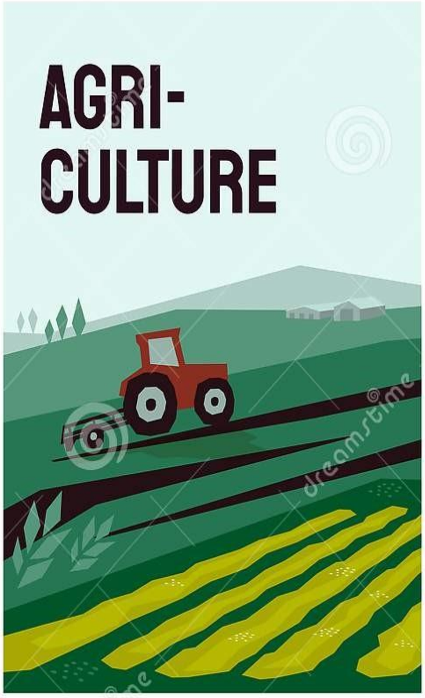

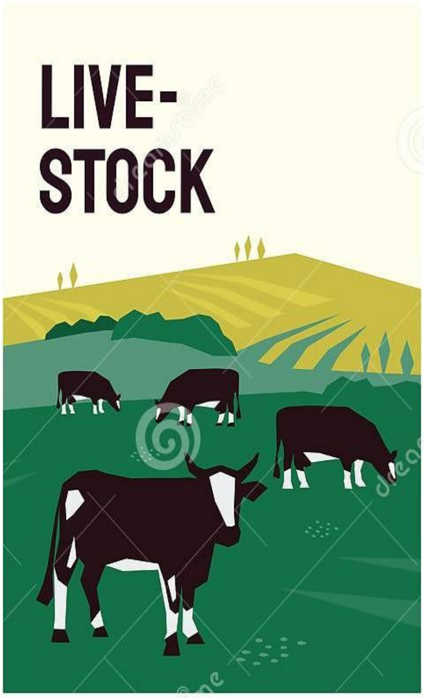

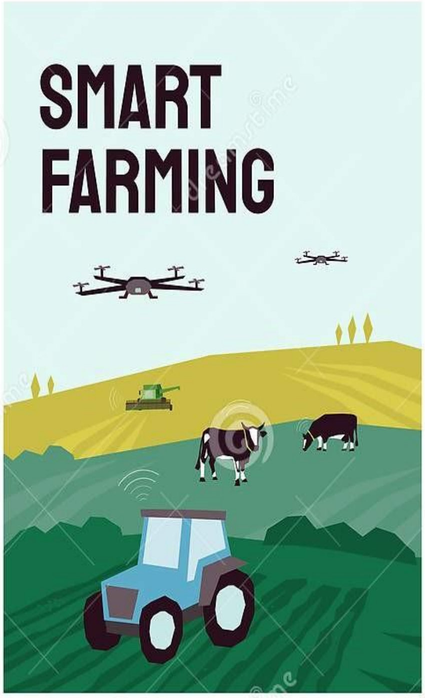

Framework for Modularized Lifelong Learning Master Curriculum

UPSKILLING THE AGRICULTURAL ENGINEERING IN EUROPE – USAGE

BOKU

Intellectual Output 1

Project - 2019-1-SE01-KA203-60562

USAGE UpSkilling of Agricultural Engineering in Europe

Funded by the Erasmus+ Programme of the European Union

USAGE PROJECT PARTNERS

LOGO	NAME	COUNTRY
	TUM - Technische Universität München	**GERMANY**
SLU	**SLU - Sveriges lantbruksuniversitet Swedish University of Agricultural Sciences**	**SWEDEN**
unibz	**UNIBZ - Freie Universität Bozen**	**ITALY**
BOKU	**BOKU - Universität für Bodenkultur Wien**	**AUSTRIA**

Contents

GLOSSARY

Formal learning - The learning that takes place in the education and training system and in universities and institutions of high artistic, musical and dance training, and that ends with the achievement of a qualification or professional qualification or diploma, also achieved in apprenticeship, or a recognized certification, in compliance with current legislation on school and university systems". Formal learning is intentional from the learner's point of view.

Non-formal learning – The learning characterized by an intentional choice of the person, which takes place outside the education and training systems and in universities and institutions of high artistic, musical and dance training, or that is implemented in any organization that pursues educational and training purposes, including voluntary, national civil service and private social and business.

Informal learning – The learning that, even without intentional choice, occurs in the performance by each person of activities in everyday life situations and the interactions that take place therein, within the context of work, family and leisure.

Knowledge - The result of assimilating information through learning. Knowledge consists of facts, principles, theories, and practices that are related to a field of work or study. In the context of the European Qualifications Framework, knowledge is described as theoretical and/or factual.

Skill - The ability to apply knowledge and use know-how to complete tasks and solve problems. In the context of the European Qualifications Framework, skills are described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, equipment and tools).

