BUSITEMA UNIVERSITY
Pursuing Excellence

FACULTY OF AGRICULTURE AND ANIMAL SCIENCE
DEPARTMENT OF CROP PRODUCTION AND MANAGEMENT

Proposed curriculum for

Master of Science in Global Change and Sustainable Agriculture (GSA)

February 2022

EXECUTIVE SUMMARY

The Sustainable Development Goals (SDGs), number 1 and 2, have everything to do with agriculture: poverty and hunger have to be halved by 2030. Projections for 2030 have shown hungrier people in Africa than in the early 1990s. Hundreds of millions of children are expected to be born over that period of time, and many of them may become new members of the hunger force. Today, tropical agriculture has been interpreted as food insecurity and hunger driven by land degradation, climate change and population pressure on land. This calls for sustainable land and water resources management to avert the negative trend in the tropics. Tens of millions of lives can be saved from hunger. Practical scientific solutions exist. Agriculture based on area expansion is always detrimental and cannot be designated sustainable unless the forgone ecosystem services are accounted for somehow. Sustainable agricultural development remains an elusive goal and incompletely understood concept by the current generation of agricultural scientists, particularly in many of the world's poorest regions where adoption is low. Low agricultural productivity continues to be a key factor in unsustainable production systems, despite decades of research on soil conservation, breeding and other sustainable practices. The challenge facing University training, researchers and policy analysts is to understand the processes causing low agricultural productivity and how to design mechanisms or a combination of technologies and practices that will provide farmers in developing countries with the economic incentives needed to adopt more sustainable land use and management practices. Many practising African agricultural scientists today have been trained in a single discipline approach, such as soil science, crop science, animal science or food science, and therefore lack a multi-disciplinary approach to address the problem of low agricultural, food insecurity and sustainable development intertwined in the moving target of hunger and increasing population. A graduate program in Global Change and Sustainable Agriculture (GSA) seeks to address the always incomplete concept of sustainable agriculture by generating a critical mass of world-class scientists that have practical intellectual and leadership capacity to offer solutions to the challenges of low agricultural productivity (including people, plants, animals, soil, water, and other resources), environmental health and poverty in the developing world. The programme focus is aligned with vision 2040 and NDPIII. Vision 2040 stresses Science, Technology, Engineering and Innovation (STEI) and industrialization. The NDPIII has its vision as “A Transformed Ugandan Society from a Peasant to a Modern and Prosperous Country within 30 years”. The program duration is two years comprising of two semesters of taught courses, followed by two semesters devoted to research work leading to a thesis. Students gain knowledge and experience in diverse discipline areas and holistic approaches necessary to understand and develop sustainable agriculture to support rural development, alleviate poverty and reach food security, especially in the developing world. The program focuses on multi-disciplinary teaching and research into five major systems: land, water, agriculture, climate and human dimension (society and economic development). The degree program focuses on investigating the internal operational challenges of these systems and the dynamics of their interaction at multiple scales to produce food. Solutions are proposed for their sustainable deployment, focusing on the conservation of; soil resources, biodiversity, and water, in the frame of combating land degradation and climate change. Experiments, participatory research, statistics and mathematical models are the primary investigative tool in our teaching and research to bridge natural and social sciences. The training also prepares one to be a hardworking, dedicated and self-reliant individual with the ability to work with diverse groups of people. In addition, the program cultivates written and verbal communication skills, which enable one to be self-motivated and fit in all walks of life.

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1.0 INTRODUCTION

1.1 PROGRAM BACKGROUND

Food production needs to grow by 70% to feed the growing world population by 2050. In terms of native soil fertility, tropical agricultural systems are simply less endowed than Europe. The major European agricultural soils have at least twice as much soil organic carbon and near-neutral soils as opposed to the acid soils of Africa. This has nothing to do with colonial history but unfavourable climate and geology. Decomposition of biomass is a rapid process in consistently warm temperatures, leaving little time for the accumulation of humus. Africa is the world's oldest land mass. The time of soil formation may range from very recent on alluvial plains or volcanic deposits to very old on stable geomorphic surfaces. Soils are intensively weathered and often derived from Precambrian rocks. As a result, extensive layers of deep fertile topsoil are rare in Africa. Nutrient-impoverished granites, basement sediments and sands cover about 90% of the African land surface. Other key components of many unsustainable agricultural systems include: degradation of soils through loss of soil organic matter and soil nutrients, high rainfall variability, climate change, drought, increasing pest and disease incidences, poor post-harvest handling and lack of value addition, marketing infrastructure, weak integration crop-livestock systems, land fragmentation and weak agricultural advisory services.

Low agricultural productivity continues to be a key factor in unsustainable agricultural production systems in developing countries, despite decades of research on soil conservation, breeding and other sustainable practices. There is a perception that everything is fine when agriculture is sustainable, even for generations to come. However, that is too simplistic because agriculture competes with other land uses in terms of space and ecosystem services. Sustainable agriculture for two billion people is not the same as sustainable agriculture for ten billion people, making it difficult. These days, too many people talking about tropical agriculture mean food insecurity and hunger driven by land degradation, climate change and population pressure on land. This calls for sustainable land and water resources management to avert the negative trend in the tropics. Tens of millions of lives can be saved. Practical solutions exist. Agriculture based on area expansion is always detrimental and cannot be designated sustainable unless the forgone ecosystem services are accounted for somehow. Intensification is strongly preferred as long as fertilisers are targeted at soil, climate, and plant interface. However, Sub-Saharan Africa has an average rate of around 10 kg of nutrients per ha, against a developing country's average of around 100 kg/ha. That is a full order of magnitude. Options enabling greater efficiency in different parts of the food chain are required. These can relate to the efficiency of water and nutrient use and the productivity of crops and animals and post-harvest storage and processing, the preparation of foods for consumption, and waste management. Scaling up sustainable agriculture is a different ballgame. Why? Because when going from the village to the province, to the river basin and the country, we come across major differences in ethnic and cultural identity, population and livestock density, cropping systems, soil and water quality, seed systems, land tenure systems, distances to markets, road networks.

A high proportion of the population in Uganda and other developing countries are still largely dependent on subsistence agriculture, a majority of whom are rural women and youth due to: (i)

low agricultural production and productivity; (ii) poor storage infrastructure; (iii) poor market access and low competitiveness for products in domestic, regional, continental and international markets; (iv) low-value addition; (v) limited access to agricultural financial services and critical inputs; and (vi) poor coordination and inefficient institutions for planning and implementation of agro-industrialization. The Sustainable Development Goals (SDGs), number 1 and 2, have everything to do with agriculture: poverty and hunger have to be halved by 2030. Hunger is particularly a problem in Africa, with projections for 2030 showing hungrier people than in the early 1990s. However, one should not forget that hundreds of millions of children are born over such a period of time, and many of them become new members of the hunger force. So, SDGs 1 and 2 are addressing a moving target. National governments and global development community are seeking new approaches to food and fibre production that maintain the quality of the environment and the health and well-being of the consumers, producers, and rural communities, now and in the future. The major barrier to operationalising international conventions, laws, and policies is the lack of qualified interdisciplinary/ multi-disciplinary critical mass of scientists to interpret, lead, and implement them and customise them to suit various circumstances.

The university's vision is to be "*a centre of academic and professional excellence in science, technology and innovation*", whereas the mission is "*to provide inclusive high standard Training, quality research and outreach for industrialization and sustainable development*." The proposed program is in line with the vision and mission as well as the University's Strategic Plan (2020/21 — 2024/25). Under objective 2: Increasing High Impact Research, Innovation and Entrepreneurship, the university will "increase the number of graduate programs and strengthen their relevance and quality." The proposed program is geared towards adding impetus to NDP III Agro-Industrialization objective of increasing commercialization and competitiveness of agricultural production and agro-processing. The programme focus is aligned with vision 2040, which stresses Science, Technology, Engineering and Innovation (STEI) and industrialization. Hence leading to the sustainable development of communities and the country as a whole by contributing to increased agricultural sector growth; reduction in the percentage of households dependent on subsistence agriculture as a main source of livelihood; and increasing the proportion of food secure households.

1.2 JUSTIFICATION OF THE MASTER OF SCIENCE PROGRAM

The proposed Master's in Global Change and Sustainable Agriculture will constitute a multidisciplinary program that brings together various specialities to provide knowledge and skills required for addressing complex problems in Agricultural development. There is an increasing demand for professionals capable of articulating and implementing more sustainable agriculture in the face of global change and unproductive low-input/low-output farming systems in developing countries to enhance a sustainable development agenda. Busitema University's considered view is that crop of the currently trained agriculturalists has skills gaps in grasping the science-policy-practice interface of agricultural and economic development issues. Many professionals working in the government sector, NGOs, and the private sector were trained in traditional specialities and therefore have limited or no interdisciplinary/ multidisciplinary competencies required for handling agricultural transformation development, which is critical for the country's sustainable development programs. These agricultural professionals were trained in a single agricultural approach such as soil science, crop science, animal science or food science and therefore lacked a multi-disciplinary approach to address the problem of low agricultural food insecurity and sustainable development. They are well placed to deal with agricultural extension objectives only but are ill-equipped to provide technical leadership and understanding the factors and processes

causing low agricultural productivity or the use of unsustainable agricultural production practices. They cannot design mechanisms that will provide farmers in developing countries with the economic incentives needed to adopt more sustainable land use and management practices in the face of global change challenges facing agricultural development. This is why subsistence agriculture dominates over 90% of the farming community in developing countries. Subsistence agriculture does not make money, does not make farmers rich but keeps them food insecure and poor. This deficiency was well highlighted during I@mak.com feasibility studies (Adipala *e/ al.,* 2001; Gombya-Sembajjwe *et al.,* 2001). Therefore, the proposed program responds to client demand and is in line with the government's policies of decentralization, parish development model, and poverty eradication that aim to improve incomes and quality of life for rural communities, improve household food security, and provide the provision of gainful employment. The emerging rural development issues call for well-rounded rural development researchers and practitioners. These practitioners must have communication and negotiation skills at the local, national, and international levels. They must also have the skills to actively participate in cross-sectoral/multidisciplinary activities and implement and monitor development programs. National policies like decentralization and the parish development model have also created new challenges that the University needs to respond to. Therefore a graduate degree program is required that will produce graduates with an integrated multi-disciplinary thinking and approach to agricultural development. The philosophy of the proposed program is to develop high quality and sustainable training strategies that will produce grassroots practitioners and leaders who are prepared to address agricultural development challenges. Uganda's agricultural industry needs a generation of creative minds with the necessary scientific interdisciplinary/ multi-disciplinary background to understand the science behind modern sustainable agricultural development in the face of global change.

Currently, there is no institution where such training is offered in Uganda or anywhere in the Eastern African region. Busitema University's Faculties of Agriculture and Animal Sciences can fill in the training gap based on qualified staff, training facilities, and relevant experience in teaching, research, and community outreach. The Master of Science in Global change and sustainable agriculture (MSc. GSA) is tailor-made to answer the challenge of elusive goals and incompletely misunderstood concept of sustainable agricultural development by the current generation of agricultural scientists in Uganda and other parts of the world where adoption is low. The graduate program will deliver innovative approaches to increase the capacity of national districts and sub-counties to handle the new roles that have emerged. The course is designed to be interdisciplinary/ multi-disciplinary, combining a wide range of inter-related subjects, reflective of the complexity of sustainable agricultural management and emancipation for rural development. Secondly, the course aims to provide a sound understanding of the underpinning theories of the development processes in rural communities, linking these theories to practical applications and examples used in contemporary sustainable agricultural management and rural development. The strategy is viewed as an innovative and more flexible approach to responding to the emerging needs of society in areas of sustainable agriculture and rural-resources development and management in general. The course is intended to offer career development opportunities for fresh students new to agricultural multi-disciplinary studies and provide new skills for existing development practitioners.

1.2.1 Uniqueness and Relevance of the program

In order to harness the expected potential of an abundant labour force and expedite the formation of critical skills to facilitate faster economic development, special programs to train in relevant

skills in emerging industries and technology have been undertaken by the government. The government of Uganda has invested heavily in its education system with a focus on relevant Science, Technology, Engineering and Innovation (STEI) and Research and Development (R&D) to produce regionally and globally competitive human resources as the main driver of economic growth that leads to prosperity. Busitema University has built a modern world-class STEI education system that provides students with first rate education compared to developed and emerging economies. The university was established to provide equitable access to higher STEI anchored education, dissemination of knowledge and advancement of learning and acceleration of the socio-economic transformation of rural communities. Busitema University is guided by a vision of being "*A center of academic and professional excellence in science, technology and innovation*". Based on its motto, *"Pursuing excellence*," the University alumni are trained to excel and make a positive contribution to society's development. The University's mission is "*To provide high standard training, engage in quality research and outreach for socio-economic transformation and sustainable development*. The University faculty of Agricultural and Animal Sciences is a leading centre of agricultural transformation in Uganda and Africa. The GSA graduate is designed to produce agricultural professionals that will bridge the gap between unproductive low-input/low-output farming systems and sustainable agricultural systems. The multi-disciplinary graduate training approach is a step away from the traditional single agricultural discipline training approach such as soil science, crop science, animal science or food science. The single discipline trained scientists are only well placed to deal with agricultural extension objectives but lack comprehensive skills in the science-policy-practice interface and therefore are ill-equipped to provide technical leadership and understanding the factors and processes causing low agricultural productivity or the use of unsustainable agricultural production practices. These professionals cannot design mechanisms that will provide farmers in developing countries with the economic incentives needed to adopt more sustainable land use and management practices in the face of global change challenges facing agricultural development.

Through this program, students gain knowledge and experience in diverse areas and awareness of the necessary holistic approaches to understand and develop sustainable agricultural systems, alleviate poverty, and reach food security, especially in the developing world. Scientific knowledge and skills are provided where the students are able to design market-oriented sustainable agricultural systems that meet the desired demands of end users under various constraints and environments, which eventually leads to increased productivity and acceptability. This is achieved by incorporating interdisciplinary coursework and a hands-on multi-disciplinary research experience in five major systems: agriculture production, land and water quality and quantity, climate change and human dimension. These systems are investigated on how they operate internally and interact at multiple spatial-temporal scales to produce food. Students will deploy experiments, participatory research, statistics and mathematical models as the primary investigative tool in our research to bridge natural and social sciences. Mathematical modelling techniques help explore; food security dynamics, interactions between human-induced environmental change, global climate change, climate variability and the socio-economic impacts on agricultural production. As a result, the program prepares a student to meet employers' needs in addition to being job creators.

1.3 TITLE

The title of the program is: "**Master of Science in Global Change and Sustainable Agriculture** (**GLOSA**)."

1.4 PROGRAM OBJECTIVES AND OUTCOMES

1.4.1 Overall Objective

The overall objective is to generate a new breed of all-rounded sustainable agricultural scientists with practical, intellectual and leadership capacity that can offer solutions to the challenges of low agricultural productivity (including people, plants, animals, soil, water, and other resources), environmental health and poverty in the developing world.

1.4.2 Specific Objectives

The specific objectives of postgraduate training in Global change and Sustainable Agriculture (GLOSA) are to:

1. To produce competent scientists with strong theoretical and analytical skills in sustainable agricultural principles and practices
2. To meet stakeholders' demand for well trained personnel in Sustainable Agriculture
3. To provide students with knowledge and skills to design and manage sustainable agricultural production systems locally and globally.

1.5 LEARNING OUTCOMES OF THE PROGRAM

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

4. Understand, assess and apply sustainable agricultural principles and practices in agricultural research and technological innovations;
5. Comprehend and analyze the complexity of agro-ecosystems, frame problems and ask critical questions in relation to food systems and people's behaviours, the nature of their development challenges and be able to provide solutions;
6. Conduct research and develop technological innovations in global change and sustainable agriculture for increased agricultural productivity and environmental protection;
7. Support community farms towards greater competitiveness and socio-economic sustainability in the agro-ecosystem system and value chain;
8. Use different research methodologies and tools embedding multidisciplinary and interdisciplinary perspectives to design sustainable agricultural systems for increased agricultural productivity and environmental protection.

1.6 PREPARATORY ACTIVITIES

The following preparatory activities were undertaken:

Consultation of stakeholders (Academics at Universities: Makerere University, Kyambogo University, Gulu University, Egerton University, Ndejje University, Uganda National Farmers' Association (UNFA), among others.

Two-day workshop with the stakeholders at Hotel Paradise, Jinja (the minutes of the workshop in appendix)

The curriculum was taken through (i) Department Board, (ii) Faculty of Agriculture and Animal Science Board; Higher Degrees and Research Committee, and (iii) Board of Graduate Studies, Research and Innovations, a committee of the Senate.

1.7 OPPORTUNITIES FOR THE GRADUATES

The Global Change and Sustainable Agriculture graduate program is designed to provide students with an interdisciplinary/ multi-disciplinary sustainable agricultural education emphasizing experiential learning opportunities. Our program builds on a solid foundation of agricultural science while providing courses and professional development opportunities in the biological, chemistry, physics, social, and economic elements of sustainability. In addition to

getting an excellent education, our graduates have the necessary skills and knowledge to apply their interests and experience toward agricultural development practices. There are many possible areas in which graduates can find opportunities which include: Researcher/Instructor/Extension Agent/Farm Advisor/ Extension & Outreach Specialist; Sustainable Agriculture Consultant; Agronomist, agricultural production expert; Sustainable Agriculture Research scientist, Environmental Compliance Officer; Agricultural Law and Policy Experts, Conservation Officer; Sustainable Livestock Production/Ranch and/or Rangeland Manager; Sales, Marketing & Outreach officer; Organic/Sustainable Retail & Support Services (organic fertilizers, seeds, equipment); Organic & Sustainable Certification Services; Agricultural Education/Program Coordinator; Sustainability Coordinator; Agricultural Entrepreneur; International Agricultural Development Advisor, Sustainable and Crop Land Management Consultant, Sustainable Development Advisor, Agricultural and Natural Resources Communications, Food security Analyst/ Advisor, Research Scientists, Disaster Risk Management Expert, Agricultural Loan Officer, Watershed Scientist, Climate Change Adaptation and Mitigation Advisor, Precision Agricultural Specialist, Rural Development Specialist, Agricultural Extension Educator, Food and Agricultural Science Editor, and Natural Resources Conservation Specialist.

2.0 RESOURCES

2.1 HUMAN RESOURCE

Busitema University Faculty of Agriculture and Animal Sciences already has qualified staff with PhDs in BioGeo-Sciences, Agronomy, Soil Science, Crop Science, Natural resource management; Agricultural Economics, Agricultural Extension Education, Rural development. Relevant qualified staff are also available in sister faculties such as; the Faculty of Natural Resource Management, Faculty of Science and Education;Faculty of Health Sciences; Faculty of Management Sciences. The above staff will offer full-time teaching and research services for the program. **See Appendix B.**

2.2 TECHNICAL AND INFRASTRUCTURE FACILITIES

2.2.1 Teaching and learning facilitiesLaboratory facilities

Busitema University Arapai Campus, which will house the program, has two spacious, well-equipped soil and crop science research laboratory and a computer laboratory that serve as the advanced training facilities. These facilities are vital for practical and hands-on teaching and learning and shall be used by students for learning, training, and during their research project works.

Lecture rooms:

The campus also has adequate lecture rooms and spacious lecture halls to support this program.

Modern library and ICT facilities:

Busitema University Arapai campus is equipped with a library with a “state-of-the art” ICT- based library with E-learning facilities, linking together all university campuses.

2.2.2 Research and innovations facilities

Busitema University Arapai Campus has a library computer laboratory with an internet connection. The university farm at Arapai provides hands-on field facilities. Arapai campus has long-term research collaborations with National Agricultural Research Organization (NARO) centers in the region, such as; National Semi Arid Resources Research Institute (NaSARRI),

Buginyanya Zonal Agricultural Research and Development Institute (BUZARD), National Agricultural Research Laboratories (NARL-Kawanda), National Crops Resources Research Institute (NaCRRI). Besides, the university also has linkages and partnerships with world-class institutions running similar programs: Makerere University, Uganda; Gulu University, Uganda Martyrs University; Moi University, Kenya; Egerton University, Kenya; Uppsala University of Sweden; Wageningen University and research, Netherlands; Ohio University, USA; Cornell University, USA; Dar es Salaam University, Tanzania.

