Change and Africa*, Cambridge University Press, Cambridge, UK and New York, USA, pp. 29-40.

Houghton, J. (1994). The greenhouse effect. In J. Houghton, *Global Warming, the Complete Briefing*, Lion Publishing, Oxford.

Unganai, L. (2007). Climate and extreme events. In L. Otter, D. Olago, and I. Niang, eds., Global Change Processes and Impacts in Africa: A Synthesis. East African Educational Publishers, Nairobi.

Christensen, J., B. Hewitson and others (2007). Regional climate projections. In S. Solomon, D. Quin, M. Manning, Z. Chen, M. Marquis, K. Averyt, M. Tignor and H. Miller, eds., Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA

**CABC 731:** Advanced Bio-statistics (3)

* Prerequisite course(s): Basic Statistics, Biometry

**Course description**

The course provides students with an opportunity to learn advanced topics in Biostatistics that build on fundamental principles. The contents covered will enable students understand the principles and procedures of relevant statistical methods to analyse data from agricultural research in general and climate smart agriculture in particular. Topics to be covered include: Principles of Experimental Design; Experimental Designs for Single Factor and Factorial Experiments; Comparison of Treatment Means; Analysis of Covariance; Analysis of Multi-location/year Trial; Use of Mixed Models; Assessment of Fixed and Random Effects; Analysis of Repeated Measures; Regression Analysis;Non-parametric Methods; and Multivariate Methods. The course will be supported with statistical software.

**Aims of the course**

This course aims to enable students understand and apply advanced statistical methods and data analysis to address agricultural research questions in general and climate smart agriculture in particular. The course will support students to reach a level of proficiency where they will be able to select the appropriate statistical analytical method to address specific research questions, conduct the selected statistical analysis using appropriate statistical softwares, present and interpret the results appropriately, and draw valid and insightful conclusions about the research question.

**Objectives of the course**

Upon successful completion of the course the students will be able to:

* understand the concepts involved in planning, designing their experiments and analysis of experimental data.
* understand the techniques and procedures used in design and analysis of field plot, greenhouse, and laboratory experiments
* apply appropriate statistical procedures for their research giving emphasis on designed experiments,
* determine the appropriate statistical analytical technique for different designs and data sets of agricultural research
* conduct statistical analysis using advanced techniques on complex datasets with different types of variables.
* understanding the concepts involved in time series data presentation, analysis and interpretation
* correctly interpret results and draw valid conclusions addressing the research question.
* use appropriate statistical software and interpret the results

**Mode of course delivery**

* Lectures
* Individual assignments
* Software applications

**Course contents/topics**

**Chapter1. Principles of Experimental Design**

1.1. Steps in Experimentation

1.2. Design of Experiments

1.3. Concepts Commonly Used in Experimental Design

1.4. Analysis of Variance

1.5. General assumptions underlying the analysis of variance

1.6. Data transformation

1.7. Fixed and Random Effects Models

**Chapter**2. **Designs for Single Factor Experiment**

2.1. Completely Randomized Design

2.2. Randomized Complete Block Design

2.3. Latin Square Design

**Chapter 3. Incomplete Block Designs**

3.1. Lattice Designs

3.2. Augmented Block Design

**Chapter**4. **Factorial Experiments**

4.1. Factorial Experiment in Completely Randomized Design

4.2. Factorial Experiment in Randomized Complete Block Design

4.3. Split-Plot Design

**4.4. strip plot design**

**Chapter 5. Combined Data Analysis**

5.1. Test of homogeneity

5.2. Analysis of over years data

5.3. Analysis of over locations data

5.4. Analysis of over years and locations data

**Chapter 6. Analysis of Time Series Data**

6.1. Datafrom Plot Sampling

6.2. MeasurementOverTime

6.3. MeasurementOverTimewithPlotSampling

**Chapter 7. Analysis of Covariance**

7.1 Uses of Covariance Analysis

7.2 Computation procedure for CRD

7.3 Computation procedure for RCBD

**Chapter 8. Comparison of Treatment Means**

8.1. Least Significant Difference (LSD) Test

8.2. Duncan’s Multiple Range Test (DMRT)

8.3. Tukey’s Test

8.4. Pair Comparisons with Missing Data

**Chapter9. Regression and Correlation Analysis**

9.1. Simple Linear Regression and Correlation Analysis

9.2. Multiple linear Regression

9.3. Non-linear regression

**Chapter 10. Non-Parametric Methods**

10.1. Chi-Square Test

10.2. Spearman’s Rank Correlation

10.3. The Wilcoxon Paired Sample Test

10.4. Mann Whitney U test

10.5. The Kruskal-Wallis Test

10.6. Friedman’s Test

**Chapter 11. Multivariate Methods**

11.1. Cluster Analysis

11.2. Principal Component Analysis

11.3. Discriminant Analysis

**Chapter 12. software applications (SAS, R, Genstat)**

**Assessment mechanisms**

* Assignments
* Written exam

**References**

Clewer, A. G. and D. H. Scarisbrick. 2001. Practical Statistics and Experimental Design for Plant and Crop Science. John Wiley & Sons.

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Snedecor, G. W., and W. G. Cochran. 1980. Statistical Methods, 7th ed., Iowa State University Press, Ames, IA.

Sokal, R. R. and F. J. Rohlf .2011. Biometry: the Principles and Practice of Statistics in Biological Research, 4th ed., W.H. Freeman, New York, NY.

Steel, R. G. D., J. H. Torrie and D. A. Dickey .1997. Principles and Procedures of Statistics, 3rd ed., McGraw-Hill, New York.Zar, J.H.1996. Biostatstical Analysis. 3rd edition.

**AGEC 732:** Econometrics (3)

**Course Description**

This course introduces you to advanced and newly developed economic theory and application for micro and macroeconometric models. While a sound understanding of econometric theory will be beneficial, the course emphasizes the techniques for basic empirical research, interpretation of quantitative results and model evaluations. The course starts with the specification and estimation of the linear regression model, and the application of these concepts to economic problems. Departures from the standard Guass-Markov assumptions including heteroskedasticity, serial correlation, endogeneity, omitted variables and errors in variables and the models used to handle them including generalized least squares, instrumental variables and nonlinear regression models such as maximum likelihood and generalized method of moments are discussed. Finally, time series and discrete choice models are presented.

**Aims of the course**

The aim of the course is to provide the students with a rigorous foundation in econometrics.

**Objectives of the course (intended learning outcomes)**

At the end of the course the students are able to:

* specify the model, estimate it and make inference,
* formulate a hypothesis of interest and test it,
* apply econometrics to test economic theory,
* apply statistical software such as Stata, SPSS, etc. to analyze data, and
* read and understand articles published in professional journals.

**Mode of delivery**

Lectures, assignments, practical lab-sessions (hands-on Stata) and article evaluations

**Chapter 1. Introduction to Econometrics**

1.1. What is Econometrics?

1.2. Steps in Empirical Economic Analysis

1.3. Economic Data

1.4. Causality and the Notion of Ceteris Paribus

**Chapter 2. Classical Linear Regression Models**

2.1. Assumptions

2.2. Least Squares

2.3. SampleProperties of Least Squares

2.4. Tests

2.5. Inference

**Chapter 3.Structural Change and Specification Analysis**

3.1.Binary Independent Variables

3.2.Nonlinearity

3.3.Structural Changeand Model Stability

3.4.Specification Analysis

3.5.Model Selection Criteria

**Chapter 4. Instrumental Variables and Simultaneous Equation Models**

4.1.Instrumental Variables Estimation

4.1.1. Endogeneity

4.1.2. The IV estimator

4.1.3. Two stage least squares (2SLS)

4.2. Simultaneous Equation Models

4.2.1. Introduction

4.2.2. Identification

4.2.3.Estimation methods

4.2.4.Specification tests

**Chapter 5. Other Estimation Methods**

5.1. Generalized Least Squares

5.2. Method of Moments

5.3. Maximum Likelihood

**Chapter 6.Time-Series Models**

6.1.Stationary Stochastic Process

6.1.1. Autoregressive moving averages

6.1.2. Stationarity

6.1.3. Autocorrelations of stationary stochastic process

6.1.4. Partialautocorrelations of stationary stochastic process

6.1.5. Univariate time series

6.2.Nonstationary Time Series

6.2.1.Nonstationary process and unit roots

6.2.2. Integrated process and differences

6.2.3. Random walks, trends and spurious regressions

6.2.4. Tests for unit roots

6.3.Cointegration

6.3.1. Common trends

6.3.2. Error correction and VAR representations

6.3.3. Tests for cointegration

6.3.4. Testing cointegration relationships

**Chapter 7. Discrete Choice Models**

7.1. Binary Choice Models

7.1.1. The regression approach

7.1.2. Latent regression approach

7.1.3. Random utility models

7.2. Estimation and Inferences of Binary Choice Models

7.3.Bivariate and Multivariate Probit

7.4.Ordered Choice Models

7.4.1. Ordered probit

7.4.2. Bivariate ordered probit

7.5.Multiple Choice Models

7.5.1. Multinomial logit

7.5.2. Conditional logit

7.5.3. The Independence of Irrelevant Alternatives assumption

7.5.4. Nested logit

7.5.5. The mixed logit

7.6. Count Data Models

7.6.1. Poison distribution

7.6.2.The Poison regression model (PRM)

**Assessment mechanisms**

70% of the assessment will be based on final exam and the remaining 30% from mid-semester exam, homework, assignment and class participation.

