**MSc in Soil Science**

**Course List**

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| **Year-I: Semester-1 Course Title** | **Course Code** | | **Credit Hours** |
| Biometrics for Agricultural Sciences | AGRO-512 | | 3(2+1) |
| Soil Chemistry and Mineralogy | SoSc-511 | | 3(2+1) |
| Soil Microbiology and Biochemistry | SoSc-512 | | 3(2+1) |
| Soil Physics | SoSc-513 | | 3(2+1) |
| Soil Genesis and Classification | SoSc-514 | | 3(2+1) |
| Conservation Agriculture | SoSc-515 | | 2(1+1) |
| Research Methods | SoSc-516 | | 1(1+0) |
| **Total** | | 18 | |

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| **Year-I: Semester-2 Course Title** | | **Course Code** | | | **Credit Hours** | |
| Soil Fertility and Plant Nutrition | | SoSc-521 | | | 3(2+1) | |
| Remote Sensing and GIS\* | | NRM-616 | | | 2(1+1) | |
| Cropping Systems and Agro-forestry | | SoSc-522 | | | 3(2+1) | |
| Land Use Planning and Evaluation\* | | NRM-626 | | | 3(3+0) | |
| Soil and Water Conservation | | SoSc-523 | | | 3(2+1) | |
| Instrumentation and Analytical Techniques | | SoSc-524 | | | 2(0+2) | |
| Graduate Seminar | | SoSc-525 | | | 1(0+1) | |
| **Total** | | | **17** | | | |
| **Year-II: *the whole year* Course Code** | **Course Title** | | | **Cr. Hrs** | |
| SoSc-631 | M.Sc. Thesis Research | | | 6 | |

**Course Description**

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| **Course Code:** | **AGRO-512** |  |
| **Course Title:**  **Objectives:** | **Biometrics for Agricultural Sciences** | **3(2+1)** |

 To make students acquaint with statistical research methods used to solve problems in agriculture and related disciplines.

 To develop capacity for designing, handling of experiment, data collection and interpretation.

**Theory**

Review of descriptive statistics and basic inference. Overview of sampling concepts: simple random sampling and proportional sampling and sample size determination. Principles of experimental design: randomization, replication, error control. Modeling: translating study designs into statistical models considering both treatment and blocking structure; assumptions underlying a model; approaches to model fitting; correct handling of continuous and factor explanatory variables; data analysis, presentation and interpretation of coefficients and model output; Techniques for generalized linear models. Principles of survey and questionnaire design. Use of MS Excel, SPSS, Genstat and SAS and other software used in experimental design and data analysis.

**Practical**

Lay-out of experiments. Preparation of analysis of variance table. Use of different tests of significance. Separation of means. Data analysis and interpretation of factorial experiments. Reporting results of experiments. Computation of linear regression and correlations. Transformation of experimental data and use of statistical packages for data analysis.

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| **Course Code:** | **SoSc-511** |  |
| **Cou rse Title:** | **S oil Ch emistry and Min eralogy** | **3(2+1)** |
| **Ob jectives :** |  |  |

 To understand chemical principles, ion ex change, retention and chemical remediation.

 To understand the origi n and formation of different soil minerals and their role in agriculture and environment.

**Con ten t**

Chemical principles; Water and solute interactions; Soil solution-solid interaction; Mineral dissolution: Congruent and incongruent; Neo-formation of minerals in soil; Thermodynamics and applications in soil Organic matter: Composition and fractionation; Surface chemistry of soil matrix; Sorption and desorption: Chemical, physical and specific Langmuir, Freundlich and Vanselow models; Cation exchange: Selectivity coefficients, equivalent fraction concept; Hysteresis in ion exchange Anion exclusion; Molecular retention: Specific and non-specific Reactions of metal chelates in soils; Chemical behavior of ions / elements in aerated and submerged soils; Buffering reactions in soil Chemical remediation of contaminated soils and water; Concept and significance; Chemical and structural classification of soil minerals; Carbonate, sulphate, sulphide and phosphate minerals; Phyllosilicate, allophane and imogolite in soils; Kaolin, halloysite and serpentine minerals: Structural and morphological characteristics; Micas: Structures, formulae, and weathering; Vermiculite: Structure, composition and properties; Smectites: Structure, composition and properties; Chlorites: Structure, composition and properties; Inter-stratification in layer silicates; Oxides and hydroxide of Al, Fe and Mn; Significance of soil minerals in plant nutrition, engineering, physics and microbiology; Impacts of soil minerals on environment.