2.2.3 Outreach and knowledge transfer facilities

Busitema University Arapai campus has established crop, soil and animal clinic centers where farmers bring specimens and seek guidance on case-by-case management. The center will serve as a site for practical testing, modification, and fine-tuning of developed technologies of graduates, leading to entrepreneurship and strengthening the country's capacity in agricultural innovations from the laboratory to the market place.

2.3 PROGRAM FUNDING

The program's main funding source shall be through tuition fees (self or private institutional student sponsorships). **See Appendix A**. Various resources shall also be generated by faculty staff under the program through bankable research and outreach projects, consultancies and donor support, some of which resources will be used to strengthen program facilities and activities.

2.4 Collaborating Institutions

The faculty of Agriculture and Animal Sciences (FAAS) of Busitema University has had strong research, learning and training collaborations with the following institutions: National Agricultural Research Organization (NARO) centers in the region, such as; National Semi Arid Resources Research Institute (NaSARRI), Buginyanya Zonal Agricultural Research and Development Institute (BUZARD), National Agricultural Research Laboratories (NARL-Kawanda), National Crops Resources Research Institute (NaCRRI). Besides, the university also has linkages and partnerships with world-class institutions running similar programs: MAAIF, UNFF, Makerere University, Uganda; Gulu University, Uganda Martyrs University; Moi University, Kenya; Egerton University, Kenya; Uppsala University of Sweden; Wageningen University and research, Netherlands; Ohio University, USA; Cornell University, USA; Dar es Salaam University, Tanzania, Sokoine University, Tanzania, UNFAO, SG2000 (Table 1). The installation of a graduate programme on Global and Sustainable Agriculture strengthens the collaboration and opens up further opportunities to join collaborations in research, learning, training and resource mobilization to support agricultural transformation in the future.

Table 1. Collaborating Institutions

Institutions	***Mandate***
Ministry of Agriculture, Animal Industry and Fisheries (MAAIF)	• Ensuring collaboration with all relevant government and non-government agencies in the sector, • Financing and Participation in the collaborative research Projects, • Supporting technology dissemination and field training, • Directorate of Agricultural Extension Services (DAES) is responsible for the

	coordination of public agricultural advisory and extension services
National Agricultural Research Organisation (NARO)	• Financing and Participation in the collaborative research Projects, • Ensuring dissemination and application of agricultural research results, organising conferences and workshops
Uganda National Farmers Federation (UNFF)	• Young graduate support; • Ensuring dissemination and application of agricultural research results, organising conferences and workshops; • Promote agricultural shows and trade fairs; • Promote commercialization and Industrialization of agriculture innovations;
United Nations Food and Agricultural Organization (UNFAO)	• Financing and technical support through participation in the research Projects and training; • Supporting technology dissemination and field training.
Sakasakawa Global (SG2000)	• Financing and Participation in the collaborative research Projects, • Ensuring dissemination and application of agricultural research results, organising conferences and workshops

3.0 PROGRAM REGULATIONS

3.1 PROGRAM DURATION

The Masters of Science in Global Change and Sustainable Agriculture will be a two-year (four-semester) program by Taught Courses and Dissertation. During the training:
Each student shall take a minimum of EIGHTEEN (18) courses, fourteen (14) of which shall be core courses and any four (4) elective courses of one's choice. In the second year, students will do courses and research in a Global Change and Sustainable Agriculture project, leading to writing a master's thesis. Depending on the student's bachelor's degree background, undergraduate courses may be done for students to fully acquire the knowledge needed to complete the Master of Science degree in Global Change and Sustainable Agriculture. A student will be required to submit a dissertation on an approved topic that carries a minimum of 7 Credit Units in year two. Joint internal and external examination of the Dissertation is mandatory. The Minimum Graduation load for the program is 60 CUs.

3.2 ADMISSION REQUIREMENTS

Although a Biology and Chemistry courses are required at 'O' level, to be eligible to apply for the Master of Science in Global Change and Sustainable Agriculture, the candidate must hold a Bachelor's degree of second class lower division and above from a recognized university in any of the following fields; Soil Science, Crop Science, Animal Science, Horticulture, Food Science, Chemistry, Biology, Physics, Agricultural Extension, Agricultural Engineering, Botany, Plant Biotechnology, Forestry, Ecology, Conservation Biology, Natural Resources, Sociology, Geography, Agribusiness, Economics and Social Sciences.

3.3 TARGET GROUP

The GLOSA program will be multidisciplinary, and students from a wide range of backgrounds and experiences will be admitted to the program. Consideration will be given to field officers and individuals with first degrees in any of the natural sciences and humanities disciplines, and any other relevant university qualifications and other recognized institutions will be admitted for the program

3.3.1. Projected Student numbers

It is proposed that the program starts with 20 students in the 2022/23 academic year, and the number shall be increased gradually to 10 students per intake over a period of 3 years, as shown in Table 1. The increase in student number will take into account infrastructure, human and financial resource capacity to handle the program.

Table 1: Projected student numbers

Activity	2022/23	2023/24	2024/25	2025/26
Student numbers Admitted	20	20	20	20
Cumulative student numbers	20	40	60	80

3.4 ASPECTS OF GENDER AND EQUITY

Uganda is actively promoting gender and equity at all levels because it is a pre-condition for sustainable development. Busitema University has a strong affirmative policy. The current female enrollment at graduate and undergraduate levels at the Faculty of Agriculture and Animal Sciences is about 30%. The program will specifically target female candidates with a view to increasing the percentage to 50% gender divide.

4.0 EXAMINATION REGULATIONS

4.1 GENERAL REGULATIONS

The general Master's degree regulations of Busitema University, as stipulated in the Graduate Studies Handbook, shall apply.

4.2 METHOD OF ASSESSMENT

Assessment will be done through coursework which will include home assignments, classroom and take-home tests, field study trips with trip reports, project work and presentations and written examination. Course work will carry a total of 40%, and written examination or project work presentations carry 60%. The overall pass mark is 60%.

4.3 GRADING OF COURSES

Each course shall be graded out of a maximum of 100% marks and assigned an appropriate letter grade as shown below: To record a pass mark in a course unit, a student must achieve a minimum mark of 60%. The student must also have attended at least 70% of all scheduled classes, practicals and presentations.

Marks %	Point	Letter grade	Grade	Remarks

80-100	A	5.0	Excellent
75-79	B+	4.5	Very good
70-74	B	4.0	Good
65-69	C+	3.5	Fairly good
60-64	C	3.0	Satisfactory
0-59	D	0.0-2.5	Fail

4.4 CALCULATION OF CUMULATIVE GRADE POINT AVERAGE (CGPA)

The Cumulative Grade Point Average at a given time shall be calculated based on using the Equation (1) shown below:

$$GPA = \frac{\sum_{i=1}^{n}(PG_i \times CU_i)}{\sum_{i=1}^{n} CU_i} \quad \text{.....(1)}$$

Where PG_i is the Grade Point score in course, i; CU_i is the number of Credit Units of course, i; and, n is the number of courses taken in that semester or recess term. CGPA is calculated using a formula similar to the one above, but *n* is the number of courses taken from the beginning of the program up to the time when the CGPA is being calculated.

4.5 COURSE RETAKING

I. A student shall retake a Course or Courses when next offered again in order to obtain at least the Pass Mark (60%) if he/she had failed during the first assessment in the course or courses.
II. A student who has not done course work will not be allowed to sit for final examinations
III. A student who has failed to obtain at least the Pass Mark (60%) during the Second Assessment in the same Course or Courses retaken shall receive a warning.
IV. A student may retake a Course or Courses when next offered again in order to improve his/her Pass Grade(s) if the Pass Grade(s) got at the first Assessment in the Course or Courses were low. A student who fails to attain higher marks after retaking to improve, the examination results of the first sitting are recorded on the transcript and shall not be recorded as **Retake**.
V. Where a student misses to sit examinations for justified reasons, his/her results shall be not recorded as **Retake** when the examination(s) is/are next offered.
VI. Attend all the prescribed lectures/ tutorials/ practicals/fieldwork in the Course or Courses;
VII. Satisfy all the requirements for the course-work component in the Course or Courses; and
VIII. Shall sit for the University Examinations in the course or courses.
IX. A student who accumulates more than four (4) Retake Courses will be requested to stay put.
X. Students are required to register for retake course(s) first before registering for new courses offered in that semester and the retake courses should fit into the approved normal load so as to avoid timetable clashes.
XI. A final year student whose final Examination Results have already been approved by the

Graduate Board and has qualified for the Award of the MSc. in Global Change and Sustainable Agriculture (GLOSA) Degree, shall not be permitted to retake any Course(s). When a student has retaken a course the better of the two Grades he/she has obtainedin that course shall be used in the computation of his/her cumulative Grade Average (CGPA).

XII. Whenever a course or courses has/have been retaken, the Academic Transcript shall accordingly indicate so.

XIII. Students shall pay for retake(s) registered for.

4.6 ACADEMIC PROGRESS

At the end of every semester and recess term, students' progress shall be classified into Normal Progress, Probationary Progress, and Discontinuation.

4.6.1. Normal progress

This occurs when a student has passed (Grade point of 3.0) all the courses that he/she has taken so far, since the beginning of the program.

4.6.2 Probationary Progress

A student who has obtained the Grade Point (GP) of less than 3.0 shall be placed on probation. Such a student shall be allowed to progress to the next semester/academic year but shall still retake the course(s) he/she has failed the assessments later on and obtained at least the pass mark (60%) in the course(s).

4.6.3 Discontinuation

When a student accumulates three consecutive probations based on CGPA, he/she shall be discontinued. A student who fails to obtain at least the Pass Mark (60%) during the Third Assessment in the same course or courses retaken shall be discontinued from his/her studies at the University. A student who has overstayed on the program by more than five (5) years shall be discontinued from his/her studies at the University.

4.7 DISSERTATION

Students are required to demonstrate their ability to independently undertake research and analysis. Each student will be required to pursue and complete the dissertation. To pass the dissertation, the candidate shall satisfy the supervisor(s), reviewers and examiners in the written report and project presentation(s).

4.8 REQUIREMENTS FOR THE AWARD OF THE DEGREE

The degree of Master of Science in Global Change and Sustainable Agriculture (GLOSA) shall be awarded to a candidate who obtains 60 credit units, gained from 18 courses and research thesis. Furthermore, the student will have to pass all the courses in a period stipulated by the University Senate and Council.

4.9 CLASSIFICATION OF THE AWARD

The degree of Master of Science in Global Change and Sustainable Agriculture (GLOSA) shall be awarded to a student who fulfils all the requirements for the program. The Master's degree shall not be classified.

4.10 QUALITY ASSURANCE

The quality assurance practices like the other programs in Busitema University in general shall apply. A student will be required to attend at least 70% of the lectures given in a course, do and pass all the coursework assignments, tests and laboratory exercises before he/she can sit for a written examination. Performance of each of the lecturers assigned to teach the students shall also be closely monitored to ensure they comply with the curriculum requirements. This will be partly achieved by giving the students assessment forms to assess their teaching staff on the content taught, mode of delivery, self-explanation, appearance for lectures, tutorials, and practical field study trip sessions.

5.0 PROGRAM STRUCTURE

The graduate program will follow a modular approach to teaching and learning. In order to balance first-class theoretical education with extensive business and industry experience to prepare students for a challenging and diverse career, the program is designed as follows: First year covers the theoretical/lecture (including laboratories), and practical component of the course. The student will develop a research proposal during the first semester of second year, which will have to be defended before the faculty's higher degree committee.

5.1 PROGRAM COURSES

The program courses shall give the students the required skills for problem solving, empower them for critical thinking, and give them the necessary research, leadership, communication, and negotiation capabilities that they need to succeed in their careers. The emphasis of the courses will be on process, innovation and product development.

5.2 SYLLABUS

Table 2. Course breakup

Domain	***Allied Courses***
Global Environmental Change	Global Change, Planetary Boundaries and Sustainability Global food systems and Feeding a Hungry Planet Global Ecosystems and Agroecosystems Climatology and Water cycle Agriculture, food security and international law
Biophysical Farm Environment	Soil Ecology Advanced Soil physics Advanced Soil Chemistry Sustainable Agriculture Advanced Plant Nutrition and Soil Fertility Ecological Organic agriculture, Advanced Land Use Planning and Policy Climate Smart Agriculture Agricultural Entomology and Plant Parasitic Nematodes Crop physiology Plant Pathology Advanced Agronomy Life Cycle Analysis Biogas & Alternative Energy Renewable Energy for agricultural production and value chain management Tropical animal husbandry systems and sustainable food production Postharvest Handling and Value Addition

Society & Economy	Agriculture, Food Policy and International Law, Gender & Development.
Tools and Applications	Research methods and Graduate Seminars Computer Applied Statistics and Biometrics with R and Rmarkdown Spatial statistics with geostatistics, R and QGIS GIS and Remote Sensing in Digital agriculture,
Research	Publications and Thesis

5.3. SKILLS COURSES

Table 3: Hands-on Skills courses in the program.

	Domain	Allied Courses
1	Tools and Applications	Applied Statistics and Biometrics with R and Rmarkdown Spatial statistics with geostatistics, R and QGIS GIS and Remote Sensing in Digital agriculture,
2	General Research Courses	Research methods and Graduate Seminars/ Scholarly Writing Publications and, Thesis

6.0 PROGRAM STRUCTURE AND DETAILED COURSE CONTENT
6.1 PROGRAM STRUCTURE

The MSc. GSA program just like the other programs in Busitema University will be run on semester system. The Table 3-4 below outline the courses and their loading to be offered in the program.

Table 4: First Year Courses

S/N	CODE	COURSE NAME	LH	TH	PH	CH	CU	COMMENT
		YEAR ONE: SEMESTER ONE						
1	MSA 7101	Research methods and Graduate Seminars	30	10	30	45	3	CORE COURSE
2	MSA 7102	Soil Ecology	30	10	30	45	3	CORE COURSE
3	MSA 7103	Advanced Soil physics and Water management	30	10	30	45	3	CORE COURSE
4	MSA 7104	Advanced Soil Chemistry	30	10	30	45	3	CORE COURSE
5	MSA 7105	Sustainable Agriculture	30	10	30	45	3	CORE COURSE
6	MSA 7106	Computer Applied Statistics and Biometrics with R and Rmarkdown	30	10	30	45	3	CORE COURSE
7	MSA 7107	Spatial statistics with geostatistics, R and QGIS	30	10	30	45	3	CORE COURSE
							21	
		YEAR ONE: SEMESTER TWO	LH	TH	PH	CH	C.U	
8	MSA 7201	Advanced Plant nutrition and Soil Fertility	30	10	30	45	3	MANDATORY COURSE
9	MSA 7202	Global Change, Planetary Boundaries and Sustainability	30	10	30	45	3	MANDATORY COURSE
11	MSA 7203	GIS and Remote Sensing in Digital agriculture	30	10	30	45	3	MANDATORY COURSE
12	MSA 7204	Global food systems and Feeding a Hungry Planet	30	10	30	45	3	MANDATORY COURSE
13	MSA 7205	Global Ecosystems And Agroecosystems	30	10	30	45	3	MANDATORY COURSE
14	MSA 7206	Ecological Organic agriculture	30	10	30	45	3	MANDATORY COURSE
							21	

Table 5: Second Year Courses

S/N	CODE	COURSE NAME	LH	TH	PH	CH	CU	COMMENT
		YEAR TWO: SEMESTER ONE						
15	MSA 8101	Advanced Land Use Planning and Policy	30	15	15	45	3	ELECTIVE
16	MSA 8102	Climate Smart Agriculture and green growth	30	15	15	45	3	ELECTIVE
17	MSA 8103	Advanced Agronomy	30	15	15	45	3	ELECTIVE
18	MSA 8104	Climatology and Water cycle	30	15	15	45	3	ELECTIVE
19	MSA 8105	Life Cycle Analysis	30	15	15	45	3	ELECTIVE
20	MPB 8102	Crop physiology	30	15	15	45	3	ELECTIVE
		Sub total					**6**	
		YEAR TWO: SEMESTER TWO	**LH**	**TH**	**PH**	**CH**	**C.Us**	
21	MSA 8201	Agriculture, food security and international law	30	10	30	45	3	ELECTIVE
22	MSA 8202	Tropical animal husbandry systems and sustainable food production	30	10	30	45	3	ELECTIVE
23	MSA 8203	Postharvest Handling and Value Addition	30	10	30	45	3	ELECTIVE
24	MSA 8204	Gender & Development	30	10	30	45	3	ELECTIVE
25	MSA 8205	Biogas & Alternative Farm Energy Systems	30	10	30	45	3	ELECTIVE
26	MPB 8201	Plant pathology	30	10	30	45	3	ELECTIVE
27	MPB 8104	Agricultural entomology and plant parasitic nematodes	30	10	30	45	3	ELECTIVE
		Sub total					**6**	
28	MSA 8206	MSc. THESIS	0	0	630	210	**12**	CORE COURSE
		Grand Total Credit Units (CUs) for MSc.					**66**	

7.0 DETAILED COURSE DESCRIPTION

The program content is implemented in course form where each covers a particular aspect of training. Each unit has a code and credit units attached to indicate its weight. For the master's degree program, the coding shall start with MSA to indicate Master in Global Change and Sustainable Agriculture followed by digit 7 to indicate MSc. This shall be followed by digit 1 to indicate first academic year (01) or 8 to indicate second academic year (8). The third-place digit signifies the semester (1 or 2) (e.g., MSA710 or MSA720 for first year first and second semesters respectively and MSA810 or MSA820 for second year sem 1 and sem 2 respectively). The fourth digit place shows the course number starting from 1 to infinite (7101, 7201, 8101 and 8201) for first- and second-year courses respectively.

7.1 YEAR 1: SEMESTER 1

7.1.1 COURSE NAME: RESEARCH METHODS AND GRADUATE SEMINARS

COURSE CODE: MSA 7101

CREDIT UNITS: 3

COURSE OVERVIEW

Combining research and national development, working for and with rural people, and making a real difference to the future requires special skills and approaches in both planning, data collection, analysis, scientific writing and publication. The course will cover the following topics: 1). The Philosophy of Research (Defining Research, Differentiating Research methods and research methodology, and Research as a way of knowing, Role of research and researchers in development; Concepts and terminologies in research; steps of a research project). 2). Sources and Types of Data (Sources of primary and secondary data, Cross-section and time series data, Sample design and sample size, Methods of data collection, Conducting PRA). 3). Managing Data (Data management, Organizing data, Quality control: Checking and cleaning data, Verification, validation and fabrication, Ethical issues in data management (fabrication, data mining, etc). Documentation of data processing, archiving and data ownership issues, and Use of computer packages as practical lessons for data management, coding and data management skills). 5). Data analysis and interpretation of results (Exploratory data analysis, Quantitative analysis, Qualitative data analysis, Drawing conclusions, Limitations in analysis); presentation and interpretation of results, reproducible research processes;

6a). Writing research proposals and thesis writing (Defining the Research Focus, Research proposals and budgets: main features, Writing Concept notes. Ethical considerations in research, managing for Impact – promoting research findings. Structure and design of Thesis technical reports – citations and bibliography, guidelines for creating concise tables and figures are presented. How to write and publish a scientific article; scientific literature search and analysis, good scientific practice and how to avoid plagiarism. Sources of literature, e-resources, citing/referencing (references *versus* bibliography).

6b). Structure and design of technical reports; students will be taught how to write different scientific text documents such as grant proposals, Writing Policy briefs from technical reports, Editing and critiquing of research papers, and conference abstracts. By reviewing/critiquing and discussing a journal article, and peer-reviewing an abstract of a fellow student by using an online tool, module participants will train how to give and receive constructive feedback. Finally, students will choose a topic for their term paper (see below) to further apply the newly acquired knowledge).