**References:**

Econometric Analysis of Cross-sectional and Panel Data, Wooldridge

Greene, W. (2008). Econometric Analysis,

Gujarati, N.D. (2004). Econometrics-Basic econometrics. 4th edition, McGraw-Hill. NY.

**8.2 Sub-specialization courses**

**A) Crops**

**CACI 742:** Improvement of Crops for Resilience (3)

* **Prerequisite course(s):**Plant Physiology; Principles of Genetics/Crop Improvement; Plant Breeding

**Course description**

The course provides students with an opportunity to learn crop improvement techniques with special reference to resilience to biotic and abiotic stresses, especially induced by climate change. The topics to be covered include: crop physiology and genetics under climate change; classification of biotic stresses; concepts in insect and pathogen resistance; analysis and inheritance of resistance; host defense responses to pathogen invasions; acquired and induced immunity and systemic acquired resistance (SAR); host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions; types and genetic mechanisms of resistance to biotic stresses; phenotypic screening methods for major pests and diseases; classification of abiotic stresses; genetics of abiotic stress resistance; genes and genomics in breeding cultivars for resistance/tolerance against abiotic stresses; utilizing marker assisted selection (MAS) procedures for identifying resistant types in economically important crops; screening crops for resistance/tolerance against abiotic stresses; understanding the climatological parameters and predisposing crops to biotic and abiotic stress factors; and ways of combating them.

**Aims of the course**

This course is intended to provide learners with a breadth of current knowledge on principles and practices of improving crops for resilience to stresses mainly caused by climate change to solve problems or find solutions in crop production systems.

**Objectives of the course**

Upon successful completion of the course, the students will be able to:

* Identify the various types of biotic and abiotic stresses influencing crop production
* Analyze the effects of climate change on crop production
* Comprehend the principles and practices of climate smart agriculture
* Analyze the mechanisms and genetics of resistance of crops to biotic and abiotic stresses
* Apply the techniques and procedures used for crop improvement for resilience
* Identify the climatological parameters and predisposing biotic and abiotic stress factors and design ways of managing them.
* Screen/select crops for biotic and abiotic stresses
* Apply analytical and selection techniques for improving crops for resilience

**Mode of course delivery**

* Lectures
* Reading assignments
* Laboratory, ~~and~~ field practical and visits
* Term paper writing and presentation~~s~~

**Course contents**

**Chapter 1.Introduction to Biotic and Abiotic Stresses**

1.1. Effects of biotic and abiotic stresses/stressors on crop production

1.2. Influence of climatological parameters on biotic and abiotic stress factors

1.3. Importance of crop improvement to biotic and abiotic stress resistance

**Chapter 2.** C**rop Physiology and Genetics Under Climate Change**

2.1. Influence of climate change on crop physiology

2.2. Climatic change factors affecting host reaction to pests

2.3. Implications of the climate change factors and their significance in plant breeding

**Chapter 4.** C**lassification of Biotic Stresses/Stressors**

4.1. Nature and diseases caused by fungi

4.2. Nature and diseases caused by bacteria

4.3. Nature and diseases caused by viruses

4.4. Nature and diseases caused by nematodes

4.5. Emerging and re-emerging crop diseases

**Chapter 5.** C**oncepts in Insect and Pathogen Resistance**

5.1. Principles of pathogen and insect resistance to pesticides

5.2. Factors influencing development of pest resistance to pesticides

5.3. Strategies to prevent development of pest resistance to pesticides

**Chapter 6.Analysis and Inheritance of Crop Resistance**

6.1. Types of plant resistance to pests

6.2. Mechanisms of inheritance of resistance

6.3. Genes and genomics in breeding varieties for resistance/tolerance to abiotic stresses

6.4. Advances in developing resistant crop varieties to pests

**Chapter 7.Host defense Responses to Pathogen Invasions**

7.1. Mechanisms of resistance of crops to insect pests

7.2. Mechanisms of resistance of crops to plant pathogens

**Chapter 8. Host-Pathogen Interaction**

8.1. Principles of disease development

8.2. Responses of host plants to infection

8.3. Gene-for-gene hypothesis; molecular evidence for its operation

8.4. Application of host-pathogen interaction in disease management

**Chapter 9. Genetic Mechanisms of Resistance to Biotic Stresses**

9.1. Genetic mechanisms of resistance to biotic stresses

9.2. Degrees of crop resistance/susceptibility to pests

9.3. Strategies to lengthen the life of crop varieties developed using major gene resistance

**Chapter 10. Breeding Methods for Abiotic Stress Resistance**

10.1. Moisture stress/drought and water logging and submergence

10.2. Acidity, salinity/alkalinity/sodicity

10.3. High/low temperature

10.4. Stress due to soil factors and mineral toxicity

**Chapter 11. Physiological and Phenological Responses of Crops to Stress**

11.1. Physiological responses of crops to abiotic stresses

11.2. phenological responses of crops to abiotic stresses

**Chapter 12. Breeding Methods for Biotic Stress Resistance**

12.1. Techniques for developing resistant crop varieties to crop diseases

12.2. Techniques for developing resistant crop varieties to insect pests

**Assessment mechanisms**

* Term paper and presentation
* Written examination
* Class discussion/quizzes

**References**

Araus, J. 2011. Crop Stress Management and Global Climate Change. CABI Climate Change Series

Ceccarelli S, Galie A, Grando S: 2013. Participatory breeding for climate change-related traits. Genomics and Breeding for Climate-Resilient Crops: Concepts and Strategies, Volume 1. Edited by: Kole C. pp. 331-376. Berlin: Springer Science & Business, 8

Chijioke. O.B., Mekbib Haile and Waschkeit, C. 2011. Implication of Climate Change on Crop Yield and Food Accessibility in Sub­Saharan Africa. Interdisciplinary Term Paper ZEF Doctoral Studies Program. 27 pp.

Cossani CM, Reynolds M.P. 2012. Physiological traits for improving heat tolerance in wheat. *Plant Physiology*, 160: 1710-1718.

George T. 2014. Why crop yields in developing countries have not kept pace with advances in agronomy. *Global Food Security*, 3: 49-58.

Legrève, A. and Duveiller, E.. Preventing Potential Disease and Pest Epidemics Under a Changing Climate. International Maize and Wheat Improvement Center (CIMMYT) and CAB International. Pp. 50 – 70.

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Roy SJ, Tucker EJ, Tester M. 2011. Genetic analysis of abiotic stress tolerance in crops. Curr*Opin Plant Biol.*, 14: 232-239.

Tester M, Langridge P. 2010. Breeding technologies to increase crop production in a changing world. *Science,* 327: 818-822.

Weller, D.M., Raaijmakers, J.M., Gardener, B.B. and Thomashow, L.S. (2002) Microbial populations responsible for specific suppression to plant pathogens. *Annual Review of Phytopathology* 40, 309–348.

**CACI 752:** Climate Resilient Crop Production Systems (2)

**Course description**

Current trends in population growth suggest that global food production is unlikely to satisfy future demand under predicted climate change scenarios and depletion of natural resources. In order to maintain food security in the face of these challenges, a holistic approach that includes stress-tolerant germplasm, sustainable crop and natural resource management, and sound policy interventions are needed. The course will enable learners understand the principles and practices of enhancing crop production and productivity while contributing to mitigate climate change and preserving the natural resource base through a major shift in the way land, water, soil nutrients and genetic resources are managed to ensure that these resources are used more efficiently. Topics include discussions of food security and climate change; water and soil management for climate-resilient crop production systems; conservation and sustainable use of genetic resources; climate-resilient crop management; adapting to biotic and abiotic stresses; sustainable and resource-conserving technologies and new tools for enhancing crop adaptation.