Competence - The demonstrated ability to use personal, social and / or methodological knowledge, skills and abilities, in work or study situations and in a professional and personal development environment. In the context of the European qualifications framework, competence is described in terms of responsibility and autonomy

Lifelong Learning - All learning activity undertaken throughout life, with the aim of improving knowledge, skills and competencies within a personal, 1civic, social and/or employment-related perspective'. It gives a new dimension to lifelong learning activity undertaken in formal, non-formal as well and informal learning settings.

Modularization - Modularization is based on the principle of dividing the curriculum into small discrete modules or units that are independent, non-sequential, and typically short in duration.

Module - Module is a unit of work in a course of instruction that is virtually self-contained and a method of teaching that is based on the building up of skills and knowledge in discrete units.

Climate-smart agriculture is an approach that helps guide actions to transform agri-food systems towards green and climate resilient practices.

Smart Farming - Also known as Farming 4.0 or digital farming, smart farming is the application of information and data technologies to optimize complex farming systems. It involves individual machines and all farm operations.

Precision Farming - A management approach that focuses on (near real-time) observation, measurement, and responses to variability in crops, fields and animals.

ISOBUS (ISO 11783) - a standardized communication protocol used in agriculture and forestry machinery. The main purpose is to enable plug & play integration between vehicles (e.g. tractors) and implements (e.g. sprayers) across manufacturers

Up-Skilling - It aims to help adults acquire a minimum level of literacy, numeracy and digital skills and/or acquire a broader set of skills by progressing towards an upper secondary qualification or equivalent (level 3 or 4 in the European Qualifications Framework (EQF) depending on national circumstances).

Re-Skilling - Learning new skills and competencies to carry out a different occupation or career path https://reskilling4employment.eu/en/

List of Abbreviations

CSA - Climate-smart agriculture

DSS - Decision support system

DT – Digital transformation

ECTS – European Credit Transfer and Accumulation System

ESD – Education for Sustainable Development

EQF - European Qualifications Framework

FIS – Farm Information Systems

FMIS – Farm Management Information Systems

GIS – Geographic Information System

GNSS - Global Navigation Satellite System

GPS – Global Positioning System

ICT – Information and communications technology

IoT – Internet of things

LCA – Lifecycle Assessment

LLL – Lifelong Learning

PA – Precision Agriculture

PDCA – Plan-Do-Check

PF – Precision Farming

PLF – Precision Livestock Farming

SDGs – Sustainable Development Goals

SFT - Smart Farming Technology

1.PREAMBLE

The increasing world population as well as recent challenges and changes in production brought by climate change put an increasing demand on efficiency in the agricultural sector. Simultaneously, accelerating technological development provides possibilities for a range of novel tools that can be used to mitigate these challenges, also known as smart farming, which refers to the modern application of ICT in agriculture, including such practices as precision agriculture, agricultural automation and robotics, management information systems and more. The International partners from Sweden (SLU), Germany (TUM) and Italy (UNIBZ) formed together with BOKU a working group with the aim of an international education program for agricultural engineering focusing on animal welfare, biodiversity, artificial intelligence, and nutrient efficiency.

Digital transformation is the integration of digital technology and has the objective to analyze data in real-time for better decision making, where it involves the modeling and the simulation of physical-mathematical and social processes and the monitoring of machinery that using information and communication technologies. The fourth industrial revolution technologies are the driver for this transformation in the agricultural sector, and generally affects many spheres of life including education.

*"*Digital transformation *comprises a spectrum of activities, encompassing both digitisation and digitalisation.* Digitisation *can be described as the "technical conversion of analogue information into digital form", while* digitalisation *is the term often used to describe the socio-technical processes surrounding the use of (a large variety of) digital technologies that have an impact on social and institutional contexts.*[1]

Digital transformation is inherently linked to strategic changes in the business model as a result of the implementation of digital technologies.[2]

Climate-smart agriculture (CSA) is an integrated approach to managing landscapes—cropland, livestock, forests and fisheries—that addresses the interlinked challenges of food security and accelerating climate change. On the global level USAGE master programme aims in up/re skilling to achieve increased productivity, enhanced resilience, and reduced emissions and to contribute to progress on SDGs for climate action, poverty, and the eradication of hunger.[3]

[1] Kelly Rijswijk, Laurens Klerkx, Manlio Bacco, Fabio Bartolini, Ellen Bulten, Lies Debruyne, Joost Dessein, Ivano Scotti, Gianluca Brunori, "Digital transformation of agriculture and rural areas: A socio-cyber-physical system framework to support responsibilisation", Journal of Rural Studies, Volume 85, 2021,Pages 79-90, ISSN 0743-0167 https://www.sciencedirect.com/science/article/pii/S074301672100125X

[2] Verhoef, Peter & Broekhuizen, Thijs & Bart, Yakov & Bhattacharya, Abhi & Dong, John & Fabian, Nicolai & Haenlein, Michael. (2021). "Digital transformation: A multidisciplinary reflection and research agenda". Journal of Business Research. 122. https://www.researchgate.net/publication/337003569_Digital_transformation_A_multidisciplinary_reflection_and_research_agenda

[3] Matteoli, F., Schnetzer, J., Jacobs, H. (2020). Climate-Smart Agriculture (CSA): "An Integrated Approach for Climate Change Management in the Agriculture Sector". In: Leal Filho, W., Luetz, J., Ayal, D. (eds) Handbook of Climate Change Management. Springer, Cham. https://link.springer.com/referenceworkentry/10.1007/978-3-030-22759-3_148-1

A key element of the continuing education modularized master programme - USAGE is to encourage learning mobility between countries and disciplines –inspiring more engineers to choose a career within smart farming, and more agronomists to further specialize in technological subjects.