7). Planning and Managing Research for Development (The public goods nature of research, Financing of research, Beneficiaries of research, Planning and coordination of research, New

trends in research and development). 9). The concept of 'Seminar' and role of 'Graduate Seminars' in Graduate Training/Research: preparing and delivering seminar presentation/academic talk effectively to an academic audience; small groups of students preparing and presenting seminar presentations in form of tutorial sessions to peers (who act both as the audience group and evaluators) as well as to Departmental/ Faculty Staff and student community on special academic events such as the Annual Faculty Postgraduate Students' workshop.
8). Visual displays: use of visual aids and related audiovisual equipment in delivering effective presentations: Visual aids defined; Types: Visual aids vs. audio-visual aids. General use of visual aids: purpose. Selecting (audio-)visual aids. Preparing (audio-)visual aids. Application of (audio-) visual aids in formal presentation settings ***(***seminar, symposium, workshop, conference).

COURSE OBJECTIVES

- To provide students' knowledge and skills to understand what is a research problem? Why is it important? How am I proposing to investigate it? Why is this approach appropriate? How is it grounded in the literature, and what does it add to literature? What did I expect to find/learn, i.e., my hypotheses/expectations? What did I actually learn? Why is what I learned important, i.e., what are the implications for further research or for policy?
- To provide students' knowledge and skills to operationalize the above questions in his/her thesis undertaking.

LEARNING OUTCOMES

By the end of the course, the student will:

- Acquire knowledge and skills on essential components of the research process (defining the research focus, formulating questions and hypotheses, research design, data collection, analysis, interpretation and report writing)
- Develop a range of research tools (qualitative and quantitative) relevant for agricultural economists engaged in a variety of research and development efforts
- Appreciate the advantages, limitations and complementarities of different research approaches and methods according to context, purpose of research and type of data required
- Apply qualitative and quantitative data analysis techniques used to organize data into some meaningful form;
- Have acquired skills required in the management and processing of data including commonly used computer packages (for example R, SPSS, STATA, etc.)
- Be able to undertake postgraduate research project for their thesis, and,
- Have acquired an understanding of the role of effective research for development
- Prepare and present effective oral presentations in seminars, workshops, conferences, symposia and other academic fora ; including presentation techniques, preparation of transparencies, slides; selection and use of appropriate audiovisual aids and equipment such as power point, overhead projector etc.
- Moderate discussions during seminars, workshops and conferences
- Evaluate presentations
- Communicate clearly and effectively research outputs to relevant audiences
- Write publishable academic/journal articles/papers following acceptable formats

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

Thematic Plan

Topic	Contact Hours			
	Lecture	**Seminar**	**Practical**	**Sub-total**
1. The Philosophy of Research	4	-	2	**6**
2. Sources and types of data	6	2	2	**10**
3. Managing Data	6	-	3	**9**
4. Data analysis and interpretation	6	-	2	**8**
5. Writing research proposals and reporting	5	-	2	**7**
6. Planning and Managing Research for Development	3	-	2	**5**
Total	**30**	**2**	**13**	**45**

S/N	Topic	Content	CH
1	The Philosophy of Research	• Defining Research • Differentiating Research methods and research methodology • Research as a way of knowing - The logic of Science	4
2	The Philosophy of Research cont...	• How is research used in development work and rural transformation • Role of research and researchers in development • Concepts and terminologies in research	4
3	Sources and Types of Data	• Sources of primary and secondary data • Cross-section and time series data	5
4	Sources and Types of Data cont...	• Sample design and sample size • Methods of data collection • Conducting PRA	5
5	Managing Data	• Data management • Organizing data • Checking and cleaning data	3
6	Managing data cont...	• Verification, validation and fabrication • Ethical issues in data management (fabrication, data mining, etc) First Mid Term	3
7	Managing data cont...	• Documentation of data processing, archiving and data ownership issues • Use of computer packages as practical lessons for data management, • coding and data management skills	3
8	Data analysis and interpretation	• Exploratory data analysis • Quantitative analysis • Qualitative data analysis	4

9	Data analysis and interpretation cont...	• Drawing conclusions • Limitations in analysis Second Mid-Term	4
10	Writing research proposals and reporting	• Defining the Research Focus • Research proposals and budgets: main features	2
11	Writing research proposals and reporting cont...	• Writing Concept notes • Structure and design of technical reports – citations and bibliography	1
12	Writing research proposals and reporting cont...	• Writing Policy briefs from technical reports • Editing and critiquing of research papers	1
13	Writing research proposals and reporting cont...	• Ethical considerations in research • reproducible research processes • Managing for Impact – promoting research findings	1
14	Planning and Managing Research for Development	• The public goods nature of research • Financing of research	3
15	Planning and Managing Research for Development cont..	• Beneficiaries of research • Planning and coordination of research • New trends in research and development	2
16-17		Revision and exams	
	Total		45

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

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2. Research Methodology in Applied Economies: Organising, Planning, and Conducting Economic Research. Don Ethridge 1995. Iowa State University Press/AMES. pp.271
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Agricultural and Forest Sciences University of Wales, Bangor, Gwynedd LL57 2UW
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10. Gopen G.D & Aswan J.A. (1990). The Science of Scientific Writing: Writing with the reader in mind.
11. Colin Price, 2003: The style and presentation of written work; Notes for users

7.1.2 COURSE NAME: SOIL ECOLOGY
COURSE CODE: MSA 7102
CREDIT UNITS: 3

COURSE OVERVIEW

The course will provide students with a comprehensive view of ecological interactions in soils. It deals with the interactions between plants, soil and soil organisms, the roles played by soil organisms in decomposition of organic material, nutrient cycling (C, N, P) and stability of agricultural and natural ecosystems. Other topics include the importance of soil organisms for soil fertility, mycorrhizas and their effects on plant productivity and plant communities, microbial ecology, bioremediation, root growth and the biology of the rhizosphere.

COURSE OBJECTIVES

- To provide students with a comprehensive view of ecological interactions in soils
- To provide students with knowledge and skills required to optimize soil biology and plant nutrient use efficiency, enhance plant productivity, improve sustainability of agricultural systems

LEARNING OUTCOMES

At the end of the course learners should be able to:

- Students will gain experience in methods to evaluate different groups of soil organisms as well as soil processes/properties through demonstrations and hand-on activities.
- Participants in this course will be given an awareness of the importance of nutrient cycling in agricultural and natural ecosystems, the factors affecting nutrient availability and how management will affect nutrient cycling
- Students will acquire practical knowledge about common analyses methods to assess nutrient cycling including microbial activity and N and P availability in soils

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	What is Soil Ecology?	Soil Ecology?	2
2	Rhizosphere	Roots and rhizosphere as microhabitat	4

	Ecology		
3	Soil biodiversity	Abundance, distribution and survival mechanisms of soil Invertebrates communities: Bacteria and Protozoa; Fungi.	2
4	Structures, abundance and distribution	Structures, abundance and distribution of microfauna: Nematodes and earthworm communities and their adaptive strategies.	2
5	Structures, abundance and distribution	Structures, abundance and distribution of macrofauna: arthropod communities and their adaptive strategies. Impact of Soil biodiversity populations on soil environment ranging from soil formation, productivity and health	2
6	Methods of studying soil diversity	Direct; observation and isolation and Indirect; signatures and molecules- molecular techniques (PCR - DGGE, TGGE, SSCP, T-RFLP, Pyrosequencing), biomarkers and PLFA analysis, new microscopic and image analyses. Stable Isotopes in Soil Ecology.	3
7	Soil Ecology Concepts and the functioning of the soil system	Decomposition and SOM dynamics; litter system; rhizosphere processes; cycling of C, N and P. Reactions of plants to excess and deficiency, role of plants, mycorrhizas and soil fauna in C, N and P cycles, soil structure, soil fertility, global change, greenhouse gas emissions.	4
8	Abiotic and biotic interactions	Effects of N deposition, Acid deposition, invasive species. Nitrogen fixation, organisms involved, taxonomy, genetics, strain selection, biochemistry of N_2 fixation, measurement of N_2 fixation, factors affecting the process application in farming systems. Mycorrhizal associations; types, significance, potential and limitations.	4
9	Applications in Soil Ecology …..	Soil biodiversity and industry; fertilizer or soil amendments, food and beverages, medicines and bio-1control agents, pesticides, plant growth promoting hormones.	3
10	Applications in Soil Ecology …..	Biotechnology and applications of beneficial soil organisms for sustained agroecosystems; rhizobia and mycorrhizal inoculants; plant growth promoting products; Bioremediation techniques (concept, importance, applications and limitations); pharmaceuticals; bioinformatics and biosafety; fate of genetically engineered organisms.	4
11	Applications in Soil Ecology …..	Promotion and control of beneficial (symbionts) and detrimental (parasites, predators, pathogens): Rhizosphere symbionts of plants; Mycorrhizal fungi and PGPR. Deleterious organisms to plants; Soilborne plant pathogens, biocontrol, mechanisms, applications and disease suppressive soils.	3
12	Applications in Soil Ecology …..	Deleterious organisms to humans; Pathogens from manure.	4
13	Applications in Soil Ecology …..	Relying on soil organisms in low input and organic management systems: Science of composting; Biological indicators of soil health. Optimize plant nutrient use efficiency, enhance plant	4

		productivity, improve sustainability of agricultural systems, increase soil carbon sequestration, or mitigate and adapt to climate change.	
14	Tools and technologies	Tools and technologies to assess and interpret soil health with the goal of enhancing the adoption of soil health biological assessments and best practices in managed plant systems.	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

1. Coleman, D.C., Callaham, M.A. Jr., and Crossley, D.A. (2018) Fundamentals of Soil Ecology, 3rd Edition, Academic Press.
2. Orgiazzi, A., Bardgett, R.D., Barrios, E. et al. (2016) Global Soil Biodiversity Atlas, European Commission, Publications office of the European Union

7.1.3 COURSE NAME: ADVANCED SOIL PHYSICS AND WATER MANAGEMENT
COURSE CODE: MSA 7103
CREDIT UNITS: 3

COURSE OVERVIEW

This course is designed to introduce students to the fundamental properties and processes of soil and water that affect food security and sustain ecosystems. Soils constitute a central link between air, ground and surface water, and living organisms and are thus crucial to ecosystem functioning. This basic course aims at providing profound knowledge on and insights in physical properties and processes of and in soil, and how to measure and model them, applying physical and mathematical laws. Soil-water relationships are central to the course. A profound understanding of soil physical properties and processes is essential in studies on water and chemical transport in soils, irrigation and drainage, biomass production, trafficability, soil erosion, soil compaction and ecosystem functioning, among others.

COURSE OVERVIEW

- To introduce students to the fundamental properties and processes of soil and water that affect food security and sustain ecosystems.
- To provide students with profound knowledge on and insights in physical properties and processes of and in soil, and how to measure and model them, applying physical and mathematical laws

COURSE OBJECTIVES

At the end of this unit you will be able to:

- Articulate and quantify the factors and processes that determine the composition and

behaviour of soil, composition of water, soil water storage and the movement of water on the land surface;

- describe the most important properties of soil and water for food production and sustaining ecosystem functions and link this to human and climatic factors;
- Apply standard lab and field methods to determine hydrophysical properties of soil; Use soil-moisture sensors and tensiometers to measure soil-moisture status; Explain the principles behind lab and field methods, and instrumentation for monitoring soil-moisture status;
- Analyse simple to more complex water transport processes in soil;
- Evaluate physical quality of soils;
- Apply parameter estimation methods to determine soil hydraulic properties;
- Apply numerical models to predict changes in water content and matric potential with time;
- Explain hydrophysical and soil mechanical properties of soil;
- Explain the principles behind water and chemical transport in soil;
- Present and discuss research results to peers

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Soil solid phase	Composite soil properties, Soil structure	2
2	Water retention in soils	Properties of water related to porous media, Soil-water content/ water storage,	3
3	Energy status of water in soil	Energy status of water in soil.	4
4	Energy status of water in soil …	Water retention curve	3
5	Water movement in soil	Infiltration and Infiltration models,	3
6	Water movement in soil …	Water flow in capillary tubes, Water flow in saturated soil,	4
7	Water movement in soil …	Water flow in unsaturated soil	4
8	Chemical transport in soil	Conservation and flux equations, Convection-dispersion equation.	4
9	Lab and field work	Sample soil and measure soil physical and hydraulic properties from fields with different land use.	3
10	Lab and field work …..	Field measurement of water content and matric potential is measured.	3
11	Lab and field work …..	Data are used to assess the effect of land use on soil health using soil physical quality indicators.	3
12	Lab and field work …..	Laboratory/computer exercises and report are designed to develop communication, team work and collaborative efforts.	3
13	Soil & Water management	Rain fed agriculture, Why Soil & Water conservation? Soil erosion, Soil & Water conservation practices, Mechanism of crop adaptation under moisture deficit condition, water harvesting practices	3

14	Irrigation and drainage practices	Calculating water requirements, Irrigation and drainage practices	3
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

1. Analysis of Soil Physical Properties by Majumda and R. A Singh
2. Introduction to Soil biophysics by Daniel Hillel

7.1.4 COURSE NAME: ADVANCED SOIL CHEMISTRY

COURSE CODE: MSA 7104
CREDIT UNITS: 3

COURSE OVERVIEW

This course aims to provide students with the chemical aspects of soil that are of importance in understanding its functioning, management and use of soil. Along the trajectory, relevant chemical methods of soil analysis are studied.

COURSE OVERVIEW

i) To provide students with the chemical aspects of soil that are of importance in understanding its functioning, management and use
ii) To introduce students to chemical methods of soil analysis, interpretation, recommendations and reporting

COURSE OBJECTIVES

- Understand the chemical properties of soils
- Understand chemical principles underlaying analytical approaches
- Evaluate the suitability of analytical approaches for characterizing soil properties
- Interpret analytical results of soil analysis

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Soil composition	SI units; Soil particle formation through weathering	2
2	Soil composition …	Types of clay, their structure and formation processes	2
3	Soil composition …	Types, origins and significance of the negative charge	2
4	Soil composition …	Soil organic matter (SOM) types; Charges on soil OM	3
5	Soil composition …	Importance of SOM in tropical sesquioxides based soils	2
6	Soil solution phase	Characteristics; chemistry of water as a solvent; review of colligative properties of water in solutions	3
7	Ionic concentration, activity and reactions	Ionic concentration versus activity; Activity coefficients; Ionic strength; Standard state of a substance;	3
8		Types of reactions in soil and their equilibria constants	4
9	Surface charge	Double layer theory (Double diffuse layer, DDL) and factors that affect DDL	4
10	Adsorption/desorption phenomena and exchange reactions	Adsorption and desorption; Isotherm models; Phosphorus sorption and desorption isothernms; Exchange reactions and equilibria state computations; Cation and anion exchange reactions	4
11	Acidity and alkalinity and management	Significance and instrumentation for measurement of soil pH; Types and causes of acidity; management of acidity (e.g. by liming and acid tolerant crop varieties)	4
12		Significance of exchangeable aluminium in phytotoxicity and acidity soil management, hydrolysis reactions; Lime requirement determination methods;	4
13	Redox chemistry	Redox potential reactions and implications to soil fertility and environmental quality; Carbonates; Sesquioxides; Soluble salts; Sorption	4
14	Nutrients	nitrogen, phosphorous, potassium and secondary macronutrients and Trace elements.	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

1. N.C. Brady & R. R. Weil, 2008. The Nature and Properties of Soils. 14th ed., Pearson International Press;
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3. Bohn H.L., McNeal B.L., O'Connor, G.A 1985. Soil Chemistry. John Wiley and Sons, Inc. New York.
4. Sparks, D. L. 1995. Environmental Soil Chemistry. Academic Press, New York. USA.
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7. Surface Chemistry. http://www.chem.qmul.ac.uk/surfaces/scc/scat2_l.htm. Accessed March 2011.

7.1.5 COURSE NAME: SUSTAINABLE AGRICULTURE
COURSE CODE: MSA 7105
CREDIT UNITS: 3

COURSE OVERVIEW
In view of global change spanning from population growth, migration, and urbanization to climate change, land degradation and water scarcity, the sustainable use of human and natural resources for the continued provision of quantitatively and qualitatively adequate food poses a major challenge to all stakeholders involved in agricultural production worldwide. This course therefore addresses the basic concepts and principles of sustainability and sustainable agriculture, in its ecological, economic and social dimensions. Approaches to determine the bio-physical and socio-economic sustainability of a land use systems and of agricultural value chains are evaluated, and possibilities to implement sustainable management strategies along the continuum of water, soils, plants, animals, producers and consumers are discussed, thereby also accounting for relevant temporal and spatial scales.

COURSE OBJECTIVES

- To explain the concepts of sustainable Agriculture
- To explain the causes of unsustainable Agricultural practices

LEARNING OUTCOMES:
At the end of this course the students should be able to: -
- Understand the concepts of sustainable Agriculture
- Understand the causes of unsustainable Agricultural practices
- Identify practice and adopt different sustainable agricultural practices
- Construct and use appropriate technologies for sustainable agriculture
- To start and manage an organic farm

DELIVERY MODE AND TIME ALLOCATED
This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Definition and principles	Introduction to Sustainable Agriculture; principles sustainable agriculture;	2
2	The three "E's" of sustainability	Common themes of sustainable agriculture; The three "E's" of sustainability (a. Economic viability, b. Environmental health, c. Equity (social)).	2
3	conventional and non-conventional agricultural	Differences between conventional and non-conventional agricultural production	2

	production	Advantages and disadvantages of sustainable agriculture	
4	History of Sustainable Agriculture:	Worldwide, Regionally; Advent and crises of modern agriculture;	4
5	Sustainable ways of agricultural production	Sustainable ways of agricultural production like; Organic farming, Integrated Pest Management, Biological control,	4
6	Sustainable ways of agricultural production...	Agroforestry, Conservation farming, Regenerative agriculture	4
7	Sustainable ways of agricultural production...	Agroecology,	4
8	Sustainable ways of agricultural production...	Sustainable land management, Climate Smart Agriculture.	4
9	Impacts of conventional agriculture on the environment	Non sustainable ways of Agricultural production and causes for this	2
10	Approaches and supporting initiatives to sustainable agriculture	Sustainable management strategies along the continuum of water, soils, plants, animals, producers and consumers value chain. Crop-livestock integration	4
11	Indicators of Sustainable Agriculture	Yields, Economics, Ecological Processes, and Social Issues	3
12	Reasons Why We Should Support the Revitalisation of Small Farms in the Global South	Reasons Why We Should Support the Revitalisation of Small Farms in the Global South; The SDG 2: Promoting Food security, Nutrition and Sustainable Agriculture;	2
13	Barriers to developing agriculture sustainability	The development challenge of transforming agriculture;	4
14	The potential of sustainable agriculture for climate change adaptation	sustainable agriculture for climate change adaptation Bio-physical and socio-economic sustainability of a land use systems and of agricultural value chains	11
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

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7.1.6 COURSE NAME: COMPUTER APPLIED STATISTICS AND BIOMETRICS WITH R AND RMARKDOWN
COURSE CODE: MSA 7106
CREDIT UNITS: 3

COURSE OVERVIEW

The aim of this course is to provide an introduction to R, a computer language and environment for statistics and graphics. The course will cover statistical tools and experimental designs, computer statistical packages. Emphasis is on a practical approach to the proper conduct of agricultural field and laboratory experiments in crop, soil, and animal sciences. Procedures and techniques of data analysis, interpretation, and presentation will be discussed.

COURSE OBJECTIVES

- To get familiar with the R environment by means of RStudio,
- To use R for manipulation and exploration of data and to perform all statistical analyses learned in the basic and advanced statistic courses,

LEARNING OUTCOMES

After successful completion of this course students are expected to be able to:

- read data into R from various sources;
- carry out statistical analyses as learned in previous statistical courses, with the help of the R language and environment for statistical computing and when necessary extend its basic functionality with specific packages;
- adapt and combine standard functions from basic R and packages to solve a given problem;
- adequately use standard programming constructs: loops, if-then-else statements, repetition, selection, functions, etc., to write basic program scripts to fully automate the statistical analyses;
- visualize results from statistical analyses, when possible, with the basic R graphics system;
- write reports in Rmarkdown language in which the statistical analyses and results visualization are integrated (as being part of Reproducible Research).