**Practical**

Determination of exchangeable ions; Comparison of Freundlich and Langmuir models; Developing titration curves

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| **Course Code:** | **SoSc-512** |  |
| **Cou rse Title:**  **Objectives:** | **S oil Microb iology and Bioch emistry** | **3(2+1)** |

 The objective of this course is to equip the stude nts regarding the microbial behavior in soil and application in agriculture and the environment.

**Con ten t**

Rhizosphere: plant-microbes and microbe-microbe interactions; Microbial cycling of elements: Macro and micronutrients and heavy metals; agricultural and environmental significance; Biochemistry and biotechnology of BNF; application in agriculture and environment; Mycorrhizal symbiosis; Plant growth regulators, phytotoxins and siderophores: Microbiology and biochemistry; Composting: microbiology and biotechnology; agricultural and environmental application; Bioremediation of contaminated soils: Biodegradation and detoxification; Use of stable isotopes in microbiological research; Metabolic and nucleic acid based analysis of soil microbial diversity; Bio-fertilizers: Present and future prospects.

**Practical**

Isolation of bacteria, actinomycetes and fungi; Enrichment techniques, Sulphate reduction; Organic matter decomposition; Inoculation techniques; Techniques used in N2-fixation.

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| **Course Code:** | **SoSc-513** |  |
| **Course Title:**  **Objectives:** | **S oil Ph ysics** | **3(2+1)** |

 The course is aimed to teach the students regardin g movement of water, air, heat and pollutants in soil and their management.

**Con ten t**

Soil physical properties and inter-relationships; Nature and physical behavior of clay and clay minerals; Properties of water: Molecular, fluid and colligative; Soil water potential and its components; Measurement of water in soil; Water characteristics curves: Hysteresis; Saturated and unsaturated water flow; Infiltration models: Horton, Kostiakov, Green and Ampt, and Philip’s; Flow in capillary tubes: Poiseuilles’ law ; Extended Darcy’s law and its application; Richards equations for transient water flow; Free and artificial drainage: Drainage design equations; Heat flow in soil: Thermal properties; factor affecting; heat flow equations; Transport of gases and water vapors through soil Solute transport in soil; solute conservation equation, convection-dispersion equation; Estimation of crop water requirement; Miscible displacement and breakthrough curves; Transport of inert, non-adsorbing and adsorbing chemicals in soil; Volatile organic compounds transport in soil.

**Practical**

Measurement of soil water, soil strength, particle density, soil water characteristic curves, infiltration rate and saturated hydraulic conductivity; Problem sets

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| **Course Code:** | **SoSc-514** |  |
| **Course Title:**  **Objectives:** | **Soil Genesis and Classification** | **3(2+1)** |

 The course is aimed to comprehend different soil categories and their importance for particular use .

**Con ten t**

Concepts and importance; Introduction to soil taxonomy; Criteria of classification; Properties diagnostic to categories; Diagnostic horizons and other diagnostic properties; Soil moisture regimes: classes and importance; Soil temperature regimes: classes and importance; Categories and nomenclature; Keys to categories: order, suborder, great group and sub group FAO and other systems of classification; Agro ecological zones of Ethiopia; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non- crystalline silicate minerals and their identification; Soil forming Processes (active and passive factors); Factors of soil formation, climatogenic soil, soil formation models, soil forming processes; weathering of rocks and mineral transformations soil profile.

**Practical**

Designation of genetic horizons found in Ethiopia; Identification of taxonomic names: orders, suborders, great groups, subgroups, families and series; Identification of rocks and minerals; Morphological properties of soil profile in different landforms; Classification of soils using soil taxonomy.

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| **Course Code:** | **SoSc-515** |  |
| **Course Title:** | **Conservation Agriculture** | **2(1+1)** |

**Content**

Sustainable agriculture, Africa’s agricultural performance, agriculture and poverty eradication, agriculture and environmental services; introduction to conservation agriculture, principles of conservation agriculture, effects of the various aspects of conservation agriculture, main practices involved, advantages and limitations of conservation agriculture; importance of soil cover in conservation agriculture, benefits of soil cover, effects on soil erosion, effects on soil fertility and structure, soil cover options, types of soil cover, legume cover crops, establishment and management of cover crops; land degradation, categories of soil degradation, soils and sustainable agricultural productivity, soil organic matter, soil organisms, functions of soil organisms and soil organic matter and factors influencing soil organic matter; various categories of conservation agriculture equipment, types of equipment, utilization and maintenance, seed and fertilizer/manure placement and distribution, calibration; general crop management considerations in the application of conservation agriculture: general agronomic principles in crop husbandry, crop pest and diseases and mitigation options, soil fertility, soil mineral deficiency and means of correction, calculation of gross margin and gross margin analysis; Drip irrigation in the context of conservation: introduction to drip irrigation, importance of drip irrigation, principles of drip irrigation, design of simple drip

irrigation, advantages and disadvantages of drip irrigation and system management.