1.1. Background of USAGE Framework for Modularized LLL Master Curriculum

Modularization is based on the principle of dividing the curriculum into small discrete modules (5-7 ECTS) that are independent, no sequential, and typically short in duration. Students accumulate credits for modules which can lead to the accredited qualification for which a specified number of credit point is required. According to Hornby, as cited in Yoseph and Mekuwanint (2015) and Malik (2012), module is a unit of work in a course of instruction that is virtually self-contained and a method of teaching that is based on the building up of skills and knowledge in discrete units. Therefore, a module is a course that together with other related courses can constitute a particular area of specialization. Each unit or module is a measured part of an extended learning experience leading to a specified qualification(s) "for which a designated number, and normally sequence, of units or modules is required."[4]

Following the modular approach and in order to meet the needs in up/re-skilling it´s expected target groups, USAGE project partners provided training for teachers in innovative pedagogical approaches which are more flexible and follow learner-centered approach and designed a Guide within the guidelines for validation of informal and non-formal learning ensuring greater access to the education. Furthermore, USAGE project partner BOKU provided internal guidelines for the modularization of a single module ensuring the quality assurance and comparative analysis among partner institutions regarding LLL.

The Master level learning outcomes descriptions are based on EQF level 7 and are following descriptions of knowledge, skills and competences.

The first steps in the framework development of a Master Curriculum the project partners used a pilot phase of modules developed by each consortium partner at local level. It follows literature review and knowledge-hub development to ensure the quality of the content of modules and to meet the needs in up/re-skilling in digital transformation in the agricultural sector including all fields in the below figure1[5]:

[4] Wondifraw Dejene | Dorothy Chen (Reviewing editor) (2019) The practice of modularized curriculum in higher education institution: Active learning and continuous assessment in focus, Cogent Education, 6:1 https://www.tandfonline.com/doi/full/10.1080/2331186X.2019.1611052

[5] M J Vera-Contreras,, F H Vera-Rivera and E G Puerto-Cuadros, "Curricula framework for a digital transformation master's in science and engineering", published under licence by IOP Publishing Ltd Journal of Physics: Conference Series, Volume 1938, IV Workshop on Modeling and Simulation for Science and Engineering (IV WMSSE) 15-16 March 2021, Bucaramanga, Colombia https://iopscience.iop.org/article/10.1088/1742-6596/1938/1/012026/meta

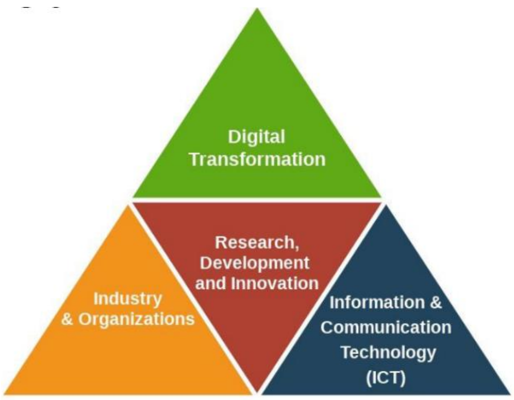

Figure 1

This framework shall serve as the basis for the Curriculum development of the future potential modularized LLL master program in Upskilling Agricultural Engineering in Europe-USAGE.

2. QUALIFICATION PROFILE

In the last few decades, agriculture has played an important role in the worldwide economy. A rapidly growing population has an increasing impact on the current agricultural production and is creating pressure on crop and animal production that is reflected in intensive farming, land fragmentation and reduction of quality and quantity of natural resources. This, in turn, leads to higher food insecurity, more greenhouse gas emissions, and large-scale environmental degradation. Food production, therefore, needs to adapt to accommodate a growing population and changing climate.

USAGE master program addresses the needs in skilling of people in precision farming or smart farming shifting from traditional agricultural management methods to a more precise and resource-efficient approach ensuring the sustainability and high productivity.

The master's programme in Upskilling Agricultural Engineering in Europe-USAGE is a degree programme which serves to deepen and extend students' pre-vocational academic education. The master`s programme in Upskilling Agricultural Engineering in Europe short USAGE is the international modularized lifelong learning master programme that focuses on the digital transformation as one of the key topics in agriculture and shapes agribusiness in times of change by offering professionals deep understanding of sector and the underlying technologies.

Furthermore, the master programme offers education and teaching of technological fundamentals for the future such as automation and artificial intelligence. By using a common language and precise terminology in a continuous, research-based education and upon solid theoretical foundation the graduate will learn to distinguish between Precision Farming, Smart Farming and Digital Farming in the field of crop, grass, livestock farming as well as in the field of fruit production.