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Programming in R	Introduction and basic functionalities, coding styles, functions and programming,	2
2	Programming in R …	data management, data visualization, dynamic report generation	2
3	Statistical analyses in agricultural sciences	Review of statistical concepts (boxplots, QQ plots, distributions, classical tests, correlations, analyses of count and proportion data)	4
4	Statistical analyses in agricultural sciences ….	• Regression (simple linear and multiple linear regression models, polynomial, non-linear, logistic)	4
5	Statistical analyses in agricultural sciences …	• Statistical modelling, model types and model simplifications • Transformations	3
6	Statistical analyses in agricultural sciences …	• Field social/economic and agricultural surveys, identification of target populations, data attributes and population parameters.	2
7	Statistical analyses in agricultural sciences …	• Experimental designs, sampling and sample estimates, design of survey instruments and data collection procedures, data verification and data management,	2
8	Statistical analyses in agricultural sciences …	• Data analysis and statistical applications, testing of hypothesis, error in research	4
9	Statistical analyses in agricultural sciences …	• General aspects of hypotheses formulation and testing • Data distribution (normal, categorical, Poisson) and model selection criteria	3
10	Statistical analyses in	• use of parametric statistical tests: Analyses of variance for CRD,	4

	agricultural sciences …	RCBD and factorial designs, ANCOVA, MANOVA, PCA, post-hoc tests	
11	Field practical	Field practical on experimental layout and research presentation	3
12	Statistical analyses in agricultural sciences …	• Non-parametric test procedures (e.g Chi square, Mann whitney U test), probability statistics, and analysis of categorical data.	4
13	Statistical analyses in agricultural sciences …	• Mixed model procedures (linear, non-linear)	4
14	Statistical analyses in agricultural sciences …	• Formulation of statistical models and basic programming in R as well as visualization of results in R	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

1. An Introduction to Statistical Methods & Data Analysis by R. Lyman Ott and Michael Longnecker (ISBN 978-1-305-26947-7: 7th edition); Lecture notes (WUR shop).
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7.1.7 COURSE NAME: SPATIAL STATISTICS WITH GEOSTATISTICS, R AND QGIS
COURSE CODE: MSA 7107
CREDIT UNITS: 3

COURSE OVERVIEW

The course follows a statistical analysis of spatial data with the help of geoinformatics. There are three words that define this Course; geostatistics, R and QGIS. The course is designed to take users who use R and QGIS for basic spatial data/GIS analysis to perform more advanced GIS tasks (including automated workflows) using a variety of different data.

COURSE OBJECTIVES

- To introduce Models of spatial processes that are important for research and a means to support decision making.
- To get familiar with Knowledge and skills for qualifying and implementing spatial models and evaluate their results.

LEARNING OUTCOMES

After successful completion of this course students are expected to be able to:

- explain commonly used dynamic spatial modelling methods and techniques;
- construct a simple dynamic spatial model for a given spatial problem and data set;
- investigate the spatial correlation structure of a data set using semivariogram analysis;
- apply geo-statistical interpolation and spatial stochastic simulation methods;
- construct a stochastic error model to represent uncertainty in spatial data;
- apply fist order Taylor series and Monte Carlo methods for analysing propagation of input uncertainty through spatial models

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Introduction to geostatistics	fundamentals of the geostatistics: mainly, in the area of the exploratory data analysis and regionalised (or spatial) variables/ spatial variability will be covered.	2
2	Methods of Exploratory Spatial Data Analysis (ESDA),	Quantifying the criteria for estimation sources of errors in estimation, fundamental basis of the geostatistical approach, mean and variance of the estimation error	2
3	Deterministic interpolation methods	Concept, data sources, data sampling. Modeling of continuous fields (surfaces), concept of spatial autocorrelation.	2
4	Deterministic interpolation methods …	Global and local interpolators, exact and approximating methods, Thiessen polygons, IDW, Spline functions, Trend analysis. Polygon spatial interpolation methods.	3
5	Structural analysis and structural functions	Variogram modeling and interpretation: The variogram calculation, interpretation,	2
6	Structural analysis and structural functions …	linking variogram behaviour with physical causes (geology, sampling).	3
7	Variances Estimation	Variances, covariances, Krige's volume-variance relationship.	4
8	Variances Estimation …	Extension variances and estimation variances/simple calculations in one and two dimensions. Global reserve/resource estimation.	4
9	Geostatistical methods of interpolation	Optimal estimation, ordinary kriging, cokriging, indicator kriging, cross-validation, regression kriging, block kriging and area-to-point kriging,	4
10	Geostatistical methods of interpolation …	Space-time kriging and sampling design optimization.	4
11	Statistical properties of continuous fields	Homogeneity, continuity, isotropy, point descriptors, pattern detectors for point, line and polygon objects descriptors.	3
12	Statistical properties of continuous fields …	Detectors of spatial distribution for point, line and polygon objects, Moran Index.	4
13	Statistical properties of continuous fields …	Local Indicators of Spatial Autocorrelation (LISA). Methods of objective classification	4
14	Statistical properties of continuous fields …	Apply fist order Taylor series and Monte Carlo methods for analysing propagation of input uncertainty through spatial models	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting

the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

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7.1.8 COURSE NAME: ADVANCED PLANT NUTRITION AND SOIL FERTILITY

COURSE CODE: MSA 7201
CREDIT UNITS: 3
COURSE OVERVIEW

The course concerns relationships between nutrient availability and uptake by plants and nutrients taken up and crop growth**.** Managing crop nutrients is one of the most important factors in producing a successful crop. Fertilizers and other nutrient sources are major production expenses, and their mismanagement can lead to serious environmental consequences for both air and water quality. Nutrient management is also one of the more complicated aspects of producing crops, as considerations vary by nutrient source, their methods of measurement and assessment, placement, timing, rate of application, and are dramatically affected by soils and the weather.

COURSE OBJECTIVES

- To deepen the student's knowledge & skills to address plant nutrition and soil fertility management and grow better crops, reduce production expenses, and reduce the environmental impact from farming activities

LEARNING OUTCOMES

At the end of the course learners should be able to:

- Key processes underlying mineral nutrition of higher plants;
- The roles and functions of the various nutrients in metabolism and growth of higher plants
- How to assess nutrient adequacy for plant growth
- How to develop interventions

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Introduction to Nutrient Management	• Definition of soil fertility; Features of a fertile soil; Definition and causes of soil degradation; Soil fertility challenges to crop production in Uganda; Soil fertility management practices • Definition of plant nutrition and plant nutrients. Pathways for soil nutrient loss • Essential macronutrients and micro-nutrients, the 4R concept (right source, right rate, right time, and right place and serve to guide farmers to the management practices), adaptive management, nutrient management planning, regulations protecting air and water quality.	2
2	Nutrient uptake and transport in the plant	• Nutrient movement from soil to plants (Root interception, diffusion, and mass flow); Pathways for ion uptake in plants (Apoplastic, Symplastic and Vacuolar); Active vs passive transport; Factors influencing nutrient uptake by plants; Selective ion uptake and the carrier theory (affinity and capacity); Nutrient uptake, growth rate and nutrient content; Effects of stress on nutrient uptake (salinity, drought). optimization of plant population and planting geometry in relation to soil fertility • Mechanisms to increase the efficiency of nutrient availability, uptake and use, •	3
3	Factors influencing nutrient uptake of plants	Rhizosphere, transport of nutrient to root surface, shape and structure of root system, interaction with micro-organisms	2
4	Soil Fertility Nutrient sources	Forms in the soil, cations and anions, factors affecting nutrient movement and availability, leaching, mineralization, nutrient interactions	2
5	Soil Organic Matter and Microbiology	Role of microbes on nutrient uptake and availability, crop residue and soil organic matter management, use of cover crops	2
6	Nitrogen in the Soil	The nitrogen cycle including mineralization, nitrification, immobilization, denitrification and symbiotic fixation, factors affecting nitrogen trans-formations	3
7	Phosphorus and Potassium in the Soil	Phosphorus and potassium forms and transformations, soil factors affecting availability to plants	4
8	Secondary Nutrients and Micronutrients Forms and transformations	Calcium, Magnesium and Sulfur, and others. Soil factors affecting availability to plants	4
9	Soil pH and Soil Amendments/ Salt Affected Soils	Soil acidity, alkalinity, and salinity effects on crop production, active and reserve acidity, managing soil environments with soil amendments. Dynamics and availability of nutrients in acid, highly weathered soils, alkaline soils, and paddy soils.	4

10	Problems with Al-toxicity and salinity	Nutrient Assessment and Diagnostics Soil and plant sampling techniques, site-specific sampling, lab tests for soil and plants, types and use of sensors, factors affecting lab and sensor results. Nutrient balances assessment.	4
11	Fertilizers and Fertilizer Additives Fertilizer analyses	Types and characteristics of fertilizer products (organic, foliar, biofertilizers and mineral fertilizers), advantages and disadvantages of different fertilizers; field characteristics that affect use, elemental vs. oxide, use of fertilizer additives. Integrated nutrient management (INM)/ integrated soil fertility management (ISFM). Fertilizer calculations, Recommendations and Economics Sufficiency level, removal/replacement, and nutrient balance approaches, P-based vs. N-based. Grade analysis and determination of fertilizer application rates; how recommendations are derived, probabilities of response. Fertilizer use efficiency (FUE), FUE indices, and methods for improving fertilizer and nutrient use efficiency (the 4 Rs for effective fertilizer use)	3
12	Diagnosis of nutrient problems	• Effect of nutrient imbalances on plant metabolism and development of plant harvest products, the nutrient concentrations and processing quality. Understanding the relationship between plant nutrition and plant health and its significance in the value-added food chain. Function of different nutrients in the plant especially with respect to plant health (susceptibility, tolerance, resistance)/ nutrient deficiency and toxicity in plants. • Methods of diagnosing nutrient problems: Yield gap analysis; Soil testing; Plant tissue analysis; Field observations; Diagnostic keys; Nutrient flow analysis; Resource flow mapping; Computer based diagnostic tools. Mitscherlich, Baule and Inverse- yield- nitrogen laws	4
13	Fertilizer Application Timing and Placement	Nitrogen fertilizer Application Timing and Placement Crop response and environmental considerations regarding different Methods of nitrogen applications. P and K Application, Timing and Placement. Crop response and environmental considerations regarding preplant, sidedress, and split applications of Phosphorus and Potassium.	4
14	Nutrient cycling in special cropping systems	Livestock manure management, composting, shifting cultivation, intercropping, agroforestry, paddy rice	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

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7.1.9 COURSE NAME: GLOBAL CHANGE, PLANETARY BOUNDARIES AND SUSTAINABILITY

COURSE CODE: MSA 7202
CREDIT UNITS: 3

COURSE OVERVIEW

Global change, which largely refers to planetary-scale changes in the Earth system mainly caused by anthropogenic activities, is threatening sustainable development prospects in multiple ways. This course will cover the concepts related to such global change, global environmental changes, Planetary Boundaries, sustainability and globalization; their implications on food, water and health; and various solutions including climate change adaptation and mitigation measures.

COURSE OBJECTIVES

The course aims;

- To provide knowledge to students from a global perspective, on the main contemporary global dynamics, with particular attention to the issues of; sustainable development, environmental change, climate change and environmental governance, at different spatial scales (local-regional, national, international).
- Students will have acquired knowledge on the main contemporary global dynamics and their relationship with sustainable development.

LEARNING OUTCOMES

At the end of the course, they will be able to:

- understand the main dimensions of the concept of sustainable development, implications of climate change;
- comprehensively integrates and balances the three dimensions of global challenges: environmental, social and economic;
- explore the nexus of global change and the Earth system to find answers towards global sustainability;
  understand the nexus of climate change and the water, food and health sectors.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Sustainability	The essential Question is: What is sustainability and why is it important? Sustainability at the intersection of the environment, society and economics. SDGs: The 17 newly minted UN Sustainable Development Goals (historical evolution, key theories, and concepts of sustainable development.	4
2	Sustainability …	Sustainability and its Main Challenges of Natural Resource Depletion (Planetary Boundaries – environmental limit).	2
3	Sustainable Development …	What is Sustainable Development? The Definition of Sustainable Development as an Ambiguous Compromise. The Concept of Sustainable Development. Core principles/ pillars of sustainable development; "weak" and "strong" approaches to sustainable development.	4
4	Sustainable Development …	The Triple Bottom Line: Sustainability has the role of protecting and maximising the benefit of the 3Ps (**people, planet and profits)**. "Green" vs. "Sustainable?" Triple Crisis − Poverty, Water, and Food. Wealth distribution and the regional relationship between poverty (Compare standard of living-poverty & en-equality), Education, Population growth, Health and the environment). The United Nations and Global Sustainability.	4
5	Sustainable Development …	Linking the Local to the Global: Can Sustainable Development Work. Major issues affecting sustainable development and how sustainable development can be achieved in practice.	4
6	Global sustainability initiatives	Population growth and economic growth and sustainability. Implications of overuse of resources (global change); Environmental limits in Planetary Boundaries of nine planetary systems: climate change, ocean acidification, stratospheric ozone depletion, nitrogen and phosphorus cycles, global freshwater use- pollution of lakes and rivers, change in land use, biodiversity loss and invasions by non-native species, atmospheric aerosol loading, and chemical pollution.	3
7	Environmental Ethics, Global Environmental governance & Sustainable Development:	approaches, tools and actors; the role of ethical values. Global sustainability initiatives (e.g., International environmental policy: Brundtland Report, Earth Summit, Agenda 21 - Rio declaration (UNCCD, CBD, UNFCCC), Kyoto Protocol, Earth Charter, Copenhagen, Future Earth and the 2030 Agenda for Sustainable Development, the Paris agreement.	3
8	Climate and Social Change Impact on Food, Water and Health	• Climate Science and Projection, Water Sustainability under Climate Change, Urban Water Management in Developing Countries, • Food Sustainability under Climate Change Stress, • Sanitation and Health Issues in Urban Area.	4
9	Climate Change Mitigation and	Climate Change Mitigation and Adaptation impact on different sectors like water (water harvesting & efficiencies), food (CSA) and health (global	2

	Adaptation	warming, Climate projections and extreme events, natural hazards and disaster occurrence)	
10	Climate Change Mitigation and Adaptation …	Climate monitoring for disaster reduction. Early warning systems for drought and desertification.	4
11	Land degradation, Land use change and Ecosystem Dynamics	Land degradation; Definitions and concepts. Components: Physical, chemical, biological and socio-economic. Significance and severity levels. Causes, processes and effects of land degradation. Natural resource-specific degradation, indicators and interventions.	3
12	Land degradation, Land use change and Ecosystem Dynamics	Satellite observations are critical for tracking changes in ecosystem conditions and effectively managing ecosystems to mitigate adverse consequences. Assessment of land degradation, including economic aspects. An important aspect of the course will focus on outlining prevention and mitigation approaches to these threats. Ecosystem services that will be covered in the course will include provisional services (food, biomass, genetic, medicinal and other resources); regulatory and support services (air quality, erosion, climate, pollination, water storage and filtration, nutrient cycling, etc.), and cultural services. Options for land resource conservation/ Soil and water conservation.	2
13	Global Change and Challenges of Biodiversity and Ecosystem Services and it governance.	Ecosystem Assessments at Local, National, Regional to Global Scale. Agricultural biodiversity and agro-diversity. Farming as an integral part of the environment at the scale of landscapes and biomes. Importance of biodiversity to communities. Develop an understanding of how biodiversity is important for our existence in terms of crops and livestock, pollination of crops, plant protection, food, fuel, water, recreation and other ecosystem services. Biodiversity loss, maintenance, enhancement and conservation. Soil biodiversity; benefits. Factors affecting soil biodiversity. Biodiversity as an indicator of soil quality and environmental health. Invasions by non-native species. Monitoring and evaluation; In-situ and ex-situ Case studies on agricultural biodiversity management (successes and failures). Models for biodiversity management.	4
14	Agencies dealing with global assessment and conventions on biodiversity.	Convention on Biological Diversity (CBD), Aichi Biodiversity Targets, and Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). Toward the Creation of a Sustainable Society in Harmony with Nature and governance of biodiversity and ecosystem services.	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

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7.1.11 COURSE NAME: GIS AND REMOTE SENSING IN DIGITAL AGRICULTURE
COURSE CODE: MSA 7203
CREDIT UNITS: 3

COURSE OVERVIEW

The course covers GIS functions and Remote Sensing to provide students with basic knowledge on the use of smart tools important for driving decisions towards more sustainable ways of natural resource management in agriculture.

COURSE OBJECTIVES

- This course aims to build insight in the science behind Geographic Information Systems (GIS) with a focus on natural land resources, complemented with a hands-on PC training in the use of GIS software to perform an advanced integrated spatial analysis that supports land use related decision-making.

LEARNING OUTCOMES

At the end of the course learners should be able to:

- Understand and correctly use specific terminology and principles related to GIS in general 1 and land information systems more specifically when communicating with experts
- Being capable to equip a GIS laboratory with the necessary hardware and software, being at the same time aware of the importance of required human expertise;
- Understand and recognize the importance of map projections in GIS and being capable to define and/or change map projection and coordinate systems
- Being aware of the applicability of LIS in various other scientific disciplines and in interdisciplinary assessments involving natural land resources
- Importing, exporting and editing digital information from various sources
- Performing basic as well as advanced spatial analyses on digital maps representing vector and raster data structures
- Interpolate point maps to raster maps;
- Perform an integrated spatial analysis on the basis of digital information (cartographic modelling)

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	GIS definition and general functionalities	Basic map concepts: vector and raster data structures, topology, sources of geographical information (maps, remote sensing, GPS); Hardware and software (QGIS & R).	3
2	Projections and	Map scale, projections and coordinate systems	4

	coordinate systems		
3	GPS and smartphones	GPS and smartphones	3
4	Basic GIS functions	Editing, transformations, map join,.. and DBMS	3
5	Practical exercises	On-screen digitalisation, editing of vector layers and adding attribute information, Map production: Correct visualization of spatial information (coordinate reference systems, color maps).	4
6	Geo-processing	Intersection, union, clipping	2
7	Spatial analysis and cartographic modelling	Reclassification, overlay, buffer, network connectivity, contiguity, proximity, spreading, digital terrain model analysis.	3
8	Interpolation methods	trend surfaces, Thiessen polygons, Inverse distance weighting.	2
9	Physical principles in Remote Sensing	reflectance, transmittance, and absorption	4
10	Remote Sensing Sensor techniques	Passive and active sensors, satellites, field spectrometer	2
11	Methods of Image Analysis	image classification, validation/ accuracy assessment in remote sensing applications.	4
12	Mult-temporal image data processing	Mult-temporal image data processing for environmental monitoring. This technical framework is presented using agricultural examples, as e.g. the generation of maps for crop yield, assessment of species composition in mixed vegetation (e.g. grassland).	3
13	Project Assignment	GIS and Remote Sensing project	4
14	Project Presentation	Presentation	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

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7.1.12 COURSE NAME: GLOBAL FOOD SYSTEMS AND FEEDING A HUNGRY PLANET
COURSE CODE: MSA 7204
CREDIT UNITS: 3

COURSE OVERVIEW
With a world's population expected to reach 9 billion by 2050, and the difficulties posed by climate change, increasing globalization, and the shifting of global economies, the improvement of global, regional and local food systems has become even more relevant. Providing sustainable and nutritious food to the global population, with almost 690 million people undernourished in 2019 is a global challenge which engages governments, researchers and all those involved in the food production, processing and trade. Our food systems need to transform in a more sustainable manner to generate food security in the present, not compromising the well-being of future generations.

The global food system produces 34% of all greenhouse gas emissions. Left unchecked, emissions from food are projected to increase by at least 50% by 2050. But a far better path is possible because of a diverse set of climate solutions from food systems that are at hand and able to scale globally. Ranging from reinvesting in age-old agricultural practices to cutting-edge technologies, the food system presents a wide range of opportunities that can deeply reduce emissions while also providing nutrition for all and improving the health of people, animals, and ecosystems. Realizing the full potential of climate solutions in food, could, by 2030, generate $5 trillion per year in inclusive new business opportunities, create over 100 million well-paying jobs, and save $6 trillion annually in health and environmental costs.