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| **Course Code:** | **SoSc-516** |  |
| **Course Title:**  **Objectives:** | **Research Methods** | **1(0+1)** |

 To provide guidelines for research methodology, develop and improve skills in scientific writing.

 To improve students’ communication and presentation skills.

The students will be assigned topics in different areas of soil science. They will deliver a seminar which will be evaluated by a committee constituted by the department.

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| **Course Code:** | **SoSc-521** |  |
| **Cou rse Title:**  **Objectives:** | **S oil Fertility and Plan t Nu trition** | **3(2+1)** |

 The objective of this course is to comprehend the nutrients behavior and management in soil.

**Con ten t**

Basic soil-plant-relationship in plant nutrition; Macro and micro nutrients: chemical behavior and management; Nutrient behavior in submerged soils; Soil fertility evaluation: soil test calibration and plant analysis; External and internal nutrient requirements; Fertilizer management strategies: nutrient availability and fertilizer use efficiency; Fertigation and foliar fertilization; Integrated plant nutrient management (IPNM); Variable rate fertilizer technology; Nutrient-water and other interactions; Specific effects of fertilizers: plant, human and animal health; Environmental implications of fertilizer use.

**Practical**

Soil and Plant analysis; Interpretation of soil and plant analysis results; Deficiency Symptoms of macronutrients

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| **Course Code:** | **NRM-616** |  |
| **Course Title:** | **Remote Sensing and GIS** | **2(1+1)** |

**Content**

Advanced RS sensors and satellites, hyperspectral remote sensing, soft copy photogrammetry, thermal remote sensing: thermal inertia, LST and SST, RADAR interferometry, Knowledge-based classifiers, object oriented classification, Open source GIS, mobile and cloud-based GIS; Landscape elements, typology of patches and corridors, landscape dynamics, fragmentation, disturbance, spatial statistics, natural resources management; Sea Surface Temperature (SST), fisheries forecasting, coastal zone management, pollution monitoring; Forest fires, desertification, floods, soil erosion modeling, river pollution, earthquakes, tsunamis, cyclones, landslide hazard zonation, disaster management and risk modeling; Surface water monitoring and water quality assessment; Urban land use, urban green spaces, facility mapping, site selection for solid waste management,

sewage treatment site selection; Accuracy assessment: Classification, positional and spatial, contingency tables, kappa coefficient and accuracies; Project Formulation and Execution: Objective definition, satellite data selection, thematic map(s) preparation, integration of RS, GIS and GPS, spatial and non-spatial database standards, spatial database creation, errors in geospatial data, information systems; Case studies and future predictions: cases, drones, future possibilities,

integrating remote sensing into other technology.

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| **Course Code:** | **SoSc-522** |  |
| **Course Title:**  **Objectives:** | **Cropping Systems and Agroforestry** | **3 (2+1)** |

 To acquaint the students about prevailing cropping systems in the country and practices to improve their productivity.

 To gain insights on the concept of agroforestry as a sustainable land use activity.

 Agroforestry intervention methods including diagnosis & design methodologies.

**Content**

Cropping systems: definition and its importance; physical resources, complementary and competitive interaction. Effect of preceding crops and associated crops. Indices of evaluation for cropping systems. Agronomic requirements in management of cropping system. Role of integrated farming system in sustainable agriculture, cropping patterns in different ecological zones, factors affecting cropping pattern. Production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, mechanism of yield advantage in intercropping systems. Above and below ground interactions and allelopathic effects; Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system. Plant ideotypes for drylands.

Land use systems related to agroforestry- classification of agroforestry; Principles of species selection for agroforestry- criteria for species selection- indigenous vs. exotic- intraspecific variations- crown architecture of tropical trees- ideotype- criteria for selection of multipurpose trees. Multipurpose tree species- case studies for different Agroforestry systems – N fixing trees; Role of trees in soil productivity and conservation– micro-site enrichment- litter and fine root

dynamics, N fixation and nutrient pumping. Soil productivity and management in agroforestry for sustained yields; Economic aspects of agroforestry; Diagnosis and Design of agroforestry systems and practices– methodology- Trends in Agroforestry systems research and development; Climate change and Kyoto Protocol- Role of Agroforestry in mitigating climate changecarbon trading- REDD- C sequestration potential of common trees.