The Master level learning outcomes descriptions are based on EQF level 7[6]:

[6] European Union, "Description of the eight EQF levels"
https://europa.eu/europass/en/description-eight-eqf-levels

— Level 7 - learning outcomes

Knowledge	Skills	Responsibility and autonomy
Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research Critical awareness of knowledge issues in a field and at the interface between different fields	Specialised problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields	Manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches; take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams

The qualification profile is the part of the curriculum that describes which academic and professional qualifications the students should acquire in the course of the degree programme.

It consists of two parts:

2.1 Knowledge and personal and professional skills

This section should include knowledge and skills, both personal and professional, that graduates of this program should have mastered, listed in detailed form as learning outcomes. Possible formulations include: “After completing the program, the graduate will have the skills to…”; “Graduates of the program are qualified to…”, etc.

The smart agriculture is an effective lever to (1) Ensure the agro-ecological transition for biodiversity and ecological processes to design efficient, sustainable and beneficial productivity; (2) Integrate vegetal and animal phenotyping tools and methods to set up and improve new production systems adaptable to local complex environmental conditions; (3) Connect farm animals for more sustainable and respectful production system by using sensors at the individual level; (4) Evolve consulting agriculture services towards more personalized and targeted advice; based on data analysis in nearly real time.

This modularized continuing education Master´s programme offers a multidisciplinary education in diverse topics of agricultural engineering, social economics, and environmental implications. This 3-pillar principle offers topics for gathering the knowledge and personal and professional skilling in:

I. Agri-Technology in digital transformation: smart crop farming, smart grass farming, precision livestock farming, ICT, agricultural technology and mechanical systems, basics in agro-robotics, smart sensors and actuators, GNSS, GIS, FIS, ISOBUS, IoT, FMIS and data management, artificial intelligence, cyber security, micro-controller’s connectivity, UAV, European Risk Assessment and Regulations, rapid prototype and business model, additive manufactory, functional safety and electrification of drives.

II. Agricultural Economics and Management

III. Environmental implications: biodiversity and climate change mitigation, SDGs, certification of product systems, small-scale farming, labelling, LCA.

The programme is taught in English and some courses are offered in home language. The holistic approach of the master programme provides participants with an opportunity to develop their individual competences for critical thinking, communication and working in teams, as well as problem solving skills. In the professional realm, graduates gain these interpersonal skills, and they may develop which provide more opportunities for professional development.

Understanding the philosophy of the LCA, knowing what problems an LCA is suitable for, knowing the structure and methodology of an LCA, identifying strengths and weaknesses as well as alternatives to an LCA, being able to use different impact assessment methods, creating and implementing LCA projects in group work, being able to assess the impact and to interpret the outcomes

After completing the program, the graduate will have:

transversal skills

Increased level of critical thinking, initiative and enterpreneurship, to adapt to working environment and people, adaptability, interpersonal skills, intrapersonal skills (self-discipline, ability to learn independently, flexibility and adaptability, self-awareness, motivation), time management skills, and organizational skills, media and information literacy, global citizenship

critical thinking ability for applying precision agriculture technologies for decision making

Knowledge of

Smart Farming Technology (SFT): Farm Management Information Systems, Precision Agriculture and Agriculture automation and robotics.

Agriculture IoT Engineering

The fundamentals of smart farming approach and its purpose for achieving higher productivity

Strategies based on multidisciplinary knowledge and techniques to solve practical problems in precision agriculture.

The key elements of positioning technology and usage of those in conjunction with off-road vehicles, like agricultural vehicles

Demonstrate knowledge and understanding in the field of agricultural economics and management

Climate smart farming trade offs and synergies

Strategies and practices of sustainable production and consumption

Ecology with reference to local and global ecosystems, identifying local species and understanding the measure of biodiversity

Understanding the philosophy of the LCA, knowing what problems an LCA is suitable for, knowing the structure and methodology of an LCA

The type of problems for which LCA is the best solution

Development and methodic of the LCA

Skills to

To identify, to indicate and interpret the principles and aims of precision farming

To differentiate between precision farming and smart farming applications

To discover and apply the technological requirements of smart farming

Evaluate different technologies and tools offered on the market

The potential, benefits and drawback of automated steering systems in agriculture and for precision crop farming

Evaluate the robustness and transferability of sensing and modelling methods

Explain and evaluate different PLF applications from the end-user perspective including different potential users

To argue against destructive environmental practices that cause biodiversity loss

To highlight the importance of soil as our growing material for all food and the importance of remediating or to plan, implement and evaluate consumption-related activities using existing sustainability criteria

To identify strengths and weaknesses as well as alternatives to an LCA

To use different impact assessment methods, creating and implementing LCA projects in group work, being able to assess the impact and to interpret the outcomes

Competences to

ASSESS, CREATE AND MANAGE:

GIS projects and apply geodata within their field

Spatial data and have the ability to compare different GIS tools for their own field data for surface calculations and simulations as well as to implement GIS data from different sources

Create basic routines to simulate dynamic behaviour using numerical solutions

Create methods for carrying out modular and integrated designing of a FIS, with the capability of identifying the key components necessary to perform reliable and quality decision making processes at farms