This course provides a critical perspective on the global food system. We will examine the components of a food system include farming, food processing, distribution, consumption, recycling, and much more. It's an interconnected set of biological, technological, economic, and social activities that are essential to society. Food systems can range from local to international, from traditional to organic. We will then examine current challenges that have arisen as a result global change, including food waste, inequitable labour practices, health concerns, and inefficient food aid. Throughout the course we will focus on how inequities relating to race, class, gender, and indigeneity affect people's experiences within the global food system.

The overriding goal of this course is for you to gain a general understanding of the current and historical relationships between soil, agriculture, people, their food supply, and the systems in which food is produced. The course seeks solutions to the challenge of achieving global food security and sustainability. Ultimately, we will seek to answer the question, "Can we feed the world without destroying it?" How do we create a healthy and sustainable diet for the growing world population? What can I do to make food consumption and production more sustainable? Learn about the fundamental changes occurring in the global food system, the environment, and our civilization as a whole. We will explore the role of science and technology in informed decision making, how to approach inherently interdisciplinary problems, how to identify solutions that are truly sustainable in the long term, and how to inform the public of our findings.

COURSE OBJECTIVES

- Demonstrate a basic knowledge of issues, concepts, and theories that help us understand the relationships between food, the natural environment, and human society,
- Identify the historical and current factors that shape the global food system,
- Understand some of the main theories and concepts around the geography of the global food system.
- Recognize the contributions that plants and plant products make to human well-being,
- Critically examine the problems the world faces regarding food production, trade, and consumption,
- Recognize and defend one's own values regarding food production, trade, and consumption,
- Discuss and communicate the concept of sustainability as it relates to agriculture

LEARNING OUTCOMES

At the end of the course learners should be able to:

- learn about food security worldwide, the effects of malnutrition, how we manage ecosystems that provide food resources and more.
- Understand recent developments like advanced technology impact farming.
- Gain understanding on agriculture's role as the material basis of world civilizations.
- Explore the historical development and current state of world agriculture.
- Gain understanding how agricultural systems and human cultures have been shaped by the world's physical environments.
- Gain skills on the use "thematic maps" to increase our understanding of the worldwide distribution of natural environments and agricultural production.
- Understand components of today's major agricultural systems. Examples from industries ranging from rice to livestock, and the experiences of smallholder farmers.
- Learn about the impacts of industrialization, urbanization, population growth, marketing, and transportation on the diversity and supply of food today.
- Understand what is food security? How do poverty, inequality and other factors affect the nutrition of not just individuals, but entire countries?
- Discuss current world, national, and regional events (political, social, climatic, economic, etc.) that affect or are affected by agriculture.
- Explore the effects of climate change, energy policies, and other current global issues on agriculture.
- Learn about regulations influencing production, trade and other aspects of agriculture.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Background and History of the Global Food System	*a)* What is the global food system and how has it been theorized? How have food systems changed? What structures have shaped the current global food system? *b)* Colonizing Food systems, *c)* Agricultural Industrialization and Corporatization, *d)* Global Governance and the Cost of Cheap Food	4

2	Challenges and issues within the current global food system	What are the key challenges and issues within the current global food system? What are people doing to resist these challenges? a). Food Waste, b). Food Workers, c). Development and Food Aid, and d). Consumption and Health.	4
3	Alternatives to the Global Food System	What kinds of responses, resistances, and alternatives to the Global Food System have arisen? a). Food security and food sovereignty, b). Sustainable Agriculture and the Rise of the Food Movement, c) Limits of Resistance?	3
4	Global challenges around food production	Physical (climate change, drought, extreme events), ecological (land degradation, pest & disease, pollution) and human terms (Population, political conflicts, migration) issues	3
5	Agriculture at the center of sustainable development	Emergence of modern agriculture, Risks under a Business-As-Usual scenario, Agriculture & the Sustainable Development Goals.	2
6	World soils and climate for food production	World Soil classification: their occurrence/ Spatial variability of soils in individual pedons and mapping units, genesis, geography, properties and use. Introduction (from soil data to diagnostic horizons, properties and materials; WRB classification system; USDA Soil taxonomy classification system.	3
7	The links between food and climate change	The role that climate and soils play in agricultural systems, the links between food and climate change, and food and water security and how agriculture and the rest of our environment interact.	2
8	Sustainable agriculture intensification by 2050 ….	Concept of food security is introduced as an overarching issue. Feeding 10 billion people sustainably by 2050, then, requires closing three gaps (food production gap, expected agricultural expansion by 2050 and GHG mitigation gap needed to hold global warming below 2^{o}C). The importance of productivity growth, climate adaptation and mitigation, Breeding and genetics, Nutrient management, Soil fertility management, water management, Crop protection, Good agronomy, Sustainable livestock systems, Functional diversity). production.	4
9	Sustainable agriculture intensification by 2050 ….	A five-course solutions required to simultaneously apply to close the food, land and GHG mitigation gaps so as to create a sustainable food future: (1) reduce growth in demand for food and other agricultural products; (2) increase food production without expanding agricultural land; (3) protect and restore natural ecosystems; (4) increase fish supply; and (5) reduce GHG emissions from agricultural	3
10	Food systems transformation for food security for all ….	Improved nutritional security and affordable health diets; Nutrition and health, Consumption and diets, Food losses and waste, Socio-economic dynamics of food systems and Pathways towards food security.	4
11	Food systems transformation for food security for all….	Livelihood and resilience-based approach in some of the least stable regions.	3
12	Project Assignment	Reading and Project Assignment	4
13	Project	Group Project presentations	4

	presentations …		
14	Project presentations …	Group Project presentations	2
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

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7.1.13 COURSE NAME: GLOBAL ECOSYSTEMS AND AGROECOSYSTEMS
COURSE CODE: MSA 7205
CREDIT UNITS: 3

COURSE OVERVIEW

To feed a global population that is expected to reach more than 9 billon people by the year 2050, agricultural production must increase by 60 to 100 % (Godfrey, 2010). Limited land for agricultural expansion, increasing demand for meat and dairy products, changing climate, the need to reduce degradation of soil and water and to preserve biodiversity challenges food production world-wide. Sub-Saharan Africa and Southeast Asia, regions where food security is often in jeopardy, are areas that will experience the greatest increase in demand for food. Meeting the need for food production without expanding land under cultivation and also reducing degradation of the environment requires sound understanding of the biophysical, social, cultural and economic factors that influence agroecosystems. We will examine the major components of agricultural systems including crops, livestock, soils and climate, and their interactions.

COURSE OBJECTIVES

- Utilize a variety of tools and approaches to investigate the biophysical and socio-cultural dimensions of agroecosystems in diverse regions
- Recognize and appreciate different cultural perspectives, including their own, in relation to food security and the environment

LEARNING OUTCOMES

At the end of the course learners should be able to:

- Understand world agroecosystem, farming system functioning and explain the theories underpinning farming systems analysis.
- Use simple (participatory) methods for data collection and characterization of farming systems.
- Interpret the concept of sustainable rural livelihoods, along with identifying and applying criteria, indicators and methods for its assessment.
- Analyse the contribution of agriculture to rural livelihoods and assess farm and farming system performance based on relevant indicators.
- Identify entry points, analyse trade-offs and evaluate opportunities for sustainable intensification, using scenario analysis and simple (optimization) models.
- Have insight and understanding of a wide range of methods for description and analysis of farming systems.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	The five major categories of ecosystems:	Agroecosystems; Coastal ecosystems; Forest ecosystems; Freshwater systems; Grassland ecosystems	**6**
2	The challenge of Feeding the growing world population	Meeting the need for food production without expanding land under cultivation	**4**
3	Agroecosystem Analysis.	The biophysical characteristics (climate, soils, vegetation) of Agroecosystem of each region and their prevailing farming systems, the	3

		world's crops and animals major produced, farming methods, current agricultural systems on our planet, as well as the culture and key socio-economic and political conditions that affect food production. Through online and in-class discussions, we will consider opportunities for, and challenges to, sustainable production in these regions.	
4	Agroecosystems in diverse ecoregions of the world	Agroecosystems of temperate grasslands, Midwest USA - Annual grain agroecosystems of Minnesota, Agroecosystems of tropical grasslands-Somalia, Agroecosystems of coastal Mediterranean and montane regions Morocco, Malawi, Agroecosystems of tropical moist broadleaf forests - India, Agroecosystems of tropical rainforests – Panama.	2
5	Farming systems analysis	Developing an understanding of the interactions between the environment, crops/pastures, livestock and agricultural management in different international farming systems of agroecosystems. What constitutes a farming system; how a farming system in any region is a unique product of climate, soils, economy, and history; how farming systems are dynamic through integration within an ever changing global physical and economic environment; and what methods are used to study farming systems.	3
6	Farming systems analysis	Cover problem identification, limitations to agricultural production and yield, causes of problems, interventions to resolve these problems through science-based planning and agronomic management practices, and the consequences of the interventions are investigated towards carving out pathways for sustainable development of smallholder farming systems.	3
7	Assessing vulnerability of agricultural production	Assessing vulnerability of agricultural production and aspects of food security and poverty in the face of global environmental, social and economic change.	3
8	Analysis of the sustainability of farming system productivity	Under special consideration of the physical, chemical and biological soil quality as well as the efficient water use in the seasonal tropics.	3
9	World farming systems	Developed world farming systems (intensive, high inputs, large scale, market-oriented) and the developing world farming systems (extensive, minimal inputs, small scale, subsistence) focusing on for example dryland systems in Africa, rice based farming systems in Asia and mixed farming systems in Europe and America.	3
10	DEED cycle (Describe, Explain, Explore and Design) of farming systems	Field on-site group observation of rural household activities, farms, and farm practices, and rural livelihoods indicators (income, food security, nutrition) for characterizing different farming systems. Using the DEED cycle (Describe, Explain, Explore and Design) a wide range of methods for description and analysis of farming systems will be introduced and used.	4
11	Pathways towards Sustainable farming systems	Designing pathways towards Sustainable farming systems and sustainable development under environmental and climatic constraints in which flourishing livelihoods are integrated within a healthy environment, including the role indigenous knowledge of farmers plays in traditional and modern agriculture.	3
12	Aspects of sustainable agriculture	Aspects of sustainable agriculture (crop production, animal production, labour, gender, household economics, markets, energy, biodiversity, landscape).	4

13	Project presentations …	Group Project presentations	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

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7.1.14 COURSE NAME: ECOLOGICAL ORGANIC AGRICULTURE
COURSE CODE: MSA 7206
CREDIT UNITS: 3

COURSE OVERVIEW

Organic Agriculture – Why? Concern about food safety and security and environmental sustainability is increasing. Organic farming is an integrated system of agricultural production based on ecological principles, promotion of biodiversity, biological cycles and organic matter recycling to maintain and improve soil fertility and environmental sustainability. Organic agriculture helps to build sustainable livelihoods through sustaining natural resources, increase agricultural productivity and earn a price premium for their certified organic produce. This raises farmers' household income which is reinvested in health, education and food. The regulations for organic crop cultivation prohibit the use of chemo-synthetic pesticides, mineral fertilizers, growth promoters and Genetically Modified Organism. Indiscriminate use of these chemicals in conventional farming poses a serious threat to the quality of produce as well as the environment. In view of this, the course is designed to train students on organic farming practices, quality analysis of the products, environmental impact assessment, health benefit of the organic food etc. The course covers the following topics:

COURSE OBJECTIVES

To train students on sustainable organic farming practices, quality analysis of the products, environmental impact assessment, health benefit of the organic food etc.

LEARNING OUTCOMES

At the end of the course learners should be able to:

- the students should be able to design resource efficient farming system for small and marginal farmers for improving their economy while meeting the quality food demand in a sustainable environment.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Organic Agriculture – Why?	Concern about food safety and security and environmental sustainability is increasing.	**2**
2	Organic Farming principles	Concepts and principles of organic farming.	3
3	Key indicators of organic farming	Biophysical indicators of organic agriculture	2
4	Organic agriculture Input management	Compost production, vermicomposting, Compost quality, Compost utilization and marketing, Mulching; Green manuring; Cover crops; Organic fertilisers.	3
5	Organic crop management	field crops, horticulture and plantation crops.	3
6	Plant protection measures	Biopesticides, natural predators, cultural practice. Selecting appropriate techniques of control; Weed identification.	3
7	Transition to organic agriculture	Rotation design for organic system, Transition to organic agriculture, farming system.	3
8	Opportunities, challenges and barriers of organic agriculture	Opportunities, challenges and barriers existing for beginning and established farmers; Strengths, weaknesses, opportunities and threats.	3
9	Quality analysis of organic foods	Antioxidants and their natural source, organic food and human health.	4
10	Organic Certification	Standards of organic food and marketing/ Organic Certification	3
11	Organic agriculture and sustainable livelihoods	- sustaining natural resources, increase agricultural productivity and earn a price premium for their certified organic produce.	4
12	Feeding the world with Organic agriculture	Can organic agriculture feed the world?	4
13	Project presentations …	Group Project presentations	4

14	Project presentations …	Group Project presentations	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

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7.1.15 COURSE NAME: ADVANCED LAND USE PLANNING AND POLICY

COURSE CODE: MSA 8101

CREDIT UNITS: 3

COURSE OVERVIEW

This course involves a detailed study on how land can be utilized to its full capacity and potential by first surveying it and classifying it into different classes, and then evaluating it. Finally drawing out farm plan showing how different farm enterprises have been allocated on the farm and factors that influence allocation. It also gives highlights on laws and policies on land use.

COURSE OBJECTIVES

- The **overall objective** of this course is to train students in the use of soil survey and land evaluation techniques for effective land use planning

The **specific objectives** are:

- To give students the knowledge and skills to carry out soil survey, land use planning, and use the soil information for land evaluation
- To develop competence in the use of remote sensing and GIS tools to carry out a soil survey for land evaluation purposes
- To enable students learn how to integrate soil survey and land evaluation into land use planning and be able to implement development and research projects in this field

LEARNING OUTCOMES

At the end of the course learners should be able to:

- Explain the selection and evaluation of different land characteristics or soil quality indicators as they are used in existing land use planning and evaluation techniques.

- Critically evaluate the basic concepts, advantages/disadvantages, and output quality of existing land evaluation techniques, and use this to decide upon their applicability.
- Apply existing land evaluation techniques to evaluate land suitability, ecosystem service delivery or soil quality Judge the environmental and socio-economical uniqueness of each land evaluation study, and translate it into adapted land evaluation techniques.
- Integrate soil degradation and climate change scenarios with land suitability assessment in a GIS environment

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Definitions	Land use planning, land evaluation, land capability classification and land suitability classification	2
2	Land use planning	Uganda's Land resources and Use; land Use types; focus of land use planning, planning at different levels, people involved in land use planning, steps in land use planning and methods used in land use planning.	3
3	Land evaluation	definition and principle objective, principles in land evaluation, major terminologies in land evaluation, land capability classification and land suitability classification. Existing land potential evaluation systems: review and applications: USDA Land Capability Classification (LCC); System and Highly Erodible Lands (HEL); FAO Agro-Ecological Zoning (AEZ and GAEZ) System. Land potential evaluation for valuation and taxation: the European experience.	2
4	Geographic Information System	components, functions and applications of GIS, types of GIS data, sources of GIS data, maps, map projection and coordinate system, ArcGIS Graphical User Interface and GIS softwares. Soil spatial data interpolation techniques and spatial processing.	3
5	Planning and establishment of a farm	definition and objectives, characteristics of a good farm, components of farm planning, factors to consider when planning, steps in farm planning and establishing a farm and farm layout. Ecosystem and landscape scale planning. Evaluate hows, whats, whys of crop management by solving real-world problems that agricultural professionals face. State-of-the-art production/management practices for major agricultural crops. Challenges in land use planning.	3
6	Catchment Management Plans (CMPs)	Water management zones in Uganda - Simulation of spatially distributed systems (e.g., SWAT model). Principles and components of watershed management, factors affecting watershed management, Characterization and delineation of model watershed. Catchment land use changes, hydrology and climate change impacts.	3
7	Land surveying	Concepts of soil survey and land evaluation, History of surveying and mapping, Importance of soil survey and land evaluation. **TYPES OF SOIL SURVEY AND LEGEND DESIGNS:** Reconnaissance survey; Exploratory survey; chain surveying and leveling; Semi-detailed survey; Detailed survey and Legend construction. Principles of surveying**. THE SOIL SURVEY PROCEDURE:** Filed reconnaissance; Design of a field survey; Field soil survey; Soil sampling; Laboratory tests and analyses; Soil	3

		mapping. **SOIL SURVEY AND MAPPING USING REMOTE SENSING AND GIS TECHNIQUES:** Definitions of remote sensing and GIS; Geographical information for natural resources management; Use of aerial photographs in soil survey; Use of satellite imagery in soil survey**.** Presentation of soil survey results in a map.	
8	Land tenure and land use systems	land tenure systems (traditional and current), customary laws of some Ugandan communities, the pre-independence government land policies and legal frame works, the current land use and ownership policies in Uganda and other developing and developed countries and respective acts of parliament.	3
9	Gender in land use planning	role of gender in land use planning, Land use and accessibility by gender, gender issues in land use and implications and gender in land use policy and law.	4
10	Land laws and policies in Uganda	laws and policies for protection of land lords, tenants and laws and policies for protection of natural resources, wetlands, waters, fauna and flora.	3
11	Land acts of Uganda	Uganda land acts, land amendments acts and the current land amendment act of Uganda.	4
12	Enforcement of land laws and policies	Roles of the executive, the land boards, tribunals, the judiciary and elders courts and challenges and recommendations.	4
13	Laboratory tasks	creation of basin maps using QGIS, land suitability evaluation using ArcGIS, measuring distance on land using pacing, drawing a farm plan, surveying by chaining and differential leveling.	4
14	Project presentations …	Group Project presentations	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

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7.1.16 COURSE NAME: CLIMATE SMART AGRICULTURE
COURSE CODE: MSA 8102
CREDIT UNITS: 3

COURSE OVERVIEW

Agriculture contributes significantly to global warming through large scale greenhouse gas emissions. At the same time many agriculture systems are vulnerable to climate change and without adaptation global food production could significantly reduce affecting food security. In response to these challenges the concept of climate smart agriculture has been developed. During the course the students will learn about the main principles of climate smart agriculture.