**Practical**

Survey and analysis of land use systems in the adjoining areas. Diagnosis and Design exercise for the selection and refinement of relevant agroforestry systems and practices.Visit to successful

agroforestry system models and study their functional dynamics.

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| **Course Code:** | **NRM-626** |  |
| **Course Title:** | **Land Use Planning and Evaluation** | **3(3+0)** |

**Content**

Basic concepts and principles defined in the FAO Land Evaluation Framework, land characteristics and land qualities: the data sources and their interpretation; land classification methods designed for agriculture, grazing, forestry, engineering and taxation purposes; qualitative and semiquantitative land evaluation tools: qualitative tools include the fertility capability classification and land suitability classifications for rainfed and irrigated agriculture, conversion of these qualitative, physical land classifications into yield data allows; concepts in productivity estimation and crop growth modeling, its application and a semi-quantitative crop growth model; advanced applications of land evaluation science such as population supporting capacity estimations, fuzzy logic applications, and soil quality assessments; Soil and landform; Kinds and levels of soil survey; Aerial photographs and their interpretation; Stereoscopic vision theory; Field traverse selection; Purposes, characteristics and identification of mapping units; Mapping legend, mapping and taxonomic units; Interpretation and use of soil survey reports; Land capability and suitability classification; Application of GIS, GPS, and remote sensing in soil survey.

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| **Course Code:** | **SoSc-523** |  |
| **Course Title:** | **Soil and Water Conservation** | **3(2+1)** |

**Content**

The soil resource, water resources, historic perspective of erosion; Erosion by Water: Types of erosion, processes, rainfall erosivity, runoff erosivity, soil erodibility, models for estimating losses i. USLE, ii. Revised USLE iii. Water Erosion Prediction Project; Water erosion control in cropland, i. Soil management and cropping systems, ii. Structural controls; Erosion by Wind: a. Processes b. Factors c. Wind erosivity d. Soil erodibility e. Models for estimating losses: i. Wind erosion equation ii. Revised wind erosion equation iii. Wind erosion prediction systems f. Erosion control in cropland: i. Windbreaks ii. Crop residues iii. Conservation tillage; Tillage erosion; Erosion in range and pasture Systems: a. Rangelands vs. pastures b. Degradation of grazing lands c. Impact of grazing on soil properties d. Grazing systems e. Conversion of cropland to and from pasture; Restoration of degraded soils: a. Saline and Sodic Soils: i. Causes ii. Remediation b. Mined Soils; Dryland soil water management: a. Water cycle b. Water conservation c. Water drainage

**Practical**

• Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index

• Computation of kinetic energy of falling rain drops

• Computation of rainfall erosivity index (EI30) using rain gauge data

• Visits to a watersheds

**Course Code: SoSc-524**

**Cou rse Title: Instrumen tation and An alytical Techn iq u es 2(0+2) Objective:**

 The objective of this course is to equip the students with the principle, theor y and operation of the specializ ed instruments used for soil and plant anal yses.

**Con ten t**

Laboratory management and sample handling; Use of basic laboratory equipments: furnace, oven, desiccators, balance etc; Specialized instruments: principle, theory and operation; Spectrophotometer: UV, visible and IR; Flame photometer; Atomic absorption spectrophotometer; Inductively coupled plasma meter and direct current plasma meter Chromatography: paper, thin layer, gas and HPLC; Microscopy: scanning and transmission; X-ray diffractometry and electron

probe micro-analysis ; Mass spectrophotometry; Electro Ultra Filtration; Ion meter: selective ion electrodes; EM-38 and EC probe; Neutron moisture probe/time domain reflectrometery (TDR); Oxygen diffusion rate meter; Thermocycler PCR (polymerase chain reaction); Gel electrophoresis

apparatus; Applications: data analysis and management.

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| **Course Code:** | **SoSc-525** |  |
| **Course Title:**  **Objectives:** | **Graduate Seminar** | **1(0+1)** |

 To provide guidelines for research methodology, develop and improve skills in scientific writing.

 To improve students’ communication and presentation skills.

The students will be assigned topics in different areas of soil science. They will deliver a seminar which will be evaluated by a committee constituted by the department.