2.2 Professional qualifications

Within the focus on Inter-sectoral collaboration and from a skill needs perspective, the USAGE project implements sectoral approaches addressing the following issues:

- types of skills and competencies that jobs may require;
- emerging jobs;
- changing skill profiles of occupations;
- the ability of the training system to meet the needs of industry

For these purposes USAGE sectoral focus groups are:

- Practical farming
- Agribusiness
- The food industry
- Retailers
- Extension service and administration
- IT sector
- Environmental Science-education and research institutions

This program typically covers the large field of educating adults at all levels. Class work, seminars, lectures, research, and hands-on learning may be utilized to increase a student's knowledge of learning institutions and the different abilities of adult students. Specializations within this master's degree may include computer literacy, agricultural literacy, community development, and industrial training and development. Assessment of learning environments and institutions with the goal of improving them is often a component of this program.

By working firsthand with such technologies, participants gain a deep understanding of the possibilities of current and future potential. All the hardware necessary for the program will be provided.

Employees working in agribusiness and related sectors at the intersection of business and technology who desire to extend their knowledge of Smart Farming Technologies. Participants should be keen to learn more about the digital transformation of agriculture in order to evaluate its potential or implement it in their work environment. Participants can be both professionals within the agricultural industry or have a management background.

The modularized Master program is structured to provide subject-specific knowledge for selected professionals of the agricultural sector (e.g. farmers, animal agronomist, farm managers, sales managers), public agricultural institutions and ministries of agriculture. The Master program is also aimed to the regular students at advanced level within agriculture program, animal science as well as to the engineering students from other universities.

The graduates will find career prospects and potential job opportunities in the high-tech agricultural sectors, technical consultancy, Government and international agencies, agronomy, farm management and agricultural engineering. The qualification will have a positive impact on promotions of the graduates within their current companies and will improve job opportunities in this sector as higher qualified professionals.

3. ADMISSION REQUIREMENTS

The admission and application within the Master´s program USAGE is regulated with the common and harmonized procedure conducted in a consortium by all partner universities. At each partner university students must fulfill the common Admission criteria. The admission criteria, since the program is mainly aimed to the lifelong learning participants, is regulated by validation procedure of non-formal and informal learning for the students with diverse education background.

Admission to each module (course) requires a bachelor´s degree in natural resources, life sciences or technical sciences, or a degree from an advanced technical college. In individual cases also applicants without the above-mentioned degrees but with demonstrated long-standing relevant professional experience may be considered for admission to the certificate coursees. The certificate courses are structured to provide subject-specific knowledge for selected professionals of the agricultural sector (e.g. farmers, farm managers, sales managers, administration officers), public agricultural institutions and ministries of agriculture, IT sector, food industry and retailers, science research institutions, education sector, industry and etc.

It is required from the course participants to:

- Possess relevant competences and skills in mathematics, physics, chemistry, biology, geography and technological topics
- Basic knowledge in IT and advanced computer skills
- Basic knowledge in agriculture
- Adequate language skills of English

4. MODULARIZED LLL MASTER PROGRAME STRUCTURE

In this academic-industry collaboration, a modularized curricular framework is proposed for a master's program in digital transformation for agricultural engineering and follows the literature review and analysis, labor market trends and needs in re/up-skilling, LLL approach and quality assurance and will be the basis for formalizing the LLL modularized master's degree Curriculum.

The programme consists of modules (courses) each 5-7 ECTS and other requirements worth a total of 120 ECTS credits.

Modular degree Master program USAGE is outcomes-based approach learning program and allows learners to achieve their academic goals in a way that works for them, making lifelong learning with expert support more accessible than ever before. It is designed to shift the focus from time-based learning to competency-based learning. Instead of being confined to a certain number of hours in the classroom, learners can progress through the program at their own place, as long as they demonstrate that they have acquired the required skills and knowledge.

The workload required to complete a specific learning outcome in a module is expressed in ECTS credits. One ECTS credit corresponds to 25 60-minute credit hours, and one academic year is worth 60 ECTS credits (1,500 credit hours).
The following applies to the assignment of ECTS credits:

1. The skills students are required to acquire in an individual teaching unit (course, module, etc.) must be defined and listed in the form of learning outcomes.
2. A workload in hours is set based on these outcomes, i.e., the time students will typically need to achieve these outcomes. This is usually an estimated value.
3. When estimating the workload, all learning activities must be taken into account. Learning activities include:
    a. Contact hours (= course time held in the presence of both instructors and students); including examinations
    b. Independent work (course preparation, studying for exams, writing homework and papers, preparation for examinations)
4. Allocation of ECTS credits is done independently of teaching staff assignments.
5. The workload is then the total number of hours required of the student to complete the teaching unit and to pass examinations.

4.1 Learning Units

In order to achieve a high level of interest and performance, the USAGE modules are organized in 3 pillars (agri-technology in digital transformation, economics and management, environmental implications) within relevant topics and learning outcomes that are prepared in compliance with the definitions for EQF level 7 (EQF – European Qualifications Framework definitions).