COURSE OBJECTIVES

To help students understand that;

- Agriculture contributes significantly to global warming through large scale greenhouse gas emissions. At the same time many agriculture systems are vulnerable to climate change and without adaptation global food production could significantly reduce affecting food security.
- In response to these challenges the concept of climate smart agriculture has been developed

LEARNING OUTCOMES

At the end of the course learners should be able to:

- apply the main principles of climate smart agriculture;
- analyse the impacts of climate variability and climate change on agricultural systems;
- describe the essential processes that are important in crop-climate interactions;
- develop and critically assess adaptation and mitigation measures related to agricultural systems;
- integrate adaptation and mitigation measures into a climate smart agricultural system.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Why climate-smart agriculture, forestry, livestock and fisheries	1. Climate change impacts on: crop, livestock, fisheries and Apiculture. 2. Learn how agricultural systems including both plant and animal systems contribute to climate change through the emissions of CO2, N2O and CH4. Main processes causing these emissions and which mitigation measures can be used to reduce greenhouse gas emissions.	2
2	Climate change	Integrating adaptation and mitigation into existing farming systems,	3

	adaptation and mitigation strategies	subsectors (e.g., crop, livestock, fisheries and Apiculture), and land and water use practices to transform Agriculture and food systems in order to meet the related challenges of food security and climate change. Mitigation climate change: Managing landscapes for climate-smart agricultural systems: Managing agriculture, forestry and fisheries at a landscape scale through appropriate land-use planning and decision making based on a participatory, consensus-based and people-centred approach.	
3	Agricultural Water management under climate change	Water management in both rainfed and irrigated agriculture (crop evapotranspiration, changes in the amount of rainfall, and variations in river runoff and groundwater recharge) taking into account including: increased water demand by all sectors; the degradation of water quality; and heightened competition for water at various levels (community, river basin and aquifer).	2
4	Soils and their management for climate smart agriculture.	Management practices that increase soil organic carbon (SOC) content through organic matter management rather than depleting it will bring win-win benefits. These practices will maintain productive soils that are rich in carbon, require fewer chemical inputs and sustain vital ecosystem functions, such as the hydrological and nutrient cycles.	3
5	Sound management of energy for CSA.	Reducing this dependency on fossil fuels and energy, smart food systems to lower GHG emissions (clean Energy: solar & biogas).	3
6	Conservation and sustainable use of genetic resources	Conservation and sustainable use of genetic resources for food and agriculture as a raw material that farmers, breeders and researchers to respond to new conditions, including changes in climate and well-being of present and future generations.	3
7	Climate-smart crop production system.	Sustainable crop production provides farmers with options for farming sustainably, taking into account the local ecosystem. Integrated approaches—such as crop-livestock systems, rice-fish systems and agroforestry—diversify food sources and consequently strengthen the resilience of farmers' livelihoods.	3
8	Climate-smart livestock	Livestock's role in adaptation practices relates primarily to the management of organic matter and nutrients and the diversification of incomes. Including practices such as grassland restoration and management (e.g. silvopastoral systems), manure management (e.g. recycling and biodigestion) and crop-livestock integration.	3
9	Climate-smart forestry	Delivery of goods and ecosystem services from forests and trees that are essential to livelihoods and food security, to environmental sustainability, and to national development (Sustainable forest use, art & craft, honey, hunting, tourism, fruits, water).	4
10	Climate-smart fisheries and aquaculture	Maintaining the resilience aquatic systems and the communities that rely on them to allow the sector to continue contributing to sustainable development; and ways to reduce effectively the vulnerability of those most likely to be negatively impacted by	3

		climate change.	
11	Developing sustainable and inclusive food value chains for climate-smart agriculture	improve performance along the value chain from input supply, to food production, to post-harvest handling and storage, processing, distribution, marketing and retail, consumption and disposal patterns of waste. Reduction, reuse and recycling of foodstuffs, including waste as compost or to generate energy from, for example, biogas. Green technologies.	4
12	Disaster risk reduction plans, laws and policies	strengthening livelihood resilience; Proven DRR technologies and practice, legislation, institutional structures, policies and plans for a strong supportive enabling environment.	4
13	Policy Tools for the Transition to Low	Emissions- Green Growth Initiative. Implementing the Paris Climate Agreement and Net-Zero emissions. Mainstreaming Climate-smart agriculture into National Policies and Programs; Climate-smart agriculture within policy frameworks	4
14	Group Project presentations	During the course the students will design different adaptation and mitigation measures which need to be integrated into a climate smart strategy for their case e.g., crop, livestock, fisheries and Apiculture).	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

FAO, 2013. Climate Smart Agriculture: Source Book, 557 pgs. Rome

7.1.17 COURSE NAME: ADVANCED AGRONOMY

COURSE CODE: MSA 8103

CREDIT UNITS: 3

COURSE OVERVIEW

This course is to give the students detailed understanding of the agronomic parameters and factors that are directly important in determining and hence, influencing higher crop yield, the factors that influence the life span of crops and provides means of improving upon crop yield.

COURSE OBJECTIVES

- To explain the importance of physiological parameters in relation to crop yield
- To describe how to improve crop yields
- To explain how to optimize crop yields under given ecological conditions.
- To explain the various terms used in ecology
- To explain the importance of species populations in the ecosystem and their survival in the

environment
- To describe the partition of energy in an eco-system
- To describe agro-ecology versus agro-industrial systems in environmental protection.

LEARNING OUTCOMES

At the end of the course learners should be able to:

- To explain the roles of physiological parameters in relation to crop yield
- Identify the different yield components for different crops
- Explain the factors that influence the life span of crops
- Use the different parameter in measuring crop growth
- Modify growth of crops to improve yield
- Explain the terms used in ecology
- Explain organization of species in an eco-system.
- Explain the constitutes of all ecosystems and their different organizations
- Explain the approaches to study of populations
- Explain the different strategies for existence.
- Describe the flow of energy in an ecosystem
- Describe the biochemical cycles in an ecosystem

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Principles of Crop Agronomy:	Classification of Crop Plants; Factors affecting distribution of crops in the tropics; Recommended Agronomic Practices.	2
2	Crop Growth and development	Various Developmental stages; Relationship of Agronomic Principles to Different Growth Stages; Determination of Grain yield.	3
3	Seed bed preparation and Tillage	Important definitions related to seed; Objectives of seedbed preparation and tillage; Timing of tillage and seedbed preparation; Methods of seedbed preparation.	2
4	Time of planting and depth of planting	Time of planting and Depth of planting.	3
5	Plant populations and spacing	Definition of various terms related to plant population; The significance of Plant population/spacing in yield determination	3
6	Cropping systems and Practices	Types of Cropping systems, patterns and cropping practices.	3
7	Principles of Crop Rotation	Definition of Crop Rotation; Rotation Design.	3
8	Principles of Mixed cropping systems:	Advantages of mixed cropping; Types of Intercropping; Advantages of intercropping systems; Limitations of intercropping systems; Assessing yield advantage and improving yield performance in intercrops.	3
9	Yield potential	Factors that determine potential yield e.g leaf area, photosynthesis, partitioning, etc.	4
10	Factors that are	Crop growth duration and grain filling period; Leaf area index and	3

	positively related to higher crop yield	duration, defoliation; Tillering ability, prolificacy; Biological nitrogen fixation; Harvest index, heterosis; Tuber initiation and bulking.	
11	Factors that are negatively related to higher crop yield	Environmental stresses; Effects and tolerance to moisture stress/drought; Waterlogging and resistance by rice; Lodging; Shattering; Flower and pod abscission; Tolerance to pests and diseases.	4
12	Factors influencing yield	Relationships between factors that determine, influence and limit yield.	4
13	Crop modelling	point and grid simulation of crop growth (potential, water-limited, nutrient limited) (e.g., DSSAT, APSIM models) and effects of pests	4
14	Project presentations …	Group Project presentations	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

1. Boote, K.J., Bennett, J.M., Sinclair, T.R., and Paulsen, G.M. (eds.). 1994. Physiology and determination of crop yield. ASA, CSA, SSSA, Madison, WI, USA
2. Purseglove, J.W. 1988. Tropical crops: Monocotyledons. Longman. 607 pp.
3. Purseglove, J.W. 1988. Tropical crops: Dicotyledons. Longman. 719 pp.
4. Acland, J.D. 1989. East African Crops. Longman. 252 pp.
5. Youdeowei, A., Ezedinma, F.O.C. and Onazi, O.C. 1988. Introduction to Tropical Agriculture. Longman. 344pp.
6. Onwueme I.C. and Sinha T.D. 1991. Field Crop production in Tropical Africa. CTA. 480pp.

7.1.18 COURSE NAME: CLIMATOLOGY AND WATER CYCLE
COURSE CODE: MSA 8104
CREDIT UNITS: 3

COURSE OVERVIEW

This course focuses on providing students with an understanding of the components of the climate system, climate system dynamics, and factors that lead to changes in the climate system. Topics are presented in order of increasing complexity, beginning with the global energy balance and radiative transfer in the atmosphere.

COURSE OBJECTIVES

Students understand;

- The different processes of the global climate and water cycle
- How to identify mechanisms of climate change and explain the interplay of climate change, sea level, clouds, rainfall and future weather

- The challenges in better understanding and adapting to the impact of climate change on water for the coming years
- Why water for food and water for cities are the main challenges in water management and what the possibilities and limitations of reservoirs and groundwater are to improve water availability

LEARNING OUTCOMES

By the end of this course, students will be able to do the following:
- Calculate the change in Earth's global energy balance, given a change in solar output, a change in Earth's albedo, or a change in the concentration of atmospheric greenhouse gases.
- Estimate a surface energy balance at a particular location given incoming solar radiation, surface albedo and information about any relevant surface features.
- Explain (both analytically and qualitatively) how the climatologically averaged ocean and atmospheric circulation patterns redistribute heat and energy across the Earth
- Describe the hydrologic cycle and feedback associated with the cycle that may stabilize or amplify climate change.
- Be able to use climatology and their understanding of global teleconnection indices (ENSO, NAO) to assist them in weather forecasting.
- Read, evaluate, and discuss current climate research articles regarding present and future climate change.
- Interpret results from studies of present climate, as well as a range of climate models and place these results in the context of modern 'global warming'
- Use a global climate model to explore a question pertinent to climatology – describe what the model does and be able to analyze the output from this model to quantify climate sensitivity to changes in forcing and identify relevant feedback mechanisms.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Atmosphere	Its composition, extent and structure	2
2	Atmospheric weather variables	Atmospheric pressure, its variation with height; Wind, types of wind, daily and seasonal variation of wind speed, cyclone, anticyclone, land breeze and sea breeze	3
3	Atmospheric weather variables …	Nature and properties of solar radiation, solar constant, depletion of solar radiation, short wave, longwave and thermal radiation, net radiation, albedo	2
4	Atmospheric weather variables …	Atmospheric temperature, temperature inversion, lapse rate, daily and seasonal variations of temperature, vertical profile of temperature, Energy balance of earth; Equilibrium temperature of Earth	3
5	Atmospheric weather variables …	Atmospheric humidity, concept of saturation, vapor pressure, process of condensation, formation of dew, fog, mist, frost, cloud.	3
6	Atmospheric weather variables …	Precipitation, process of precipitation, types of precipitation such as rain, snow, sleet, and hail, cloud formation and classification; Artificial rainmaking. Monsoon- mechanism and importance in agriculture	3

7	Components of the climate system	Climate forcing, atmospheric dynamics, Pressure and Forces; winds, cloud formation, stability, precipitation processes, weather systems, and severe weather; Feedbacks in the climate system. Role of clouds in the climate system. The role of the oceans in the climate system.	3
8	Surface fluxes and the global hydrologic cycle	Global circulation, thunderstorms, hurricanes, mid-latitude weather systems, weather and climate forecasting. Role of the land surface in climate forcing (surface fluxes and the hydrologic cycle)	3
9	Large-scale climate processes	Large-scale climate processes such as, Earth's past climates and mechanisms of future climate change. Global atmospheric and oceanic circulation, climate variability and its role in weather forecasting (ENSO, El Niño, ODA, the NAO, and monsoons), and long-term climate forcing.	4
10	Hydro-meteological Disasters and Disasters Risk Reduction	Weather hazards - drought, floods, frost, tropical cyclones and extreme weather conditions such as heat-wave and cold-wave.	3
11	Agriculture and weather relations	climatic normals for crop, livestock and fisheries production.	4
12	Climate change and climatic variability	Climate change and climatic variability, global warming, causes of climate change and its impact on regional and national Agriculture.	4
13	Climate modelling	Overview of climate models, GCMs/ RCMs; Weather forecasting- types of weather forecast and their uses.	4
14	Field trip and practices	Visit Soroti Agrometeorological Observatory, exposure of instruments and weather data recording. Measurement of maximum and minimum air temperatures, its tabulation, trend and variation analysis. Measurement of soil temperature and computation of soil heat flux. Determination of vapor pressure and relative humidity. Determination of dew point temperature. Measurement of atmospheric pressure and analysis of atmospheric conditions. Measurement of wind speed and wind direction, preparation of windrose. Measurement, tabulation and analysis of rain. Measurement of open pan evaporation and evapotranspiration. Computation of PET and AET	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

1. Global Physical Climatology (International Geophysics Series)**,** by Dennis L. Hartmann, Academic Press, San Diego, CA, 1994.
2. *Climate Change 2007: The Physical Science Basis* (from the 4th Assessment report by the IPCC) (**http://www.ipcc.ch/)**
3. The EdGCM Cooperative (**http://edgcm.columbia.edu/)**

4. 'RealClimate' – a climate science discussion board for working climate scientists and interested members of the public. (**http://www.realclimate.org/)**
5. United Nations Environmental Network portal on climate change: (**http://climatechange.unep.net/)**

7.1.19 COURSE NAME: LIFE CYCLE ANALYSIS
COURSE CODE: MSA 8105
CREDIT UNITS: 3

COURSE OVERVIEW
LCAs are a widely used framework, employed to calculate the environmental impacts of products, processes and services through their life cycles (Hallström et al. 2015), including in food production systems (Clark and Tilman 2017). Students apply quantitative approaches in LCA.

COURSE OBJECTIVES

- Get a deeper insight into LCA
- Understand the advantages and limitations of LCA
- Critically interpret the results and its uncertainties

LEARNING OUTCOMES

At the end of the course learners should be able to:

1. Gain sufficient LCA knowledge and information about the environmental impacts of products or processes
2. Gain sufficient LCA knowledge and information for selection of best environmental option and support of decision-makers in governments, businesses and private consumers

DELIVERY MODE AND TIME ALLOCATED
This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Definition and principles	Definition of product life cycle, principles of life cycle assessment, goal and scope, product sustainability management.	2
2	Life cycle thinking	Life cycle thinking, product stewardship approaches	3
3	Life cycle inventory	Concepts/issues relating to life cycle inventory	2
4	Life cycle impact assessment of production systems	Life cycle impact assessment of production systems and interpretation	3
5		Life-cycle assessment of raw materials, manufacturing and processing, use, end-of-life and recycling, supply-chain and logistics.	3
6		International standards and related guidance, functional unit, inventory, impact assessment and interpretation.	3
7		Management applications include eco-design, product benchmarking,	3

		ecolabelling and green marketing.	
8		strengths, limitations and weaknesses of sustainability performance assessment of products.	3
9	Student project …	quantitative approaches in LCA of crops	4
10	Student project …	quantitative approaches in LCA of livestock	3
11	Student project …	quantitative approaches in LCA of fisheries	4
12	Project presentations …	Group Project presentations	4
13	Project presentations …	Group Project presentations	4
14	Project presentations …	Group Project presentations	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

Hallström, E., A. C-Kanyama, P. Börjesson, 2015. **Environmental impact of dietary change: a systematic review. J. Clean. Prod., 91 (2015), pp. 1-11**

Michael Clark and David Tilman 2017. Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice ***Environ. Res. Lett.*** 12

7.1. *2***1 COURSE NAME: CROP PHYSIOLOGY**
COURSE CODE: MPB 8103
CREDIT UNITS: 3
COURSE OVERVIEW

The course provides studies about the role of physiology in commercial yield determination by looking at the crop morphology, physiological processes like respiration, transpiration, and photosynthesis, plant-water relations, stomata physiology, plant hormone functions, seed germination and dormancy, environmental stress and modeling for commercial yield under various stress factors (biotic and abiotic). In addition, students receive hands-on training in the use of modern equipment used in crop physiology studies and several analytical techniques used in modern plant physiology in order to achieve optimum yield.

COURSE OBJECTIVES

i) To understand the canopy development process and its architecture, and its implications for efficient light harvest.
ii) To understand the mechanism of damage resistance and measurement of drought in crop plants
iii) To understand physiological basis of yield formation in crops

iv) To study various types of stresses in crop production and mitigation strategies
v) To equip the students with analytical techniques used in crop physiology

LEARNING OUTCOMES

By the end of the course students will:
i) know the importance of crop physiology
ii) know how to use the equipment and laboratory apparatus used for crop physiological studies
iii) know physiological process of germination and seed formation
iv) know the assimilation partitioning and translocation of metabolites in plants
v) know the role water in crop process (photosynthesis, phytohormones, nitrogen fixation, enzymatic activity and protein synthesis in plants)
vi) understand the process of stomatal movement and its role in adaptation against drought
vii) know the types and role of different growth regulators in plants
viii) be able to evaluate how different crops tolerate environmental stresses to produce economic yield
ix) devise strategies to improve crop production by integrating concepts, methods and models based on crop physiology
x) understand the influence of environment on growth and development of crops,
xi) be able to identify physiological indicators of maturity in crops.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
	Introduction	Role of crop physiology in agriculture. Impact of climatic extremities on growth and development of crops. Concept of potential yield and its realization in relation to agroecological zones of Uganda. Physiological and phenological attributes of tolerance in climate resilient crops.	2
	Crop productivity and modelling	Crop growth and productivity: crop growth models describing yield (Duncan/Passioura), phenology-crop productivity; growth factors related to biomass - concept of growth rates canopy photosynthesis (leaf area and net assimilation rates as determining factors). Crop response production functions. Crop production under protective agriculture. Solar radiation and available moisture regimes.	7
	Crop response to light stimulus and fate of assimilates	Light interception as a major function of leaf area index (LAI), LAD canopy architecture- Light extinction coefficient relative growth rate. Net assimilation rate. Biomass and yield relations. Assimilate partitioning, yield and yield structure analysis. Concept of source and sink: Factors influencing source and sink size and productivity. Environmental factors determining crop growth. Light, temperature and VPD, effect of photoperiod and thermoperiod on duration of growth stages. Ideotype concept-selection- indices for improving crop productivity.	
	Plant Growth	Plant growth regulators – Hormones, endogenous growth substances	9

	Regulators and Plant Development	and synthetic chemicals. Endogenous growth regulating substances other than hormones. Brassinosteriods, triacontanol, phenols polyamines, jasmonates, concept of death hormone. Classification, site of synthesis, biosynthetic pathways and metabolism and influence on plant growth and development by auxins, gibberellins, cytokinins, abscisic acid and ethylene. Concept of hormone action - hormone receptors and signal transduction. Hormonal regulation of gene expressions at various developmental stages of plant growth (flowering, seed maturity, seed dormancy). Action of hormones on cellular functions (auxins, gibberellins, cytokinins, abscisic acid, ethylene). Hormonal concept of growth and differentiations. Apical dominance, senescence and abscission. Fruit growth and development: Induction and breaking dormancy in seeds and buds. Synthetic growth regulators: Practical utility in agriculture and horticulture.	
	Seed Physiology	Structure of seeds and their storage. Seed development patterns and source of assimilates for seed development. Pathway of movement of assimilates in developing grains of monocots and dicots. Chemical composition of seeds. Physiological processes. Mobilization of stored resource in seeds. Seed maturation phase and desiccation damage, role of LEA proteins. Seed viability. Seed dormancy. Means to overcome seed dormancy	5
	Abiotic Stress Responses in Plants	Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress. Drought characteristics, water potential in the soil-plant-air continuum. Stomatal functions/VPD. Physiological processes affected by drought. Drought resistance mechanisms: Escape, dehydration postponement, dehydration tolerance, and characteristics of resurrection in plants. Water use efficiency as a drought resistance trait. Stress and hormones (ABA and Cytokinin). Oxidative stress: reactive oxygen species (ROS) – role of scavenging systems (SOD, catalase etc.). High temperature stress: tolerance mechanisms- role of membrane lipids in high temperance tolerance. Functions of HSPs chilling stress and its effects on physiological processes. Salinity: salinity effects at cellular and whole plant level and tolerance mechanisms. Breeding for salt tolerance. Heavy metal stress: aluminum and cadmium toxicity in acid soils. Role of phyto-chelatins (heavy, metal binding proteins).	8
	Post-Harvest Physiology	Senescence and ageing in plants. Ethylene effects. Monocarpic plant senescence. Gene expression during senescence. Concept of physiological maturity of seeds and environmental factors influencing post-harvest deterioration of seeds. Transgenic technology for improvement of shelf-life.	4
	Practicals/tutorials	Apply methods of measuring water availability and radiation use efficiency. Identification of growth stages of selected crops (cereals, legumes, oil crops, root crops). Identification of position, number and size of stomata. Centrifugation and use of tracers. Techniques used for studying water relations in plants. Plant growth analysis.	10

		Measurement of cell membrane permeability and stability. Demonstration of effect of magnetism on growth and development of plant. Measurement of leaf area and calculation of LAI. Calculation of indices of crop growth. Calculation of effective seed growth rate and duration. Calculation of partitioning coefficient.	
	Tutorials/practicals		
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done inform of tests (20%), assignments (10%), practicals/tutorials and report writing (10%). It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

Egli, D. 2021. Applied Crop Physiology: Understanding the Fundamentals of Grain Crop Management. CABI. ISBN: 9781789245950.