**Aims of the course**

The course is aimed to provide learners with current knowledge on principles and practices of climate resilient crop production systems thereby improve food security, adapt to climate change and contribute to climate change mitigation by developing and adopting appropriate practices and technologies

**Objectives of the course**

Upon completion of this course the learners will be able to:

* Understand principles and practices in climate smart agriculture in general and climate resilient crop production in particular their potentials and limitations,
* Understand the concept of food security and issues in achieving it.
* Understand the impacts of climate change on crop production and their management strategies
* Understand the inter-relationship among climate change, environment, food security and sustainability at global and regional level.
* Understand ways of adapting to climate change and managing the environment for crop production keeping in mind food security and sustainability.
* address the complex interrelated challenges of food security, development and climate change, and identify integrated options for crop production that create synergies and benefits

**Mode of course delivery**

* Lectures
* Field trip
* Term paper writing and presentations

**Course contents**

**Chapter 1. Food Security and Climate Change**

* 1. Ensuring Food Security
  2. Economic Impacts of Climate Change on Agriculture
  3. Impacts of Climate Change on Crop production
  4. Agriculture’s Impact on Climate Change
  5. Towards more Efficient and Resilient Systems
     1. Increase resource efficiency in crop production
     2. More resilient systems
     3. Efficiency and resilience
  6. Climate Smart Agriculture (CSA)
     1. Definitions of concepts
     2. Sustainable development and green economy
     3. CSA, green economy and sustainable development
     4. Food security and natural resources: sustainable intensification

**Chapter 2. Managing Landscapes for Climate-Resilent Crop Production Systems**

2.1 Current Pressures and Constraints of the Natural Resource Base

2.2 Climate Change Threatening Ecosystems

2.3 Reversing Trends through Climate-smart Crop production

2.4 Land Use Planning

**Chapter 3. WATER Management for Climate-Resilent Crop Production Systems**

* 1. Water Management in Agriculture: status and trends
  2. Potential Impacts of Climate Change on Water in Agriculture
  3. Vulnerability to Climate Change and Resilience
  4. Assessing Risk, and Preparing Responses
  5. Options for Adaptation to Climate Change
  6. Water Management for Climate Change Mitigation

**Chapter 4.Soils and their Management for Climate-Smart Crop Production Systems**

* 1. Principles of Soil Health,
  2. Plant-Water Interrelations
  3. Challenges of Climate Change to Soils
  4. Soil Principles for Climate Change Adaptation and Mitigation
  5. Nitrogen Management: greenhouse gas mitigation and adaptation
  6. Soil Carbon and achieving Multi-functionality through Mitigation and Adaptation
  7. Successful Examples of Soil Management Practices for Climate-smart Crop Production

**Chapter 5. Conservation and Sustainable use of Genetic Resources**

* 1. Genetic Resources for Food and Agriculture
  2. Impacts of Climate Change on Genetic Resources
  3. Role of Genetic Resources in Climate Change Adaptation and Mitigation.

**Chapter 6. Climate-Resilient Crop Management**

6.1 Multiple Cropping

6.2 Conservation Farming

6.3 Response Farming

6.4 Precision Agriculture

6.5 Organic Farming

6.6 Integrated Nutrient Management

6.7 Integrated Pest Management

6.8 Integrated Crop Management

**Chapter 7. Methods for Improving Crop Yield Under Climate and Environmental Stress**

* 1. Adapting Crops to Climate Change
  2. Reducing Greenhouse Gas Emissions
  3. Crop Improvement to Climate and Environment Stresses
  4. Crop Management to Cope with Climate and Environment Stress
     1. Agronomic practices
     2. Managing potential disease and pest epidemics under a changing climate

**Assessment mechanisms**

* Term paper and presentation
* Written exam

**References**

Akiyama H, Yan X, Yagi K. 2009. Evaluation of effectiveness of enhanced-efficiency fertilizers as mitigation options for N2O and NO emissions from agricultural soils: meta-analysis. Glob Chang Biol., 16: 1837-1846.

Antón J, Cattaneo A, Kimura S, Lankoski, J. 2013. Agricultural risk management policies under climate uncertainty. Glob Environ Change, 23: 1726-1736.

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Beddington JR, Asaduzzaman M, Clark M.2012. The role for scientists in tackling food insecurity and climate change. Agric Food Secur., 1: 10-

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Connor, D.J., Loomis, R.S., and Kenneth G. Cassman. 2011. Crop Ecology: Productivity and Management in Agricultural systems. Cambridge University press. London.

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FAO. 2012d. What is conservation agriculture? (available at http://www.fao.org/ag/ca/1a.html).

Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R. &Meybeck, A. 2011. Global food losses and food waste: extent, causes and prevention. Rome, FAO.

Halvorson AD, Del Grosso SJ, Alluvione F. 2010. Tillage and inorganic nitrogen source effects on nitrous oxide emissions from irrigated cropping systems. Soil SciSoc Am J., 74: 436-445.

Jarvis A, Lau C, Cook S, Wollenberg E, Hansen J, Bonilla O, Challinor A. 2011. An integrated adaptation and mitigation framework for developing agricultural research: synergies and trade-offs. Exp Agric., 47: 185-203.

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Wheeler T, von Braun J. 2013. Climate change impacts on global food security. Science, 341: 508-513.

**B) Livestock**

**CALI 752: Climate** Resilient Animal Production Systems (2)

**Course description**

Concept of climate resilient animal production systems, methods/tools of classification of production systems, characterization of major animal production system in the world, and in Eastern and Southern Africa based on objectively verifiable variables with a view to identify constraints and develop viable opportunities for sustainable agricultural and natural resource management, constraints of animal production. Understand their evolution and show future animal production system pathways in relation to driving forces (population, urbanization, and climate change). Mitigation targeted to feed production, enteric fermentation and manure management; CS livestock production practices including grassland restoration and management, manure management and crop-livestock integration; barriers to adopt climate smart livestock production systems. Resource use efficiency, building resilience, buffering and risk management.

**Aim of the course**

Climate change is a threat to animal production through diminished feed availability, disease outbreak, flood and high temperature. To adapt and mitigate these impacts climate resilient animal production system plays paramount importance for sustainable animal production.

This course is targeted:

* To explain different animal production systems in the world with emphasis to sub-Saharan Africa animal production system;
* To discuss concept of climate resilient animal production systems;
* To explain interrelationship between climate change and different animal production systems;
* To equip students with the knowledge, skill and attitude about climate resilient animal production systems and future perspectives in face of climate change; and
* To support students to analyze the impacts of climate change on animal production systems and *visa versa*, and measures to be taken.

**Course objectives**

* To equip the students with knowledge, skill and attitude about climate resilient animal productions systems in relation to changing global trends and how different development interventions could be designed and executed in different animal production systems.

At the end of the course the students should be able to:

* Define climate resilient animal production systems, climate resilience, climate change mitigation and adaptation;
* Characterize animal production system of a given region and recommend climate resilient animal production systems;
* Develop adaptation and mitigation strategies for a given animal production systems;
* To have in-depth understanding of the effects of climatic changes on animal production systems; and
* To evaluate the current knowledge generation process on the improvement of animal production system for climate resilience

**Mode of Delivery**

Lecture, group discussion, term paper, video, filed visit and report

**Course contents**

**Chapter 1: Introduction**

1.1 Overview of climate resilience/adaptation/mitigation and livestock production system

1.2. Concept of climate resilient animal production systems

1.3. Methods/tools of classification of production systems

1.4. Impacts of climate change on livestock production system

1.5. Impact of animal production system on environment

**Chapter 2: Characterization of major animal production system in the world**

2.1. Evolution and future animal production system

2.2. Conventional animal production systems

2.3. Climate resilient animal production systems and future perspectives

**Chapter 3: Climate resilient animal production systems**

3.1 Climate resilient animal production systems

2.2 Role of climate resilient animal production systems

2.3 Developing and evaluating climate resilient animal production

2.4 Overall principle and indicators of climate smart animal production systems

**Chapter 4: Adaption and mitigation strategies for CS livestock production systems**

4.1. Feed production, enteric fermentation and manure management

4.2. Animal’s role in adaptation practices

4.3. Management of organic matter and nutrients

4.4. Diversification of income of farmers

**Chapter 5: Climate smart agriculture practices for climate resilient animal production**

5.1. Grassland restoration and management (e.g. silvopastoral systems),

5.2. Manure management (recycling, bio-digestion)

5.3. Integration of livestock with crop, agro-forestry, and fisheries and aquaculture;

5.4. Resource use efficiency; building resilience: buffering and risk management

5.5. Barriers to adoption: lack of information, limited access to technology, insufficient capital

**Assessment mechanisms**

Written exam, presentation of term papers, assignment

**References**

AlemayehuMengistu, 2006. Country Pasture/Forage Resource Profiles. FAO, Rome Italy.

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Pierre G., Mooney, H.A., Dijkman, J., Taraweli, S., Haan, C. 2010. Livestock in Changing Landscape: Experiences and regional perspectives, Island Press.