First steps and ideas towards Modularized Master Curriculum

As the starting idea for the USAGE project, the university partners designed a model of modules structure and procedures based on modularization methodology as a valuable option for all students seeking to achieve the recognition of their abilities through learning. The model later served as the basis and an idea for the framework of a modular master curriculum and furthermore for the micro-credentials development.

The picture describes the structure and procedures regarding certification of the offered modules (programs). Each consortium university partner is represented with the color and the color present offered modules in the form of a puzzle. One module (5-7 ECTS) can be awarded with the certificate. The participants can have finished two modules and acquired certificate of 10 ECTS or 30 ECTS certificate for the whole section in smart farming. For the master thesis is required completed 90 ECTS and the Thesis it´s self is 30 ECTS which makes total of 120 ECTS.

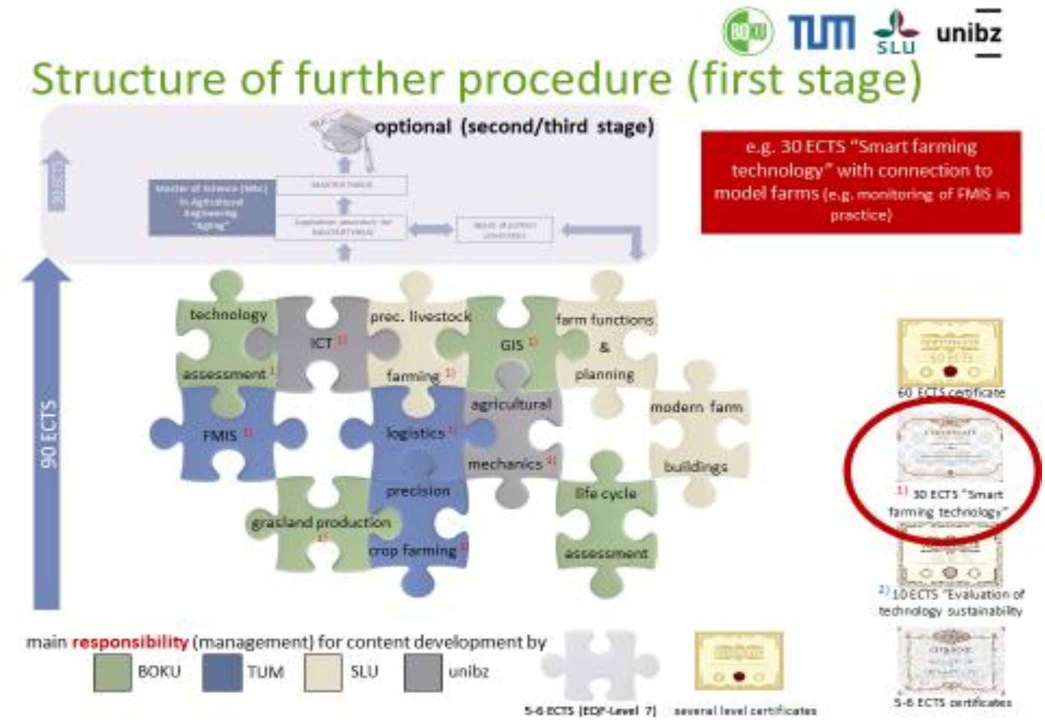

Figure 2

<u>Main topics and potential modules</u>:

Smart Technologies in livestock and crop farming: Automation technology, sensors, control technology, robotics, systems engineering, machinery certification, acclimatisation and technical installations in animal facilities, animal environment and building function

Information and communication technology (ICT) in smart farming: Data acquisition, design and utilization of databases, software systems, modelling and simulation, Farm Information Management Systems (FIMS), precision livestock farming, Matlab, GIS

Logistics and decision making processes: Multicriteria decision making, simulations, development of models and algorithms

Grassland production: Basics of forage crops, grassland management, post-harvest, principles of forage quality and feed production

Agricultural Economics and Agribusiness Management: Economic risk analysis, managerial economics, agricultural policy, marketing and industry cooperation

Technologies for the utilization of bio-based raw materials: Post-harvest technology, bio refinery, composting technology, anaerobic digestion technology, life-cycle assessment of renewable resources management systems

Basics in plant production and animal production: Crop and soil management, plant production and environment, horticulture, fruit production, animal production and environment, soil science

Environmental sustainability: Farmland ecology, soil science, water management, climate change, sustainable management, agricultural adaptation

4.2 Framework for Modularized LLL Master Curriculum

The consortium partners organized a working group in order to create a matrix within potential modules for LLL Master curriculum (see ANEX excel table). The structure follows gradation desired [0], under construction [1], designed [2], implemented [3] modules. The table contains content of modules, learning outcomes and descriptions, type of lectures, number of ECTS.

4.3 Methodology and Case-Studies

The consortium partners have developed the modules with the focus on "Smart Farming" that contain a holistic view on digitally transformed farms and agricultural data mining. In a collaboration with industry partners of the project and to meet the needs of today's students and job requirements, different types of lectures and seminars were taken into consideration. Therefore, also a research based Agri-Tech LAB from UNIBZ for the practical studies has been implemented. According to this student will learn how to use technology applications in soil management, seeding management, water management, fertilizer management, grass yield management, harvesting and production as far as product quality assessment.
The application of smart farming technologies to crop, fruits and animal production and even post-harvesting is the focus of the program. The impact of climate change on agriculture is also considered. Therefore, students will gather knowledge, skills and competences in the application of intelligent information and communication technology systems such as sensors, IoT, GIS, cloud-based processes, machine learning, artificial intelligence, networking to the farming system such as crop cultivation, livestock farming and fruit production.