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Kochhar, S.L. and S.K. Gujral. 2020. Plant Physiology Theory and Applications 2nd Ed. Cambridge University Press. ISBN:9781108639736.

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Salisbury, F. B. and C. W. Ross. 2010. Plant Physiology. 5th Ed., Wordsworth Publishing Company.

Taiz, L. and E. Zeiger. 2010. Plant physiology. 6th Ed. Sinauer Associates, Inc., Publishers, Sunderland, USA.

7.1. 22 **COURSE NAME: AGRICULTURAL ENTOMOLOGY AND PLANT PARASITIC NEMATODES**
COURSE CODE: MPB 8104
CREDIT UNITS: 3

COURSE OVERVIEW

The course provides overview of the economic importance of insect pests and plant parasitic nematode damage in agricultural cropping systems. It highlights how organisms become pests, insect and nematode damage and a brief description of control measures of insect pests and plant-parasitic nematodes to control population densities. Students will be able to relate basic insect and nematode morphological structures to ecology, life cycle, damage they cause and interactions with other organisms. Upon completion of the course students will appreciate the reasons why some insects become pests, and will be provided with intellectual tools to evaluate

whether particular species might be causing economic damage. Students will be exposed to various pest sampling techniques and pest identification and pest damage analysis in relation to particular pests.

COURSE OBJECTIVES

i) To identify insects of economic importance and acquire working skills for collecting, mounting, and preserving insects.
ii) To study the roles of insects in agriculture
iii) To provide a foundation in pest management and economic decision making as applied to agro-ecosystems.
iv) To describe a range of methods to control insect pests, including their strengths, weaknesses and compatibility;
v) To identify and collect the pertinent information to make informed-management decisions on pest management.
vi) To familiarize the students with principles of insect pest management.
vii) To familiarize the students with types of damage caused by economically important pests.

LEARNING OUTCOMES

By the end of the course students will:
i) be able to identify insects of economic importance and acquire working skills for collecting, mounting, and preserving insects;
ii) appreciate the importance of insect and nematodes that affect the commercial value of crops,
iii) learn how to identify various economically important insect pests and nematodes basing on damage they cause and body parts.
iv) develop an understanding of the distributions and abundances of economically important insect pests and nematodes and making decisions on how they can be managed.
v) develop the ability to design and perform scientific studies about insects, analyze results and be able to make pest management decisions based on EIL estimation.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1.	Introduction	Definition of insect pests and economically (parasitic, entomopathogenic) and important plant nematodes and how organisms become pests. Nematodes as indicators of pollution and toxicity.	2
2.	Body structures of economically important insects and nematodes that cause crop damage	Body structures and modifications; types of mouth parts and modifications. Leg structures and modifications. Types of economically important insect life stages. Structure, modification and physiology of different systems (digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands). Insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; artificial diets.	3

3	Insect and nematode distribution	Study of abundance and distribution and relation between the two. Implications for abundance and distribution of insects and nematodes- Law of the Minimum, Law of Tolerance, and biocoenosis. Systems approach to ecology. Basic concepts of abundance- Model vs Real world. Population growth models: Exponential vs Logistic models. Discrete vs Continuous growth models. Balance of life in nature- Concepts of Carrying capacity, Environmental Resistance. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Population dynamics- Factors affecting abundance: Environmental factors, dispersal and migration, Seasonality in economic insects and nematodes. Biotic factors- Food as a limiting factor for distribution and abundance. Food chain- web and ecological succession. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions Competition- Lotka-Volterra model, Concept of niche, ecological homologues, competitive exclusion. Prey-predator interactions- Defense mechanisms against predators/parasitoids-	5
4	Storage entomology	Types of insect pests and mites in storage. Sources and development of infestation. Detection of infestation. Fumigants and methods of fumigation. Seed protectants and their effect on seed viability.	4
5	Causes of pest outbreak and resurgence	Pest resurgence and replacement (secondary pest outbreak). Causes and management of resurgence and replacement	2
6	Forecasting pest outbreaks	Forecasting pest outbreaks and surveillance (Short term and long-term forecasting); Forecasting based on observations – climatic and empirical factors	2
7	Types of damage caused by insect pest and nematodes	Injury by chewing, piercing, sucking insects, internal feeders, subterranean insects, to stored products and indirect effect of feeding	4
8	Decision making in management of insects and nematodes	Decision-making concepts: Economic thresholds; Action thresholds; Economic injury levels.	2
9	Ecological management and control of economically important insect pests and nematodes	History, definition and evolution, scope and need for IPM. Concept and philosophy, ecological principles. Tools of pest management and their integration legislative, cultural, physical and mechanical methods. History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation. Role of insect pathogenic fungi, bacteria, nematodes, viruses, protozoa etc., their mode of action. Biological control of weeds using insects. Mass production of quality biocontrol agents- techniques, formulations, economics, field	4

		release/application and evaluation. Examples of successful biological control projects, analysis, trends and future possibilities of biological control.	
10	Chemical management and control of economically important insect pests and plant parasitic nematodes	Definition of insecticide toxicology; history of chemical control, Classification of insecticides based on mode of entry, mode of action and chemical nature. Mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals etc. Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity. Insecticide metabolism; pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence. Insecticide residues, their significance and environmental implications. Safe use of insecticides; diagnosis and treatment of insecticide poisoning. Describe methods of insect control, Classes of insecticides, their formulation and application	7
11	Practicals and tutorials	Methods of sampling insects, estimation of densities of insect and understanding the distribution parameters- measures of central tendencies, poison distribution, negative binomial distribution. Calculation of some diversity indices- Shannon's, Simpson's index and understanding their association and the parameters that affect their values. Computation of life tables. Field visit, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops; study the life history of important insect pests. Collection, identification and mode of damage of insect pests of various crops, fruits, vegetables, stored grains and household; insecticide formulations, their dilutions and safe handling; use of application equipment. Methods of sampling for nematodes. Methods of killing, fixing, preserving, staining, mounting and measuring of nematodes. Experimental techniques for proving pathogenicity, estimation of crop losses, nematicide screening, screening and evaluation for nematode resistance in crops. Molecular technique for nematode diagnostics.	10
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in inform of quizzes, tests, presentations, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

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7.1.23 COURSE NAME: AGRICULTURE, FOOD SECURITY AND INTERNATIONAL LAW

COURSE CODE: MSA 8201

CREDIT UNITS: 3

COURSE OVERVIEW

It's an ever more interconnected world out there with complex, interacting drivers of change. We will consider what a 'global food system' is and how international law is relevant to understanding global food systems. We will also introduce and discuss some of the main challenges to our current global food system. The course then, offers students different lenses playing out in the development of systemic structural and socio-spatial inequities and injustices in food systems. It develops an understanding and contextualization of the role of food justice activism within the broader narrative of the alternative food movement and offers emerging ideas about how policymakers and planners can take a role in increasing food justice beyond the more mainstream and ultimately contested notions of what is "local" and "sustainable." Students will learn about the trade-offs in environmental change and social justice that are now central to the development–environment nexus at all levels, from local to global. By exploring a range of conceptual framings of this complexity and then applying this learning to a number of exciting case-studies, you will develop the expertise to understand - and the confidence to tackle - socio-environmental challenges. The course will help participants chart their role(s) in advocating for 'just sustainability' as a defining factor in becoming food systems planners and policymakers.

COURSE OBJECTIVES

1) Provide students with knowledge they can be applied immediately to influence food safety policy, interpret international laws and regulations, and bridge the gap between regulators and industry.
2) Ensure students understand the legal complexities of food laws and regulations, and their impact on the flow of food and agricultural products across national boundaries.
3) Apply sound science and food law to the work of solving complex, practical problems related to the regulation of food.

LEARNING OUTCOMES

At the end of the course learners should be able to:

1) build knowledge of how food systems interact with human development policies at international, national and local levels.
2) gain the conceptual and practical skills necessary for the analysis and development of planned food security interventions.

DELIVERY MODE AND TIME ALLOCATED
This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	food regime theory	attempts to understand and analyse the role of agriculture in the development of a world capitalist economy.	2
2	Different areas of international law	Including environmental law, trade law, human rights law, intellectual property law, food safety law, biodiversity law, climate change law - are relevant in understanding and shaping the current food regime. A central question is what contribution international law may make in achieving food security.	3
3	The neoliberal food regime	From Colonialism to Green Capitalism: Social Movements and Emergence of Food Regimes'	2
4	Food sovereignty movements:	Resistance against the neoliberal food regime (	3
5	Food security	food availability, access to food, utilization and stability	3
6	Regimes complexes	The Regime Complex for Food Security	3
7	Food security and international (trade) law	Continuing Legal Barrier to International Food Trade	3
8	Food safety	The WHO in Global Food Safety Governance	3
9	Agricultural subsidies	The Subsidy Habit	4
10	The legal regulation of GM foods	Law and Modern Biotechnology, Why Genetic Engineering Is Not Solving Agriculture's Drought Problem in a Thirsty World	3
11	Intellectual property and agriculture	'Intellectual Property Rights in Plant Varieties: International Legal Regimes and Policy Options for National Governments	4
12	The human right to food	The Right to Food in International Law	4
13	Students projects	Project presentations	4
14		Exams	4
	Total		**45**

MODE OF ASSESSMENT
Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

Harriet Friedmann, 'From Colonialism to Green Capitalism: Social Movements and Emergence of Food Regimes' in *New Directions in the Sociology of Global Development*, ed. Frederick H. Buttel and Philip McMichael (Elsevier, 2005), pp.227-264. (Read closelypages 251-259.)

Philip McMichael, 'Global Development and the Corporate Food Regime' in *New Directions in the Sociology of Global Development*, ed. Frederick H. Buttel and Philip McMichael (Elsevier, 2005), pp.265-299. (Read closely pages 270-286; pages 286-291 as a prelude to next week's topic.)

Henry Bernstein, 'Food Regimes and Food Regime Analysis: A Selective Survey', A paper presented at the conference *Land Grabbing, Conflict and Agrarian-Environmental Transformation: Perspectives from East and Southeast Asia*, 5-6 June 2015, Chiang Mai University.

7.1.24 COURSE NAME: TROPICAL ANIMAL HUSBANDRY SYSTEMS AND SUSTAINABLE FOOD PRODUCTION
COURSE CODE: MSA 8202
CREDIT UNITS: 3

COURSE OVERVIEW

The course will attempt to answer the question; Are livestock always bad for the planet?

COURSE OBJECTIVES

- To deepen students understanding of the role of livestock production systems in sustainable agriculture and environmental quality

LEARNING OUTCOMES

At the end of the course learners should be able to:

- understand the impact of the natural and economic environment on the evolution of different types of husbandry systems as well as on their orientation and intensity of production;
- gain understanding for parameters that have to be considered when aiming at the improvement of livestock husbandry systems within a given framework; individually analyse and present a specific tropical livestock production system.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	The three dimensions of livestock production	namely; nutrition, reproduction physiology and animal breeding within an intensive and extensive production system.	2
2	Typology of livestock	Extensive overview on the different forms of animal husbandry	3

	farming systems:	systems in developing and transformation countries of Africa, Asia and Latin America, ranging from nomadism in deserts and semi-arid regions to beef ranching and intensive dairying in tropical highlands. The system-specific strategies of livestock management are analysed in view of their ecological and economic sustainability (Smallholder mixed farming systems; Pastoral systems; Commercial grazing systems; Intensive livestock systems; Links with plant-based systems).	
3	Structural transformation of livestock farming systems and food systems	The (potential) interactions of livestock with other components of the farming system are explored, thereby differentiating between market and subsistence oriented systems. The accelerated livestock revolution breeds and types (Ruminants vs monogastrics), growth in demand for livestock products, tied to human population growth, rising incomes, continuing urbanization and changing food preferences.	2
4	Intensification of livestock production scales	The notion of the livestock revolution – with its promise of dietary diversity, improved nutrition and health; economic opportunities for small-scale producers; and growing, often negative, effects on natural resources.	3
5	Evolution of crop–livestock linkages.	The role of livestock in soil fertility management, farm mechanization, food security, sustainable livelihoods, rice-fish integration	3
6	Projections and scenarios for agricultural development, focusing on livestock supply and demand in different parts of the world	Sustainability Challenges For Livestock in Agricultural and sustainable Development. Cross-cutting global challenges; Environmental challenges (sustainability of livestock husbandry; environmental effects of animal keeping and their avoidance: a) Livestock and global land use change (e.g., amazon); b) GHG emissions and environmental pollution from animal holdings), Economic challenges, Social challenges, Health challenges and Animal welfare.	3
7	Projections and scenarios for agricultural development, focusing on livestock supply and demand in different parts of the world	Key challenges in smallholder mixed-farming systems; limited access to resources, market and services, low resource efficiency and resilience.	3
8	Projections and scenarios for agricultural development, focusing on livestock supply and demand in different parts of the world	Key challenges in pastoral systems; Conflicts for land and water; Economic and policy-related discrimination, Social and gender inequity, Human and animal health challenges.	3
9	Projections and scenarios for agricultural development, focusing on livestock supply and	Key challenges in commercial grazing systems. Key challenges in intensive livestock systems; Environmental challenges resulting from intensification, Health impacts of intensive systems, Social challenges in intensive systems, Economic challenges in intensive systems	4

	demand in different parts of the world		
10	Pathways Towards Sustainable Agricultural Development Focusing On Livestock	The three-tier approach to elaborate pathways towards sustainable agricultural development for food security and nutrition: first, looking at the operational principles for pathways and the tools for solutions on the ground; second, looking at the enabling environment; and third looking at farm practices of the different livestock farming systems already identified, namely: smallholder mixed farming, pastoral, commercial grazing and intensive livestock systems. Pathways combine technical actions, investments and enabling policy instruments. 1) Operational principles for solutions towards sustainable agricultural development; Improve resource efficiency, Strengthen resilience, Secure social equity/responsibility, Controversies around solutions. 2) Enabling sustainable agricultural development solutions and responses; Investing in agriculture as an overall economic priority, Role and limits of markets, Diversification and integration, Gender, Institutions and governance.	3
11	Pathways Towards Sustainable Agricultural Development Focusing On Livestock	Pathways in specific farming systems; Smallholder mixed farming systems, Pastoral systems, Commercial grazing systems, Intensive livestock systems.	4
12	Project presentations …	Group Project presentations	4
13	Project presentations …	Group Project presentations	4
14	Project presentations …	Group Project presentations	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

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7.1.25 COURSE NAME: POSTHARVEST HANDLING AND VALUE ADDITION
COURSE CODE: MSA 8203
CREDIT UNITS: 3

COURSE OVERVIEW
Evidence from a recent Food, Agriculture and Natural Resources Policy Network (FANRPAN) study in sub-Sahara Africa reveals that farmers have inadequate capacity and technologies to 'protect their harvest', with annual post-harvest losses estimated at between 35-50 % of produced food. The course cover important practices to reduce postharvest losses agricultural products.

COURSE OBJECTIVES

- To deepen students' knowledge and skills on how to reduce food loss, waste and management of quality, packaging, marketing, and safety activities related to agricultural products

LEARNING OUTCOMES

At the end of the course learners should be able to:

- Describe the processes/factors that result in quality deterioration and loss of harvested produce
- Explain technologies/procedures applied to improve quality and reduce losses of harvested produce.
- Discuss quality attributes and standards required to maintain safety of harvested produce
- The latest insights in the postharvest physiology, ripening and deterioration processes in fresh horticultural products (fruit, vegetables, flowers and potted plants)
- Current technologies for storage, packaging and handling

DELIVERY MODE AND TIME ALLOCATED
This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Definition of terms	Postharvest physiology, Importance of Postharvest Technology.	2
2	Perishable and non-perishable crops	A Comparison between perishable and non-perishable crops.	3
3	Value of crops and their losses …	Value of harvested crops, The Postharvest Food Pipeline: Stages at which crop losses occur.	2
4	Factors causing Postharvest Losses …	Preharvest factors, Biological factors (Physiological factors, insect pests), physical and chemical factors	3
5	Factors causing Postharvest	Postharvest disorders and diseases and Environmental factors.	3

	Losses		
6	Postharvest Technology Procedures	On-farm (Primary) processing technologies, Storage technologies for primary processed products, Technologies for management of perishable produce.	3
7	Harvesting and Quality Requirements for Perishable and Non-perishable Crops	Maturity and indices, Parameters used to describe quality of commodities, Grade standards and inspection, Mechanical and Hand harvesting, Preparation of produce for the Fresh market, Packaging and packages for fresh produce.	3
8	Value addition and technology	Production of diversified products, packaging, storage and transport	3
9	Supply chain management.	Challenge to increase their handling efficiency and minimise postharvest food losses	3
10	**Practical**	Field trips to industrial plants and commercial farmers	**10**
11	**Tutorial**	Students project presentations	**10**
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

REFERENCES

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7.1.26 COURSE NAME: GENDER & DEVELOPMENT

COURSE CODE: MSA 8204

CREDIT UNITS: 3

COURSE OVERVIEW

This course examines men and women's lives and the impact upon them as a result of development and incorporation into global, economic and political systems. The course begins with theoretical approaches to gender and development, development theory, and feminist critiques. We then turn to how social change (positive or negative development) happens. We will examine in detail issues of production (formal and informal work), reproduction (health, child survival, and fertility), and the

family/household nexus (where production and reproduction meet). The seminar discussions will be about gender and globalization, and b) bringing gender into projects, program planning and evaluation.

Objectives

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

- Define gender and related concepts and appreciate its relevance to agriculture
- Identify gender aspects of agriculture and rural society
- Present, compare and apply the current theoretical approaches that explain the (re)production of gender difference
- Review research and policy questions in a gender sensitive manner
- Assess the gender-specific impact of socio-economic and political changes

Outcomes

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

- Acquire the lens of gender that help them interpret the centrality and complexity of gender in their daily lives;
- Acquire concepts and theories that can analyse how gender differences and inequalities are reinforced, constructed and challenged in different domains of social lives and at different levels, i.e. individual identities and practices, social interactions, social institutions and cultural systems;
- Apply concepts and theories of gender to critically evaluate the representations or claims in the media, popular culture, or public discourses;
- Critically evaluate the extent that gender relations have been transformed;
- Propose a plan that can promote gender equity or show how gender can be challenged and reconstructed differently.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Introduction to gender studies	Overview of gender concepts and related terms	3
2	Understanding Social Change and Development	Theories of Social Change (Economic, Political and Social) and the Gender Perspective. Sociological concepts of “demographic change”, “social structural developments and Social problems in rural areas” (deprivation, rural poverty). The individual, group, and social system; socialization and social control. Traditional societies and peasant life. Population trends and changes in the emerging rural community institutions. Organizational behaviour: contextual factors, technology and personnel.	4
3	Citizen participation in social change	Voluntary associations and Gender, primary groups, social movements, political action and client organization.	3
4	Theories of change	diffusion and adoption of innovations by gender.	3

5	From women to gender: The development of the field	What is efficient, equitable, and equal? efficiency, equity and equality, multilevel and multisectoral issues. Male bias in the development process. From WID to GAD: Conceptual Shifts in the Women and Development Discourse Gender Planning and Development	4
6	Contending perspectives, differing voices	Globalization of feminism and human rights? Who is to say what is right? Feminism and the claim to know: Contradictions in feminist approaches to women in development	3
7	Work and Gender Relations (Inside/Outside the House)	Gender and work-gender analysis; Women, Work, and Gender Relations Gender trends in agrarian change: Western and non-western countries; Intra-household Resource Allocation and Income Sources Women and Income in the Third World Relevance of gender in agricultural development;	4
8	Agriculture, Environment and Gender	Gender Relations and Food Security Women's Crops in Women's Spaces	3
9	Empowerment by women …	Feminist theories on the status of women and men; Rural development policy (representation of men and women in policies and their participation in policy processes);	4
10	Empowerment by women …	Mainstreaming gender in agricultural development (e.g. policy, research, extension, training; Gender analysis and Gender responsive planning; Gender and natural resource management; Resources, gender and poverty).	4
11	Project presentations …	Group Project presentations	3
12	Project presentations …	Group Project presentations	3
13	Project presentations …	Group Project presentations	4
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured, multiple-choice questions or a presentation of research paper).