**CALI 742:** Improvement of Livestock for Resilience (3)

**Course Description**

The course Improvement of Livestock for Resiliency covers the study of the impacts of climate change on livestock production and productivity. The course focuses on studying animal breeding and genetics and animal husbandry for adaptation and resilience, and translating these into breeding goals that can support sustainable livestock farming systems. It also covers about building resilience: buffering and risk management at farm and system level, and mitigation of greenhouse gas emissions in livestock production. It also provides brief descriptions on the animal disease emergence in association with climate change.

**Aim of the course**

Livestock make a necessary and important contribution to global calorie and protein supplies. However, livestock need to be managed carefully to maximize this contribution towards sustainable food security.

The aim of this course is therefore:

* To assesses the impact of climate change on livestock and identifies adaptation and mitigation strategies;
* To study animal breeding and genetics, and animal husbandry practices for adaptation and resilience for improvement of livestock production and productivity;
* To explore climate smart livestock production strategies
* To explores the linkages between climate change and animal diseases, and examines interrelated issues that arise from altered biological dynamics
* To learn the contribution of livestock as a green gas emitters and contributor for climate change
* To address the global challenge of mitigating GHG emissions without impacting livestock productivity
* To support students to analyze the impacts of climate change on animal health and production and to look for adaptation and mitigation strategies.

**Objectives of the course**

At the end of the course the students should be able to:

* Share emerging and innovative solutions to address livestock production and productivity in the face of climate change;
* Translate scientific knowledge into policy recommendations that favor the enhancement of livestock production and productivity;
* Development and evaluation of climate smart livestock production and productivity practices and services and their potential contribution to food security, adaptation and mitigation;
* Have in-depth understanding of the effects of climatic changes on animal health and resilience;
* Understand the applications of tools/models that are applied in livestock resilience system (for example MAPA Project, (Agro-climatic Adaptation and Prevention Models);
* Validate climate-smart technologies that support livestock production practices and strengthen local capacities to climate change adaptation and mitigation;
* Understand and support the potential contribution of the farmers on livestock resilience system;
* Evaluate current knowledge generation process on the improvement of livestock resilience to climate change; and
* Evaluate adaptation and mitigation strategies, and scaling-up of climate smart livestock production practices.

**Mode of delivery**

* Lecture, seminar/poster presentation, video/ audiovisual assisted learning
* Educational trip/visit to a Center of that engages in livestock genetics, genomics and breeding research, which are relevant to the course
* Term paper preparation and presentation

**Course contents**

**Chapter 1: Introduction**

1.1 Impacts of climate change on livestock production and productivity

1.2.1 Direct impacts of Climate change

1.2.2 Indirect impacts of climate change

1.2 Impact of livestock production on the environment

1.3 Climate resilient livestock production practices

**Chapter 2: Climate Smart Livestock Production practices**

2.1 Definition and importance

2.2 Developing and evaluating climate smart livestock production

2.3 Climate smart livestock production practices (indigenous knowledge/practices)

2.4 Principle and indicators of climate smart livestock production

2.5 Policies and institutional arrangements to support climate smart livestock production

**Chapter 3: Mitigation of greenhouse gas (GHG) emissions from livestock production**

3.1 Contributions of Livestock in GHG emissions

3.2 Intervention Actions to mitigate green gas emissions

3.2.1 Feed and nutrition

3.2.2 Animal genetics and breeding

3.2.3 Rumen modification

3.2.4 Animal health management

3.2.5 Manure and grassland management

3.2.6 Animal and farming system management

**Chapter 4: Animal genetics and breeding for climate smart livestock production**

4.1Identifying of local breeds adapted to climatic stress

4.2 Method of selection of livestock breeds for adaptation

4.3 Improvement of local genetics potential

4.4 Strategies for developing climate resilient composite livestock breeds

4.5 Improved feed efficiency (feed-to-food efficiency)

**Chapter 5: Climate Change and Emerging Diseases of Livestock**

5.1 Relationship between climate change and disease susceptibility

5.2 Climate change associated diseases of livestock

5.2.1 Infectious disease

5.2.2 Heat stress

5.2.3 Nutritional deficiency/metabolic diseases

5.2.4 Ecto-parasites

5.3 Climate change and related environmental stress

5.4 Strategies to minimize impact of climate change on livestock health

**Chapter 6: Livestock Adaptation and Resilience for climate change**

6.1 Determinants of climate change adaptation strategies

6.2 Developing performance indicators for climate change adaptation

6.3 Adapting smallholder production system to climate change

6.4 Indigenous knowledge for climate change adaptation and mitigation

6.5Building resilience: buffering and risk management at farm and system level

6.6 Factor affecting resilience

6.7 Adaptation and Resilience in Animal Breeding and genetics

6.8 Resilience against animal disease

6.9 Early action to scaling-up of best practices for climate resilient animal production

6.10 Financing climate smart livestock production

**Assessment mechanisms**

* Written exams, assignments, term paper presentations

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**C. Soil and Water**

**CASW 742:** Climate Smart Soil and Water Management (2)

**Course description**

This course covers general topics of soil and water management that give an insight into basics of theoretical principles and their applications in climate smart agriculture. The major topics to be covered under different chapters include; why climate-smart soil and water management, probable challenges of climate-smart soil and water management; Linkage among climate change, water and food security; soils and their management for climate-smart agriculture: indicators of soil health under changing climate, soil properties and processes likely to be affected by climate change and vice versa; climate-smart soil management scenarios including integrated soil fertility management, Soil and water conservation; Water management for climate-smart agriculture: status and trends of water management in agriculture, potential impacts of climate change on fresh water resources and water-dependent services such as agriculture, water management under changing climate, agricultural water management strategies for building resilience, roles of policies and institutions for agricultural water management; prospects of soil and water management scenarios at different levels (on-farm, irrigation system, watershed);Water harvesting; Emerging frontiers in climate-smart soil and water management: basics of soil-water interactions, modeling soil-water processes for improving agricultural water productivity (pedotransfer functions, soil-water flow models, quantifying crop yield-water relationships, etc), producing more per drop of water.

**Aims of the course**

Soil and water are the two most important resources for agriculture. Climate change has been affecting and is expected to continue affecting these resources either positively or negatively. Therefore, soil and water uses and their management need to be climate-smart in order to practice agriculture on a sustainable basis. In order to practice climate-smart soil and water management, it is crucial to be conversant with theories, principles, and practices of climate-smart soil and water management. This course is, thus, designed to impart theoretical and practical insights into climate-smart soil and water management practices/techniques. It aims at acquainting students with basics of soils and their management focusing mainly on how climate change affects soil attributes and water resources and vice versa, and possible management scenarios to adapt and mitigate negative impacts and explore possible opportunities. It also aims at acquainting students on sees how soil and water interact in agriculture and how principles of soil and water relations can be used in improving agricultural water productivity.

**Objectives of the course (intended learning outcomes)**

After successful completion of the course, students will be able to:

* Explain why climate-smart soil and water management is required
* Explain the link among climate change, water, and food security
* Describe soil properties and processes that are vulnerable to climate change impacts
* Explain how changes in soil attributes and processes can contribute to climate change and mitigation
* Identify climate-smart soil management practices
* Explain the status and trend of agricultural water management
* Describe potential impacts of climate change on fresh water resources and sectors that depend on water (with emphasis on agriculture)
* Identify water resources management strategies for climate change adaptation
* Identify agricultural water management scenarios for climate-smart agriculture
* Distinguish the roles of policies and institutions for effective agricultural water management
* Describe prospects of soil and water managements-related adaptations at different levels
* Comprehend emerging frontiers in climate-smart soil and water management practices

**Mode of delivery**

The course will be delivered following different modalities:

* Lectures
* Reading assignments (self-teaching on selected topics)
* Field visits and laboratory exercises
* Term papers
* Group studies

**Course contents**

**Chapter 1.Introduction**

* 1. Theories, principles and practices of climate-smart soil and water management
  2. Challenges of soil and water management under changing climate
  3. Linkage among climate change, water, and food security

**Chapter 2. Soils and Their Management for Climate-smart Agriculture**

2.1. Soil health indicators for climate change

2.2. Potential impacts of climate change on soil attributes and processes

2.3. Potential impacts of soil attributes and processes on climate change

2.4. Managing soil health for climate-smart agriculture

2.5. Integrated soil fertility management for climate smart agriculture

**Chapter 3. Water Management for Climate-smart Agriculture**

3.1. Water management in agriculture: status and trends

3.2. Potential impacts of climate change on water resources

3.3. Water management for climate change adaptations

3.4. Agricultural water management strategies for building resilience

3.5. Policies and institutional framework for improving agricultural water management

**Chapter 4. Prospects of Soil and Water Management for Adaptations at Different Levels**

4.1. On-Farm adaptation

4.2. Adaptation at irrigation system level

4.3. Adaptation at watershed, river basin and national levels

**Chapter 5. Soil-water interaction and agricultural water productivity**

5.1. Basics of soil-water interactions

5.2. Modeling soil-water processes for improving agricultural water productivity

5.3. Concept of producing more per drop of water: What is working and what is not working

**Assessment mechanisms**

* Field and laboratory reports (20%)
* Assignments (20%)
* Presentations (20%)
* Final exam (40%)

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**CASW 752:** Soil -Water –Plant- Atmosphere Relations (3)

**Course Description**

The course covers principles of soil-water- plant- atmosphere relations, role of soil constituents in soil –water –plant- atmosphere system, properties of soils in relation to plant growth, soil organic matter and climate change, fundamentals of water movement and storage in soils, mechanisms of water absorption by plant and plant water requirements, impacts of climate change on soil-water-plant- atmosphere relations. It also covers soil-water- plant-atmosphere continuum to show how water moves through the soil-plant-atmosphere system.