Case studies

1. To illustrate and apply the methodology of advanced smart farming technologies in crop farming, students will participate in the Creation of an "application map" for nitrogen fertilization with QGIS a shape file for variable sowing of maize.

2. With high accuracy in the automated steering system, the farmer is able to automatically run the tractor throughout the desired path without causing any damage to the vegetation while maintaining a wide range of measurement

5. NECESSERY ASPECTS AND TOOLS TOWARDS SDGS

The framework for the Curriculum development of the future potential modularized LLL master program in Upskilling Agricultural Engineering in Europe-USAGE addresses Education for Sustainable Development (ESD), which empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity. The program promotes holistic and transformational education and addresses learning content and outcomes, innovative pedagogy and 'learning by doing', and fosters inclusion by implementing validation procedures of informal and non-formal learning. Key topics which the programme covers and supports the SDGs development are climate change, biodiversity, sustainable production and consumption, global justice, food security and poverty reduction.

Key competences and performance of sustainability citizens:[7]

Figure 3

6. MASTER´S THESIS

A master's thesis is a paper on a scientific topic, to be written as part of a master's degree programme. The topic of the master's thesis shall be found in a subject of the master's study programme. The master's thesis is supervised by a person with a venia docendi in this subject. Joint supervision by two persons with a venia docendi is also permitted if at least one of the two persons represents a subject of the master's study programme. The topic of a master's thesis shall be chosen in such a way that it is reasonable to expect a student to be able to complete it within six months. Multiple students may jointly address a topic, provided that the performance of individual students can be assessed. The master's thesis shall be written in local language or English. The thesis defence must be held in local language or English regardless of the language of the thesis.

The modularized LLL master's programme in Upskilling Agricultural Engineering in Europe-USAGE has been completed when the student has passed all required courses and received a positive grade on the master's thesis and defensio. Graduates of this master program are awarded with an engineering diploma and the academic title Master of Science, abbreviated as MSc or M.Sc.

[7] Alexander Leicht, , Julia Heiss, Byun Won Jung, „Issues and trends in education for sustainable development", 2008, UNESCO
https://unesdoc.unesco.org/ark:/48223/pf0000261445

7. TEACHING METHODS AND EXAMINATION REGULATIONS

7.1 Teaching methods

The modularized LLL Master program has implemented more flexible teaching and learning pathways such as learner-cantered approach. This approach highlights the development of autonomy and independence in the learning environment by putting tasks for learning path in the hands of students, where the students actively participate and where the students are in focus. Constructive interdependence, personal accountability, motivated interaction, suitable use of social skills, and cluster processing are five essential components of such approach that USAGE has implemented. The methods of student-centred learning ranges from personalized learning, problem solving learning, flipped classrooms and others. Student centred-learning strategies an able student's empowerment, communications, critical thinking skills, independence, and problem-solving techniques. The teachers have implemented diverse teaching strategies such as flipped classroom, case-based strategies, strategy involving small/large group discussions, e.g., academic knowledge meet practice, seminar group discussions, observations and reflections.[8]

7.2 Examination regulations-assessment

(1) The master's programme USAGE in […] has been completed successfully when the following requirements have been met:

- positive completion of the compulsory courses worth a total of […] ECTS credits (§ 4)
- positive completion of elective courses worth a total of […] ECTS credits (§ 5)
- positive completion of free electives worth a total of […] ECTS credits (§ 6) (?)
- a positive grade on the master's thesis and the defensio

Among traditional teaching methods and approaches, USAGE implements flexible innovative learner centred approach and assessments. Course objectives and learning goals will be clearly stated, and students will be taught to assess their own work and that of their peers by asking critical questions in a constructive manner. They will be given many opportunities to practice the theoretical and practical skills they are expected to learn and perform. By learning online students will be able to increase their digital skills and by fostering many learning styles it will have enhanced student interest and engagement resulting in better performance on written reports and examination.

Assessment methods in online environment include projects, portfolios, self-assessments, peer evaluations, peer evaluations with feedback, timed tests and quizzes, and asynchronous discussion. Furthermore, approved written examinations, written and oral presentation of literature assignments and compulsory attendance of certain activities (net meetings), laboratory and reports all following the local institutional regulations. The assessment of the courses is in accordance with the "European Credit Transfer System".

[8] Donald A. Norman, James C Spohrer, „Learner-Centered Education", April 1996/Vol. 39, No. 4, Communications of the ACM
https://dl.acm.org/doi/pdf/10.1145/227210.227215

Based on the data the teachers collect, they recommend administering a wide variety of regularly paced assignments and providing timely, meaningful feedback. The teachers might highlight the value of examining the written record of student discussion postings and e-mails in order to keep abreast of evolving student understanding.