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7.1.27 COURSE NAME: BIOGAS & ALTERNATIVE FARM ENERGY SYSTEMS
COURSE CODE: MSA 8205
CREDIT UNITS: 3

COURSE OVERVIEW

Energy utilization in the farm can be an important cost aspect. This course introduces important aspects of sustainable utilization of nutrients and energy with a bias towards animal production systems. The course covers fundamental topics such as introduction to energy and the global energy overview. Students are also introduced to the concept of energy and sustainability in which the role of energy in sustainable development, circular economy and climate change are discussed. The course also delves into the various farm energy sources and how to estimate energy requirement of farm activities. Detailed discussions on biogas technology for animal waste management and energy and fertilizer recovery are introduced to students including anaerobic digestion and biochemical processes, operational parameters of biogas plants, and planning, design and construction of biogas plants, and biogas upgrading methods and utilization. The utilization of biogas digestate as fertilizer including its soil application effects, digestate conditioning and quality are also discussed. The course then discusses the role of solar in agricultural applications. This includes discussions on photovoltaic technology applications for irrigation, livestock watering, aquaculture, and refrigeration of meat and other dairy and animal products. The course concludes by discussing applications of other renewable energy sources such as wind and geothermal energy in agricultural value chain.

COURSE OBJECTIVES

1. To introduce students to global energy perspective and sustainability dynamics especially in the context of agricultural production.
2. To equip students with knowledge and skills pertaining to biogas technology and application especially in the context of resource-limited countries
3. To introduce students to agricultural applications of solar, wind and other renewable energies

LEARNING OUTCOMES

At the end of this course the students should be able to:

- Appreciate the energy gap in developing countries and the drag it imposes on her food systems
- Know the various fermentation processes that lead to biogas production
- Design, construct, operate and maintain a biogas plant
- Understand the role solar, wind and other renewable energies can play in agricultural production

DELIVERY MODE & TIME ALLOCATED

The course is conducted through a series of lectures (30 hours), practicals (15 hours) and tutorials (15 hours), adding up to a total 45contact hours.

	TOPIC	CONTENT	CH
1	Introduction	Introduction to energy, Definitions and units of energy, Global energy overview, Sub-Saharan Africa and Ugandan energy matrices, The Uganda National Energy Policy 2019.	**2**
2	Energy and sustainability	The role of energy in development, Energy and	**2**

		sustainable development, Energy and the circular economy, Energy and climate change.	
3	Farm energy	Energy utilization on the farm, Sources and uses of farm energy (Human, Animal draught, Engine, Electricity, Bioenergy, Biogas, Solar, Wind, Geothermal), Estimation of energy requirement of farm activities	**3**
4	Introduction to biogas technology	What biogas is and why it is needed, Benefits of biogas to society, Benefits of biogas to farmers	**1**
5	Biogas from anaerobic digestion	Introduction to anaerobic digestion, Substrates for anaerobic digestion, The biochemical processes of anaerobic digestion (Hydolysis, Acidogenesis, Acetogenesis, Methanogenesis), Parameters for anaerobic digestion (Temperature, pH-values and optimal ranges, Volatile fatty acids, Ammonia, Micro- and macronutrients, Toxic compounds), Operational parameters of biogas plants (Organic load, Hydraulic retention time, other parameters)	**6**
6	Biogas farm applications	Design of agricultural biogas plants (Family-scale biogas plants, Farm-scale biogas plants, Centralized co-digestion plants), Biogas properties, Direct combustion and heat utilization, Biogas upgrading (Biogas as vehicle fuel, Biomethane for grid injection)	**2**
7	Biogas fertilizers	Anaerobic digestion for animal manure and slurry management in intensive system, Raw slurry to digestate as fertilizer, Application of digestate as fertilizer, Effect of digestate application on soil, Digestate conditioning, Digestate quality management	**3**
8	Biogas plants	Components of a biogas plant (Feedstock receiving unit, Feedstock storage and conditioning, Feeding system, Digester heating system, Batch digesters, Continuous digesters, Digester maintenance, Stirring system, Biogas storage, Biogas cleaning, Digestate storage), Planning and building a biogas plant (Setting up a biogas plant project, Securing continuous feedstock supply, Siting a biogas plant, Safety of biogas plants, Economics of biogas plants)	**4**
9	Introduction to solar energy	Introduction to solar and photovoltaic technology, Rural energy and rural development, the Rural electrification challenge, Dynamics of photovoltaic rural electrification - barriers, institutions, and markets	**2**
10	Photovoltaic applications in agriculture	PV home lighting and heating, Solar dryers, PV for irrigation water pumping, PV for livestock watering, PV for aquaculture and fishing, PV for refrigeration of meat, dairy and other products, PV for electric fences,	**3**

		PV for other agriculture applications	
11	Other renewable energies (Wind and geothermal)	Fundamentals of Wind energy, Wind energy conversion systems, Wind system applications, Introduction to geothermal energy, Applications of geothermal energy in agriculture	**2**
12	**Practical**	Students biogas projects	**20**
13	**Tutorial**	Biogas projects presentation	**10**
	Total contact hours		**45**

MODE OF ASSESSMENT

Continuous assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 30% of the final students' score.

University examination: This covers 70% of the final score. It includes a written examination (essays, structured and multiple choice questions) which carries 40%, a practical examination 20%, and an oral exam 10%.

Resources available

The Arapai campus has plenty of land where all types of animal species can be kept. There are also enough personnel available to teach this course. (NB: Refer to section 3.1 and 3.2)

REFERENCE MATERIALS

- Al Seadi, T., 2008. Biogas handbook.
- BT Njuguna (2002). Biogas Technology. ISBN8122413803
- D. Craddock (2008). Renewable energy made easy.
- D. Deublein, A. Steinhauser (2008). Biogas from waste and renewable Resources.
- Kitani, O., Jungbluth, T., Peart, R.M. and Ramdani, A., 1999. CIGR handbook of agricultural engineering. *Energy and biomass engineering*, *5*, p.330.
- Pimentel, D., 2019. *Handbook of energy utilization in agriculture*. CRC press.
- Stout, B.A., 2012. *Handbook of energy for world agriculture*. Elsevier.

7.1.28 COURSE NAME: PLANT PATHOLOGY
COURSE CODE: MPB 8201
CREDIT UNITS: 3

COURSE OVERVIEW

The course aims at providing knowledge about plant diseases and their management and sharpens the skills of students in various techniques and processes associated with plant protection. During the course, emphasis is put on enhancing analytical thinking ability which helps the students in handling and solving problems associated with plant diseases and their causal agents.

COURSE OBJECTIVES

To gain an understanding of the importance of crop diseases caused by various agents.
To establish the infection and survival of plant pathogenic microbes
To be able to diagnose diseases causing agents basing on signs and symptoms
To get the information about how to manage and control plant disease by the use of various methods
To develop an insight into plant defense mechanisms against diseases.

LEARNING OUTCOMES

By the end of the course, the students will be able to: Discuss the importance of crop diseases and their causal agents. Describe the symptoms and types of plant diseases. Diagnose and identify common crop diseases and prescribe effective management options.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Introduction	History of Plant Pathology. Outline of classification of plant diseases	2
2	Plant Disease Epidemiology and Economic importance of plant pathogens and diseases	Means of dissemination (active and passive dissemination) and ideal conditions for disease development. The roles that plant pathogens and diseases play in national and international trade, bio-security, and natural environments	2
3	Seed Pathology	Pathological Effects of Seed borne diseases- i) Seed abortion ii) Shrunken seeds and Reduced seed size iii) Seed rot iii) Sclerotisation & Stromatisation iv) Seed discolouration v) Reduced or complete loss of germinability	4
	Plant Disease Development	Molecular mechanisms of pathogenesis: Elicitors, recognition phenomenon, penetration, invasion, primary disease determinant. Enzymes and toxins in relation to plant disease. Mechanisms of resistance, Structural and Biochemical defense mechanisms. R-Genes, Phytoanticipins. Phytoalexins. PR proteins, Hydroxyproline rich glycoproteins (HRGP). Antiviral proteins. SAR and ISR. HR and active oxygen radicals. Management of pathogens through satellite, antisense - RNA. Ribozymes, coat protein, RNA interference, plantibodies, hypovirulence, cross protection.	
5	Plant defense mechanisms	Structural and biochemical; pathogenesis related proteins; Reactive Oxygen Species (ROS); Role of secondary metabolites; Elicitors and Receptors; Hypersensitive reactions; Defense strategies: role of oxidative burst, Phenolics, Pathogenesis Related (PR) proteins, Elicitors. Phytoalexins in plant defense; Mechanisms underlying systemic acquired resistance.	4

6	Genetics of plant disease resistance	'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.	2
7	Pathogen identification	Microscopic techniques and staining methods, phase contrast system, chromatography, use of electron microscope, spectrophotometer, ultracentrifuge and electrophoretic apparatus, disease diagnostics, serological and molecular techniques for detection of plant pathogens. Evaluation of fungicides, bactericides etc.	4
8	Fungal aspects	Plant pathogenic fungi; ecology and spread of fungal diseases; host range; measurement of fungal growth; diseases caused by plant pathogenic fungi; pathogenicity and virulence factors of fungi; plant response to fungal infection; diagnosis of fungal diseases: symptoms, microscopic examination, isolation, confirmatory tests of fungi, pathogenicity. Fungi on seeds Characteristics of major storage fungi.	4
9	Aspects of Bacteria and Mollicutes	plant pathogenic bacteria; ecology and spread of bacterial diseases; host range; measurement of bacterial growth; diseases caused by plant pathogenic bacteria; pathogenicity and virulence factors in bacterial diseases; plant response to bacterial infection; diagnosis of bacterial diseases: symptoms, microscopic examination, isolation, gram stain test, biochemical tests, serological tests, fatty acid-based tests, Polymerase Chain Reaction (PCR)-based analysis	6
10	Viral and phytoplasma aspects	plant pathogenic viruses; ecology and spread of viral diseases; host range; diseases caused by plant pathogenic viruses; pathogenicity and virulence factors in viral diseases; plant response to viral infection; diagnosis of viral diseases: symptoms, Polymerase Chain Reaction (PCR)-based analysis, pathogenicity of viruses. Characteristics and ultra-structure of viruses/virions, isolation and purification of viruses, chemical nature, replication, transmission of viruses, economic importance of viruses. General characteristics and role of viruses in causing plant diseases.	4
	Principles of plant disease control	Attack on the parasite; strengthening of the host, modification of environments; biological control of plant pathogens; immune system (plant-microbe interaction); gene-for-gene interaction, acquired and systemic resistance (PR proteins); use of transgenics	
	Management of Plant diseases	General principles of plant quarantine. Exotic pathogens and pathogens introduced into Uganda. Sanitary and phytosanitary issues under WTO, TRIPS and PRA. Microorganisms antagonistic to plant pathogens in soil, rhizosphere and phyllosphere and their use in the control of plant diseases; soil fungistatic. Plant growth promoting Rhizobacteria. Biotechnology for crop disease management	
11	Methods of plant	Control through regulatory methods: Plant quarantine. Cultural	4

	disease control	and biological methods of control. Control through physical means. Chemical method for plant disease control: Fungicides, chemotherapy. Use of resistant varieties.	
12	Practicals	Preparation and sterilization of common media. Methods of isolation of pathogens and their identification. Preservation of microorganisms in pure culture. Methods of inoculation. Measurement of plant disease. Isolation of soil fungi by Warcup method. Measurement of fungal growth by linear determination. Study of the effect of incubation temperatures on fungal growth (150 C, 300 C & 600 C). Isolation of nematophagous fungi from garden soil/agriculture soil. Isolation of fungal pathogens from infected leaves. Study of different symptoms of plant diseases: i) Wilting ii) Leaf spot iii) Canker iv) Leaf mosaic. Inoculation and isolation of pathogens, purification of fungal culture, Koch's postulates. Methods of spore germination.	10
	Totals		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of quizzes, tests, presentations, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

Balaji Aglave. 2018. Handbook of Plant Disease Identification and Management. CRC Press. ISBN 9781138585478.

David B. Collinge. 2016. Plant Pathogen Resistance Biotechnology. John Wiley & Sons, Inc. ISBN:9781118867761.

John A. Lucas. 2020. Plant Pathology and Plant Pathogens. Willey Blackwell. ISBN: 9781118893869.

Robert Burns (Ed.). 2008. Plant Pathology: Techniques and Protocols. Humana Press. ISBN: 9781588297990.

Tronsmo, A.M., D.B. Collinge, A. Djurle, L. Munk, J. Yuen and A. Tronsmo. 2020. Plant Pathology and Plant Diseases. CABI. ISBN: 9781789243185.

APPENDIX A: PROGRAM FUNDING

The Master of Science in Global Change and Sustainable Agriculture (GSA) will be funded through:
Tuition fees. See Table 4 below

- Government funding.
- The presidential initiative proposal has been incorporated into funding for the program
- Development partners
- Project Proposals to donor agencies
- Position the program for the upcoming Africa Mobility Scheme proposals later thisyear.
- Engage SIDA for possible support of MSc and PhD in Global Change and Sustainable Agriculture (GSA).
- The MSc in Global Change and Sustainable Agriculture (GSA) budget has been developed based on costs chargeable to Uganda students admitted to the course. The budget is based on the assumption that 10 students are admitted to the course. Each of the budgets includes recurrent expenditures and projected staff costs (both academic, administrative and support staff) and capital expenditure and other running costs.

Table 4. Proposed program budget

Assuming intake of 10 students		
A. REVENUE PER SEMESTER	**Semester I**	**Semester II**
Tuition fees	Amounts (UGX)	Amounts (UGX)
Students fees	3,500,000	3,500,000
(UGX 7,000,000 per annum)		
Tuition fees for 10 students @UGX 3,500,000	35,000,000	35,000,000
Total	***35,000,000***	***35,000,000***
B. EXPENDITURE PER SEMESTER		
University Council 9%	3,150,000	3,150,000
Teaching Expenses 50%	17,500,000	17,500,000
Administrative Expenses 5%	1,750,000	1,750,000
Office Expenses 3%	1,050,000	1,050,000
Library Materials 2%	700,000	700,000
Faculty levy 5%	1,750,000	1,750,000
Utilities/Furniture 2%	700,000	700,000
Staff Development 2%	700,000	700,000
Repair/reinforcement of Materials lab 10%	3,500,000	3,500,000
Air ticket for visiting professors 12%	4,200,000	4,200,000
Total 100%	***35,000,000***	**3,500,000**

APPENDIX B: LIST OF ACADEMIC AND TECHNICAL STAFF

SN	NAME OF STAFF	GENDER	HIGHEST QUALIFICATION	AWARDING INSTITUTION	ACADEMIC QUALIFICATIONS	FIELD OF SPECIALIZATION	Staff Status
1	Assoc.Prof. Dr. Victor A. Ochwoh.	Male	PhD	University of Pretoria, SA	BSc. Agric., MSc, PhD	Sustainable Agriculture	Permanent
2	Dr. John E. Wasige	Male	PhD	University of Twente, Netherlands	BSc Agric.(Mak), MSc. (Mak), PhD (WU)	Soil science	Permanent
3	Assoc. Prof. Dr. Michael Masanza	Male	PhD	Wagenningen University & Research, Netherlands	BSc. Agric., MSc, PhD	Entomology	Permanent
4	Prof. Deo Olila	Male	PhD			Vetnary sciences	Permanent
5	Mr. Turyasingura Geoffrey	Male	MSc.	Makerere University, Uganda	BSc.EDUC and VOC studies (KYU), MSC Agric. Extension (Mak)	Agricultural extension/ sociology	Permanent
6	Dr. Peter Opio	Male	PhD	Chiba University, Japan	BSc (Agric), MSc, PhD	Horticultural sciences	Permanent
7	Dr. Asha Nalunga	Female	PhD	Michigan State University, USA	BSc (Agric), MSc, PhD	Agric. statistics	Permanent
8	Dr. David Magumba	Male	PhD		BSc (Agric), MSc, PhD	Agric. statistics	Permanent
9	Dr. Ronald Kabbiri	Male	PhD	University of Ghent, Belgium	BSc Agric. (SOK), MSc HORT(), PhD	Agric economics	Permanent
10	Dr. Simon Okiror	Male	PhD	Makerere University, Uganda	BSc (Agric), MSc, PhD	Agric Policy	Permanent
PART-TIME LECTURERS							
11	Prof. Twaha A. Basaamba	Male	PhD	Norwegian University of Life Sciences	BSc Agric.(Mak), MSc. (Mak), PhD (NMBU)	Agricultural production	Part-time
12	Dr. Isaac Newton Alou	Male	PhD	University of KwaZulu-Nata, SAl		Agricultural systems mondeling & Analysis	Part-time
13	Dr. Onesmas SSemalulu	Male	PhD			Sustainable Land Managemement	Part-time
14	Dr. Geofrey Lubadde	Male	PhD	University of KwaZulu-Nata, SAl	BSc Agric. (Mak), MSc CROP(Mak), PhD (UKZN)	Plant Breeding	Part-time
16	Dr. Saul D. Ddumba	Male	PhD	Michigan State University, USA	BA. Georg, MSc. (Reading, Uk), PhD (M)	Meteorology	Part-time
17	Dr. Geofrey Gabiri	Male	PhD	University of Bonn, Germany	BSc.Agric., MSc.Water mgt, PhD	Hydrology	Part-time
18	Mr. Akodi David	Male	MSc.	University of Ghent, Belgium	Bsc. Land Use, Msc,	Soil physics	Part-time
19	Mr. Nicholas Munu	Male	MSc.	Makerere University, Uganda	Agricultural Engineering	Agric. Mechanisation	Part-time
20	Ms. Gumisiriya Costa	Female	MSc.	Makerere University, Uganda	BSc. Agric., MSc. Crop Science	Crop science	Part-time
21	Ms. Dorothy Alibo	Female	MSc.	Makerere University, Uganda	BSc. Agric., MSc. Crop Science	Agronomy	Part-time
22	Mr. Ojuu David	Male	BSc	Makerere University, Uganda	DCP, Bsc Agric, Msc. (Crop Sci.)	Crop science	Part-time
STAFF ON ONGOING PhD TRAINING							
23	Mr. Charles Andiku	Male	MSc.	Makerere University, Uganda	Dip. Agrof. Bsc Hort.(MAK), MSc. Crop	Plant breeding, Agronomy	Permanent
24	Mr. Robert Amayo	Male	MSc.	Makerere University, Uganda	Bsc Agric, Msc crop, (PhD)	Plant pathology	Permanent
25	Mr. Denis Besigamukama	Male	MSc.	Makerere University, Uganda	Bsc. Land Use, Msc, (PhD)	Soil science	Permanent
FIELD & TECHNICIANS FOR LABORATORY EXPERIMENTS							
26	Mr. Musoba Andrew	Male	Diploma	Busitema University, Uganda	Diploma in Crop Production	Dairy production	Permanent

					&Mgt, BSc (Agric)	Pastures	
27	Ms. Akol Susan	Female	Diploma	Busitema University, Uganda	Diploma in Bee Production & Mgt, BAPM	Apiculture, Entomology	Permanent
28	Mr. Buluma David	Male	Diploma	Busitema University, Uganda	Diploma in Crop Production &Mgt, (BS Agric candidate)	Crop production & Management	Permanent
29	Mr. Oonyu Source Peter	Male	Diploma	Busitema University, Uganda	Diploma in Crop Production &Mgt, (BS Agric candidate)	Crop production & Management	Permanent
30	Mr. Muhindo Williams	Male	Diploma	Busitema University, Uganda	Certificate in Crop Production & Mgt, Diploma in Animal Production	Crop production & Management	Permanent
31	Mr. Ekaru Sam	Male	Diploma	Busitema University, Uganda	Diploma in Crop Production & Management, Bsc Agriculture	Crop science	Permanent

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Gombya-Sembajjwe, Ndemere, P., Tumwebaze, S., Nabanoga, G. and Banana, A. 2001. Developing a curriculum for in-service training in participatory and integrated local level management of natural resources of sustainable development. *A feasibility study report by the faculty of Forestry & Nature Conservation submitted to J(ãD,mak.com.*