The practical laboratory and field activities are included to explore methods and techniques used to measure soil-water and nutrients. The laboratory activities give more emphasis to instrumentation that can be used for soil, water and plant analysis for monitoring soil fertility and irrigation water quality. Field activities include installation of soil moisture measuring devices, techniques for measuring soil water and soil fertility status at field.

**Aims of the Course**

The soil-water-plant-atmosphere relation is a system through which biogeochemical processes occur at the interface of soil and atmosphere on the planet earth. Knowledge of all the processes and factors affecting these relations is vital to design management and intervention options to sustain life on the earth. The main goal of this course is,therefore, to provide learner basic knowledge on the principles of soil-water- plant- atmosphere relations and factors affecting all the processes within soil-water-plant-atmosphere system

**Objectives (Learning outcomes)**

After completing this course, students will be able to:

* Describe principles of soil-water- plant –atmosphere relations
* Describe role of soil constituents in soil-water–plant-atmosphere relations
* Discus significance of soil organic matter in soil-water-plant-atmosphere relations
* Explain impacts of climate change on soil organic matter dynamics
* Identify important soil properties influencing soil water storage and water movements within soil-plant –atmosphere system
* Describe mechanisms of water absorption by plant from soil
* Explain role of water in plant physiology
* Explain how water moves through the soil-plant-atmosphere system.
* Measure soil water and analyze soil fertility status in laboratory and at field

**Mode of Course Delivery**

* Classroom lecture
* Presentation on course topics by students
* Group work and presentation on topics related to the course
* Lab and field works

**Course Contents**

**Chapter 1. Introduction**

* 1. Principles of Soil-Water-Plant-Atmosphere Relations
  2. Role of Soil Constituents in Soil-Water–Plant-Atmosphere Relations

**Chapter 2. Soil as a Medium for Plant Growth**

* 1. Physical Support
  2. Temperature Moderation
  3. Protection from Toxins
  4. Soil as Nutrient Reservoir for Plant Growth
  5. Soil as Water and Air Reservoir for Plant Growth

**Chapter 3. Soil Organic Matter and Climate change**

* 1. Composition (Functional groups) of Soil Organic Matter
  2. Soil microorganisms and Organic matter decomposition
  3. Effects of Climate Change and Soil Management on Soil Organic Matter
  4. Soil Organic Carbon Dynamics and Climate Change
  5. Carbon Sequestration and Emission in Soil-Water- Plant -Atmosphere System
  6. Carbon Balance in Soil-Plant-Atmosphere System
  7. Soils and Green House Gasses

**Chapter 4. Soil Water**

* 1. Structure and Properties of Water
  2. Soil Water Storage
  3. Soil Water Constants
  4. Soil Water Intake (Infiltration)
  5. Soil Water Potential
  6. Movement of Water within Soil

**Chapter 5. Absorption of Water by Plant from Soil**

* 1. Mechanisms of Water Absorption by Plant
  2. Pathways of Water in Plant Root
  3. Factors Affecting Water Absorption by Plant
  4. Translocation of Water or Ascent of Sap

**Chapter 6. Plant (crop) Water Requirements**

* 1. Roles of Water in Plant Physiology
  2. Factors Influencing Plant (crop) Water Requirement
  3. Estimation (Calculation) of Plant (Crop) Water Requirement
  4. Losses of Water from Soil-Water- Plant System
     1. Losses of water from soil
     2. Losses of water from plant
  5. Water **B**udget and Balance

**Chapter 7. Soil-Water-Plant-Atmosphere Continuum**

* 1. Driving Forces for Water Movement
  2. Resistances Against Water Movement
  3. Soil and Water Management Practices
  4. Crop Management

**Practical**

1. Soil, Water and Plant Analysis
   1. Soil Analysis
   2. Water Analysis
   3. Plant Analysis

2. Soil Water Measurements

**Mode of Assessment**

* Presentation on course topics by students (20%)
* Group work and presentation on topics related to the course (20%)
* Lab and field works, and reporting (20%)
* Final exam (40%)

**References**

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**D. Policy, Institutions and Innovation**

**CAPI 742:** Economics of Climate Change (3)

**Course Description**

The course provides an understanding of climate change issues from economic perspectives. It specifically deals with the principles of economic and policy aspects of climatic change, the functioning of market mechanisms and its failure in protecting the environment and various options for climate policies, issues of public goods and externalities, the costs and benefits of various climate options for adaptation and mitigation, optimal level of greenhouse gases, tradable pollution permit markets, carbon taxes, technological innovation and R&D, the optimal approach to control climate change, relative merits of various climate change policies that will increasingly be put forward by governments and other stakeholders, international environmental agreements, and the future of climate change policies.

**Aim of the Course**

The aim of this course is to provide students with a core knowledge of the science of climate change; an ability to think critically about its economic implications; and opportunities to apply this knowledge in classroom discussions, application activities and research.

**Objectivesof the Course**

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

* outline the problem of climate change
* articulate key issues relating to climate change;
* explain the role of economic instruments in designing appropriate climate change policies;
* describe climate change issues from a developing country perspective;
* apply the principles of economics and policy to key issues of climate change, including mitigation and adaptation;
* explain the positions of the various stakeholders in the climate debate;
* demonstrate the role of international agreements and collective actions;
* discuss and compare the theoretical economic solutions to combating climate change;
* analyze, discuss, and recommend possible climate change policy issues;
* outline possible future climate policy issues; and
* undertake independent research in the area of economics of climate change.

**Mode of Delivery**

Student-centered active learning methods based on demonstrations, lectures, case studies, brainstorming sessions, and paper writing and presentation.

**Course contents**

**Chapter 1: Introduction**

* 1. The Science of Climate Change
  2. Economics, Ethics, and Climate Change
  3. Scientific consensus and scientific debate
  4. Greenhouse Effect and the Carbon Cycle
  5. Climate Change and Climate Variability
  6. Trends and Projections of Climate Variables: Basic Facts

1.7 Causes and Consequences (Impacts) of Climate Change

**Chapter2: Efficiency, Public Goods, Externalities**

2.1 [A Brief Micro Review: From Preferences to Efficiency](http://are.berkeley.edu/~traeger/Lectures/ClimateChangeEconomics/Slides/2%20Efficiency%20-%201%20Micro%20Review.pdf)

2.1.1 Preferences, utility, rates of substitution,

2.1.2 Efficiency, equilibrium, welfare theorems

2.2. Market Failure, Public Goods & Externalities

**Chapter3: Economic Analysis of Climate Change**

* 1. The Nature of Costs and Benefits
     1. Timing of costs and Benefits,
     2. Uncertainties, Distribution of Benefits,
     3. LocationalandStringency Considerations
  2. Costs of Greenhouse Gas Control: Cost Taxonomy and estimation
  3. Mechanisms to Estimate Abatement Costs
     1. Use of Economic Instruments,
     2. Use of Sinks,
     3. Introducing Distortionary Taxes,
     4. Defining Emission Baselines
  4. Benefits of Greenhouse Gas Control
     1. Scope of Benefits,
     2. Quantitative Estimates of Benefits
  5. Economics of Vulnerability, Resilience, Adaptation, and Mitigation
  6. Impacts of Climate Change on Growth and Development: Economic Modelling
  7. Structural change and competitiveness

**Chapter4: Risks and Uncertainty in Climate Change**

4.1 Risks, Expected Value, and Risk Aversion

4.2 Willingness to Pay for Risk Reduction

4.3 Uncertainty and Discounting

4.4 Uncertainty, Irreversibility, Learning, and Insurance

4.5 The Optimal Timing of Emissions Control

**Chapter5: Environmental Policy Instruments**

* 1. General Principles:
     1. Range of Policies,
     2. Widespread Participation and Unilateral Action,
     3. Cost Effective Institutions
  2. [Instrument Choice](http://are.berkeley.edu/~traeger/Lectures/ClimateChangeEconomics/Slides/3%20Instruments%20-%201%20Introduction%20on%20Instrument%20Choice.pdf) and Choice Criteria
  3. The Theory of [Bargaining (Ronald Coase)](http://are.berkeley.edu/~traeger/Lectures/ClimateChangeEconomics/Slides/3%20Instruments%20-%202%20Bargaining%20(Coase).pdf): Property Rights as ‘Instrument’
  4. Policy Responses
     1. Carbon Taxes,
     2. Tradable Permits,
     3. Subsidies,
     4. Standards,
     5. Environmental liability
     6. Research and development and Technology Transfer
  5. Incentive-based GHG Abatement Policy
  6. Climate-Related Policies in Ethiopia
  7. The Future of Climate Change Policy

**Chapter6: International Cooperation and Agreements**

* 1. A Game Theoretic Perspective
  2. International Policies and Agreements
  3. International Collective Action for Climate Change
  4. Global Carbon Pricing and the Transition to a Low Carbon Global Economy
  5. The Future of Climate Change Agreements

**Assessment Mechanisms**

* Mid-exam (20%),
* Term paper writing and presentation (20%),
* Assignments (20%), and
* Final exam (40%).

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**CAPI 752:** Institutions and Innovations in Climate Resilience (2)

**Course description**

Basic concepts of institutions, the emergence and development of the new institutional economics; property rights and environmental change; networks and social capital in combating climate change; drivers of institutional change and levels of analysis; polycentric environmental governance and climate change; technology and institutions in climate change; market-based regulations; ethics, norms and sustainability and the role of institutions in reducing corruption in climate financing; the role of community-based organizations in adaptation to climate change; market-based incentives and climate change; linkage among agriculture, environment and sustainable development; basic social and institutional innovations in supporting adaptation, enhancing resilience to climate change; analysis of cross-scale institutions and cross-sectoral linkages and partnerships to undermine the effect of climate change on agriculture; case studies in the application of different institutions in environmental governance and adoption of climate resilient technologies in Africa.

**Aim of the course**

The overlapping feature of all institutions is that they constrain or facilitate human action to improve economic performance. In all spheres of human action, institutions are nested in nature, complex and do change, some faster than others, and reduce uncertainty to achieve stability and ensure predictability in human behaviour. Human activities contributing to climate change or reducing its effects and impacts are influenced by the prevailing institutions. Students need to be exposed to the concept of institutions (rules, relations, policies and procedures) and how they function and change to mitigate the effects of climate change and to facilitate adaptation by influencing the behaviour of different actors whose production and consumption activities generate undesirable consequences to the environment.

**Objecives of the course**

By the end of the course, students are expected to:

* Describe the concept of institutions and its role in enhancing public responses to climate change
* Analyze the drivers of institutional change in order to support adaptation to climate change
* Acquainting students with the mechanisms through which different actors create new and more effective responses to the formidable challenges of climate change
* Evaluate the influence of technological, social and institutional innovations in improving resilience towards climate-induced shocks
* Synthesize global experiences in coordinating collective action to mitigate the effects of climate with specific reference to agriculture

**Mode of course delivery**

As an advanced course, the handling of this course demands greater involvement of the students. Students will be provided with reading materials in advance, get prepared for the lecture and raise points of discussion that enable them to relate theory to their own individual research projects where possible. Active participation is highly valued. Based on the course materials provided and the literature to be explored by the students, a term paper will be written. Students are required to undertake a critical literature review and present their views in the class. Personal creativity and the ability to related existing theories to institutional (regulations, legislations and constitutions, informal practices) and national climate change policy analysis is required. This exercise is expected to improve students’ theoretical understanding and analytical levels that can help them to build skills useful in their respective dissertation research. Themes for the writing of the term paper will be proposed by the instructor and discussed in the class to increase choices.

**Course topics**

**Chapter 1: The Concept of Institutions**

1.1 Basic concepts of institutions

1.2 Why institutional economics?

1.3 Old and New institutional economics

1.4 Institutions and contracts

1.5 Opportunism and Institutions

1.6 The agricultural development challenges in Africa

1.7 Neoliberals vs. Developmental state

**Chapter 2: Theories of Institutional Change**

* 1. The theory of induced institutional innovation
  2. Transaction costs theory
  3. Distributive bargaining theory
  4. Political-economy theory
     1. interest group
     2. public choice
  5. Property rights theory

2.5.1 Concept of property rights

2.5.2 Property rights regimes

2.5.3 Forces of change in property rights

2.5.4 Property rights and legal pluralism

2.5 Evolutionary theory

* 1. Case studies and examples from Africa

**Chapter 3: Collective Action in Environmental Governance**

* 1. Basic concepts and reasons for collective action
  2. The theory of collective action
  3. Polycentric governance in climate change
  4. The role of social capital in collective action and environmental governance
  5. Application of the IAD Framework
  6. Game-theory in climate change institutions
  7. Case studies and examples from Africa

**Chapter 4: The State, Private Sector and Community-Based Adaptation**

4.1 The role of community-based organizations

4.2 The state, private sector and market in adaptation

4.3. Assessing and building adaptive capacity

4.4 Community-based adaptation: cases and challenges

**Chapter 5: Ethics, Sustainability and Climate Change**

5.1. Balancing contested choices: economic growth versus environment

5.2. Ethical considerations in mitigation

5.3. Corruption risks and climate financing

5.4. Environment, agricultural development and sustainability

5.5 Institutions for sustainability: structures and processes

**Chapter 6: Social and institutional innovations in climate change**

6.1. The concept of social innovation

6.2. The process of social innovation

6.3. Supporting innovation systems

6.4. Institutions for adaptation

6.5. Institutional innovations at different scales

6.6. Agricultural innovations in building climate resilience

6.7. Cross-sectoral linkages, partnerships and coordination

6.8. Institutions in agro-biodiversity management

6.9. Policy frameworks for global cooperation

6.9.1 International agreements

6.9.2 National policies and building capacities

6.10. Case studies and examples from Africa

**Assessment**

* Term paper (30%);
* Individual assignments (10%):
* Mid-term exam (20%);
* Final exam (40%)

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**E. Biodiversity Conservation**

**CABC 742:** Genomics and Proteomics (2)

**Course Description**

The course is divided into two parts: Genomics and Proteomics. The two different disciplines of genomics (Structural Genomics and Functional Genomics) constitute four chapters and will be dealt with in some detail. Proteomic will be treated in a separate three chapters and will be dealt with the theoretical lectures in the areas of proteomics, proteins synthesis, posttranslational and chemical modifications of proteins, cellular signaling and protein targeting and quantification.

**Aims of the Course**

The Genomics and proteomics course is intended to:

* Introduce students to the various ways organisms genomes are analyzed
* Introduce students to the different research tools that are indispensible to the analysis of genomics
* Enable student understand that differential display of proteomics is useful for comparison of protein levels with potential application in a wide range of diseases.
* Enhance students’ understanding of the biochemistry of proteins, processes and pathways.

**Objectives of the Course**

The course is designed to accomplish the following objectives:

* To enable students understand the challenges and strategies of genome analysis, including features to be analyzed; sequence and polymorphisms
* To help students gain knowledge on how the physical, genetic and sequence maps are generated and how the genomes of various model organisms are compared
* To enable students to get acquainted with improved technologies used for mapping and sequencing
* To make the clear understanding between gene and protein networks.
* To help students notice that modification of a proteins can radically alter their properties
* To get the revised picture of disease from analysis of the proteome through aging, cancer, cardiovascular disease, neurodegeneration, tolerance and climate adaptability.
* To enable students have clear understandings of infectious disease and the microbial proteome

**Mode of delivery:** Lecture, Student presentation, Assignments, Group discussions

**Course Contents**

**Structural Genomics:**Comparison of genetic and physical maps, Techniques in genomic sequencing, Methods for sequencing entire genomes;Whole genome shot gun sequencing, high throughput sequencing. The Human Genome Project; Vectors for large scale genome projects; Variations in genomic sequences; Single nucleotide Polymorphisms, Copy number variations, Sequence Tagged sites.

**Functional Genomics:**Gene expression on a genomic scale; Transcriptomics, Predicting function from sequences, Gene expression and microarrays. Genomic functional profiling; Genome-wide mutagenesis. Genomic techniques in functional genomic studies.

**Proteomics**: Introduction to proteomics, protein synthesis and modification, signal transduction, targeting proteins, protein identification and quantitative proteomics.

**Course Outline**

***Part I:***Structural and Functional Genomics

**Chapter 1: Introduction to Genomics**

1.1. Genetic maps

1.1.1. Common types of polymorphisms employed in genetic mapping

1.1.2. Genome-wide identification of genetic markers

1.2. Physical maps

**Chapter 2. Characterizing DNA Structure at the Molecular Level**

2.1. History of the development of the sequencing technology

2.1.1. Chain termination sequencing (Sanger’s sequencing)

2.1.2. Capillary gel electrophoresis

2.1.3. Next generation sequencing technologies

2.2. Techniques for DNA sequencing on a genomic scale

2.2.1. Whole-genome shotgun sequencing

2.2.2. High throughput sequencing and its impact on genomics

**Chapter 3. High Throughput Instruments**

3.1. DNA sequencer

3.2. DNA arrays

3.3. Sequence maps

**Chapter 4. Gene Expression on a Genomic Scale**

4.1. Transcriptomics

4.1.1. DNA microarrays and microchips

4.1.2. Serial analysis of gene expression (SAGE)

4.1.3. Cap analysis of gene expression (CAGE)

4.1.4. Whole chromosome transcriptional mapping

4.2. Genomic Functional profiling

4.2.1. Deletion analysis

4.2.2. RNAi analysis

4.2.3. Tissue specific functional profiling

4.2.4. Locating target sites for transcription factors

4.2.5. Locating enhancers that bind unknown proteins

4.2.6. Locating promoters

4.2.7. *In situ* expression analysis

4.3. Genomic techniques in functional genomic studies

4.3.1. Chromatin immuno precipitation (ChIP)

4.3.2. ChIP on chip to map protein and DNA interaction

4.4.Genome evolution

4.4.1.Colinearitybetween related genomes

4.4.2. Evolution of multigene families

***Part II***: **Proteomics**

**Chapter 5. Introduction to Proteomics and Informatics**

5.1. Proteomics

5.1.1. Importance of proteomics

5.1.2. Subdivisions of proteomics

5.1.3. Organization of protein structure levels

5.2. Protein informatics

5.2.1. Collection, organization and analysis of biological data

5.2.2. Molecular modeling

5.2.3. Manipulation of the structure of proteins

**Chapter 6. Protein Synthesis and Modifications**

6.1. Amino acid chemistry

6.2. Protein synthesis

6.3. RNA regulation

6.4. Posttranslational modifications of proteins

6.5. Chemical modification of proteins

6.6. Locating and separating protein modifications

6.7. Protein complexes and glycoproteomes

6.7.1. Protein complexes

6.7.2. Glycoproteomes

**Chapter 7. Signal Mechanism, Protein Targeting and Identification**

7.1. Signal transduction

7.1.1. Ligands and receptors

7.2. Second messengers

7.2.1. Cyclic AMP, Cyclic GMP and G proteins

7.2.2. IP3 and DAG

7.2.3. Calcium ions

7.2.4. Tyrosine kinases

7.2.5. Hormones and growth factors

7.2.6. Cell signaling and apoptosis

7.2.7. Signal protein complexes

7.3. Protein targeting and identification

7.3.1. Plasma membrane proteins

7.3.2. Extracellular matrix or cell wall proteins

7.3.3. Endoplasmic proteins

7.3.4. Chloroplast and mitochondria proteins

7.3.5. Nuclear, cytoplasm and other organelle proteins

7.4. Quantitative proteomics

7.4.1. Chromatography and spectrometry

7.4.1.1. Atomic Absorption

7.4.1.2. UV Spectroscopy

7.4.1.3. Infrared spectroscopy

7.4.1.4. FTIR

7.4.1.5. GC - mass spectrometry

7.4.1.6. HPLC

Assessment: Assignments, presentations, quizzes, projects and practical works, final exam

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**CABC 752:** Climate Change, Biodiversity and Ecosystem Management (3)

**Course description:** The course explore the Knowledge of climate change and its impact on ecosystems and biodiversity, and explore methods and tools for assessing climate impacts to ecosystems, and biodiversity will be explored. Course topics include the climate system and greenhouse effect; changes in palaeo-climate and their impacts on ecosystems and biodiversity distributions; more recent climate changes and their observed impacts; mechanisms by which climate affects ecosystems; projections of future climate change and potential impacts on ecosystems, ecosystem goods and services, and human livelihoods; ecological niche modelling; biogeography models; dynamic vegetation models; and methods for assessing ecosystem changes and biodiversity losses will be covered in the course. Types and importance of ecosystem based climate change mitigation will be studied. Working in teams, the course participants will develop and present case studies of climate change threats to the biodiversity and ecosystem.

**Aim of the course**: The overall aim of the course is to enable biodiversity conservation in a changing climate by generating deep understanding of the implications of climate change on ecosystems (including their goods and services), biodiversity and human well-being.

**Course objective:**Objectives of the course are to develop understanding of:

* The processes of climate variability, climate change and the greenhouse effect;
* Mechanisms by which ecosystems and biodiversity have been and are expected to be affected by climate change;
* Risks from climate change and other interacting pressures that act on ecosystems and biodiversity, ecosystem goods and services, and human well-being;
* Methods for assessing climate change risks on biodiversity and ecosystem

**Mode of delivery**

* Student-centered active learning methods based on demonstrations, lectures, case studies, brainstorming sessions, and paper writing and presentation.

**Chapter 1. Biodiversity and ecosystem: linking with climate change**

* 1. Global carbon cycle
     1. Photosynthesis
     2. Respiration
     3. Carbon sequestration
     4. Greenhouse gas emission
  2. Benefits of biodiversity in a REDD++ context

**Chapter 2.Impacts of climate change**

* 1. Biodiversity
     1. Genetic diversity
     2. Phenological shifts
     3. Species diversity
     4. Ecosystem diversity
        1. Ecosystem structure
        2. Ecosystem heterogeneity
  2. Ecosystem Services
  3. Biotic interactions
  4. Threatened species and vulnerable ecosystems
  5. Responses of biodiversity and ecosystem to climate change
  6. Projection of future climate impact
     1. Predictions about future impacts
     2. Coping with complexity
     3. Modelling
     4. Monitoring
     5. Dealing with uncertainty: ecological resilience and transformation

**Chapter3. Climatic drivers for changes in biodiversity and ecosystem**

* 1. Proximate drivers
  2. Ultimate (indirect) drivers
  3. Global drivers

**Chapter 4. Mitigating climate change: the role of biodiversity and ecosystem**

* 1. Afforestation and reforestation
  2. Conserving carbon stores
     1. Reducing deforestation
     2. Maintaining ecosystem
     3. Restoring ecosystem
     4. Improving ecosystem services
  3. Investing in alternative energy
  4. New partnerships to address biodiversity and climate change
     1. Innovative financing for carbon and biodiversity
     2. Incentive mechanisms

**Chapter5. Adapting to climate change: the role of biodiversity and ecosystem**

* 1. Maintaining and restoring native ecosystems
  2. Invasive species management
  3. Landscape connectivity
  4. Adaptation in agricultural landscapes
  5. **A**daptation in water areas
  6. Reducing vulnerability
  7. Adopting indigenous knowledge to adapt to climate change

**Chapter 6. Biodiversity and ecosystem management under a changing climate**

* 1. Management principles
  2. Conservation strategies and tools
     1. Protected area networks
     2. Off-reserve conservation
     3. Managing threatening processes
     4. Recovery planning for threatened species and ecological communities
     5. Restoring ecosystems
  3. Copping with ecological complexity
  4. Policy and institutional landscape
  5. A platform for adaptation to climate change
  6. Challenges and opportunities

**Assessment:** Assignments**,** presentations, quizzes, projects and practical works, final exam

**References**

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**Emerging Frontiers to be Covered by Seminars**

There are two categories of seminar (Seminar I and II). Students will take PhD Seminar in CSA and BDC Iin the first semester and PhD Seminar in CSA and BDC II in the second semester. Students *can* choose seminar topics for CSA and BDC I from the descriptions provided. However, it is a *must* for a student to derive a seminar topic for CSA and BDC II from the descriptions given hereunder.

**1. Crops**

**Issues for seminar topics**

The seminar is intended to give insights into recent changes in plant pathogens and insect pests and the evolution of selected pathosystems and insect pests of cereal grains, grain legumes, oil crops, bulb, tuber and root crops, and vegetable and fruit crops through exhaustive literature reviewin the context of climate change. It lays emphasis on coincidence of host plant, pathogen/pest, human, time factors, and favorable environment as causes for diseases/pests and yield losses; contribution of changing weather patterns and cropping systems, abiotic and biotic components and their interaction influencing potential epidemics/outbreaks. The role of temperature and humidity as key factors influencing plant phenology, survival and multiplication rates of microorganisms and insect pests, leading to epidemics. Threats from new trans-boundary insect pests and plant diseases in the contemporary globalization accompanying the incidence/evolution of pathogens and insect pests, leading to new outbreaks; effects of climate change as a strong driver of evolutionary change on disease cycle components (survival, infection, colonization processes and latency period, production and dispersal of inoculum) and insect life cycle; extraordinary climatic events and trends in temperature, selecting pathogens/insects and their natural enemies towards new critical thresholds for inoculum/insect survival; effects of climate change on pathogen/insect pest populations by interfering with host-pathogen/insect interactions, gene expression and population dynamics. Disease/insect pest monitoring/surveillance and identifying the parameters affecting pest outbreaks and epidemic risk assessment; strategies to prevent the negative effects of pests and diseases, with special emphasis on stringent quarantine regulations, adopting cropping systems thatfavour biocontrol or avoidance, resistance breeding, cultural practices and sound phytosanitarymeasures;the value and effectiveness of integrated crop management and sustainable approaches for managing potential new disease and insect pest epidemics.

The seminar is intended for a better comprehension of the theoretical bases of several statistical models and their application for explaining the climatic and genetic causes of genotype x environment (GE) interactions. The main topics cover: effects of increases in mean temperature and climate change on annual crop production and food availability; role of plant breeding in developing more sustainable lines and varieties for less favourable environments to ameliorate extreme climate changes and the accompanying biotic and abiotic stresses. Breeding crop varieties with enhanced tolerance to heat and moisture stresses for long-term adaptation responses to climate changes. Role of multi-environment trials (METs) in breeding crop varieties for general and specific adaptation and yield stability; studying genotype x environment interaction, and predicting the performance of new cultivars in future years and new locations; METs data, including phenotypic measurements of cultivars, climatic data and molecular markers representing genetic data. Significance of appropriate statistical models and analyses in the study of response patterns of genotypes and their molecular marker attributes across different environments under varying climatic changes for developing sustainable and stable cultivars with resistance/tolerance to diverse biotic and abiotic stresses.

**2. Livestock**

**Issues for seminar topics**

This is a seminar prepared and presented by students in which they gather, organize and synthesize information on emerging scenarios of climate change and climate smart livestock production for sustainable development, food security and adaptation and mitigation. It is expected to cover recent developments and achievements, and challenges and constraints on climate resilient livestock production practices and systems. It will cover topics on climate smart (CS) large ruminant production: role of dairy, beef, buffalo, camel for food security under changing climate, early action to scale up best livestock practices and selection for adaptable and productive breeds; CS small ruminant production practices; CS poultry production practices; CS pig production practices; CS micro animal production practices; Water harvesting technologies for livestock consumption and feed production; Pasture land rehabilitation; livestock breed improvement and composite breed development for resource efficiency; manure management (reducing GHG emission, recycling technologies and best practices); and livestock policy support, institutional arrangements.

**3. Soil and Water**

**Issues for seminar topics**

These topics are selected to cover current and cutting edge science and technological information in the areas of soil and water with special emphasis to climate change adaptation, mitigation and resilience as key strategies in climate smart agriculture. Students are expected to write and present seminars in the areas of: Functions of soils in ecosystem services; Relationship between soil quality and human health; gas fluxes between soil and atmosphere in relation to climate change; application of genomics at soil-plant-microbial interface; reaction of soils to extern perturbation from climate change; resilience of soils experiencing degradation; role of soils in the pathway of contaminants, pathogens and emerging diseases; role of soils in hydro-biogeochemical processes; the fate and transport of fluids, nutrient and carbon in soils; new tools and techniques for in situ study of structure, chemistry and biology of soils; application of nano technology in the study of nutrient and water dynamics in soils; technologies of efficient water use and water productivity; technologies for watershed or river basin level soil and water management. Students are also expected to attend seminars offered by local and/or expatriate experienced expertise.

1. **Biodiversity**

**Issues for seminar topics**

A PhD student in Climate-smart Agriculture and Biodiversity Conservation (Sub-specialization in Biodiversity conservation) is expected to give a seminar on advanced topics of current importance, knowledge and modern technologies in biodiversity conservation and ecosystem management in a changing climate or related topics that are not discussed in the program listed below:

**Biodiversity and Conservation:** Topic include level and kinds of biodiversity, natural selection, speciation, physiological, population and community ecology, maintenance of species diversity, conservation, global environmental change, species extinction, threats, demography, principles of conservation science, biodiversity and climate adaptations, impacts of climate change on biodiversity conservation, sustainable development and global warming, classical and new concepts of biodiversity conservation, valuing biodiversity, endangered species and causes of endangerment, habitat protection and captive breeding, agro-biodiversity, ecological informatics and modelling techniques for conservation of biodiversity.

**Conservation genetics:** Main topics include: advances techniques in conservation of biodiversity, genetics and extinction, characterizing and conserving genetic diversity, population genetics concepts and the mechanisms that underlie genetic and phenotypic variation, use of current genomic technologies to study genetic variability, inbreeding and inbreeding depression, fragmentation of populations and gene flow, genetic diversity management, population Viability Analysis (PVA), molecular genetics of forensic science and genetic markers.

**Ecosystem ecology and management:** Topics include: ecosystem science and management, human practices in managing ecosystem, ecological structure, function, and diversity of ecosystem, physical and biological characteristics of ecosystem and their functions, disaster risk management, ecosystem and climate change,ecosystem pollution and degradation, exotic species invasions, land use and ecosystem management trade-offs and consequences, effect of climate change on restoration actions, planning and monitoring ecosystem recovery, and recolonization, revegetation and species re-introductions.

**Human dimensions of conservation science:**The topics to be covered include use of biodiversity and genetic resources, human technology and biodiversity, GMO’s as biodiversity, value of biodiversity, cultures and biodiversity, human wildlife conflicts, dynamics of zoonotic diseases, anthropogenic threats to biodiversity including habitat destruction (e.g. deforestation, fragmentation, impact of extractive industries), over-exploitation, population growth, pollution and encroachment on protected landscapes, impact of conservation interventions on communities (e.g. displacement of communities and livelihoods sources), costs and benefits of biodiversity conservation, and payment for ecosystem services.

**Global perspectives of biodiversity and ecosystem:** Topics include: species distribution patterns, origin, structure, measurement and mapping of biodiversity, global warming and impacts on biodiversity, phylogenetic and geographical patterns in biodiversity, ecosystem responses to environmental change at different scale with emphasis on climate and the carbon, nitrogen, and water cycle and their ecological effects.

**Topics in conservation science, policy and practice:**Topics to be dealt with include: renewable resource policy and governance, history, laws, policies and administrative structure of agencies dealing with renewable natural resources, conservation in the socio-cultural and political context, evaluation of *in-situ* and *ex-situ* conservation approaches, biodiversity conventions, and conservation policies and endangered species act.

**Theoretical ecology:** Models used to explain biological phenomena such as the maintenance of biodiversity, population growth, ecosystem services, eco-evolutionary dynamics, eco-epidemiology, spatial ecology and species extinction.

Students shall select specific topics as stated above and present seminars based on literature reviews so that they are exposed to the methodology of the preparation and presentation of scientific papers.

1. **Quality assurance mechanisms**

The quality of the PhD program will be assured through periodic review of the curriculum to align it with the needs of the employers and participation of the key stakeholders in the evaluation of the program. Internal monitoring of the students’ progress in their coursework, dissertation research and overall program activities by those running the program (instructors and program leaders) helps in improving and maintaining quality. The center will make use of highly qualified instructors from regional and international universities, research institutes and other organizations to teach courses and advise dissertation research jointly as well as provide seminars. Students will have access to advanced and up-to-date research facilities to carryout cutting-edge scientific research that supports the generation of new knowledge, relevant technologies and policy ideas with respect to climate-smart agriculture and biodiversity conservation. To ensure this, the center will admit highly competent and dependable candidates using a rigorous screening procedure. The program will involve its academic staff to carry out tracer study after running the program for some years.

1. **Sustainability of the Program**

Once the center of excellence is established, Haramaya University will actively promote the program and create strategies through which the center generates its own funds. It will continue to attract foreign students to the program where they will pay tuition fees and invite renowned scholars to teach and advise them. Special attention will be given to the regular updating of the curriculum to respond to regional job markets. Creating linkages with other universities through developing joint research projects and involving students in those projects and presentation of research results from these projects at international conferences could serve as a promotional strategy and improve access to financial and human resources. Devising attractive incentivesscheme for the staff teaching in this program may help motivate them establish linkages and initiate such projects.

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