After the successful completion of all the courses and examinations required in the master's programme, the completed master's thesis, after it has been given a positive evaluation by the thesis supervisor, shall be publicly presented by the student and defended in the form of an academic discussion (defensio). The committee shall consist of a committee chair and two additional university teachers with a venia docendi or equivalent qualification. The student's total performance (thesis and defensio) will be assigned a comprehensive grade. Both thesis and defensio must receive a passing grade for the student to complete the programme. The written evaluations stating the rationale for the thesis grade and the defensio grade are included in calculating the comprehensive grade and are documented separately.

The comprehensive grade is calculated as follows:

- Master's thesis: 70%
- Defensio (incl. presentation): 30%

In line with the Bologna declaration, learners and learning processes are the focus of the didactic concept developed within the framework of the continuing education certificate courses.

The teaching in the course is entirely done by distance learning with virtual meetings, which should enable the courses to be combined with work and being available for remote located participants.

8. QUALITY ASSURANCE

BOKU as the leader of this Intellectual Output will follow the guidelines[9] on quality assurance and Quality Management Cycle of a degree programme Figure 4:

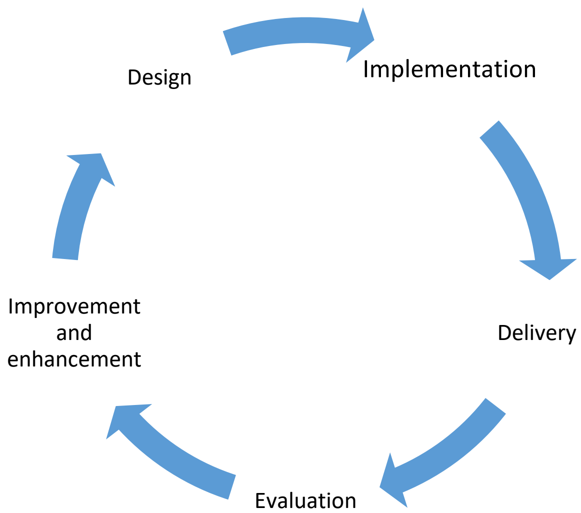

Figure 4

Furthermore, the framework represents modularized LLL master program in up-skilling the agricultural engineering in Europe and BOKU will ensure the quality by following lighter quality assurance procedure for Lifelong Learning, also based on the four steps of the Plan-Do-Check (PDCA) methodology. Monitoring and evaluation of the program will follow study program feedback by students, focus group discussions, number of participants, number of certificates etc.[10]

9. TRANSNATIONAL PROVISIONS

The introduction of lifelong learning strategies, competence-based qualifications or national qualifications frameworks, implementation of guidelines on validation procedures of non-formal and informal learning promote equality, inclusion and greater access to education. Furthermore, the graduate will be able to find a job beyond their national borders.

The United Nations SDG includes the promotion of sustainable agriculture in goal 2: zero hunger – end hunger, achieve food security and improved nutrition and promote sustainable agriculture. With scarce natural resources depleting, inevitable consequences of climate change and growing global population, agriculture must be sustainable to ensure achievement of

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[9] https://boku.ac.at/fileadmin/data/H01000/H10090/H10400/H10450/ELLS/Guidelines-2nd-ed_Curr_Development.pdf

[10] Sampson Gholston and Loyd, Nicholas (2016). "Implementation of a Plan-Do-Check-Act Pedagogy in Industrial Engineering Education". International Journal of Engineering Education. 32. https://www.researchgate.net/publication/313755576_Implementation_of_a_Plan-Do-Check-Act_Pedagogy_in_Industrial_Engineering_Education

SDG 2 and enough food for all in the future. Therefore, the program has a positive impact on Indicator 2.4.1 that reflects the multiple dimensions of sustainability: economic, environmental and social.

SDG Indicator 2.4.1[11]

Dimensions	No	Theme	Sub-indicators
Economic	1	Land productivity	Farm output value per hectare
	2	Profitability	Net farm income
	3	Resilience	Risk mitigation mechanisms
Environmental	4	Soil health	Prevalence of soil degradation
	5	Water use	Variation in water availability
	6	Fertilizer pollution risk	Management of fertilizers
	7	Pesticide risk	Management of pesticides
	8	Biodiversity	Use of biodiversity support practices
Social	9	Decent employment	Wage rate in agriculture
	10	Food security	Food insecurity experience scale (FIES)
	11	Land tenure	Secure tenure rights to land

The graduates achieve cognitive learning objectives, socio-emotional learning objectives and Behavioural learning objectives in all relevant topics of the program towards SDG 2.

10. CONCLUSION

This paper proposed a development of modularized LLL master Curriculum in digital transformation named USAGE- up-skilling the agricultural engineering in Europe and shows the interdisciplinary character of digital transformation that involves disciplines: ICT for digital transformation and industry and organizations and on the other hand it raises awareness of environmental issues and importance of climate mitigation actions as well socio-economic issues from the higher education perspective. A balance between these tree areas is proposed in body of knowledge, skills and competences, so that a master in digital transformation is able to do research on relevant problems for the productive sector and society in general (industry and organizations), contributing to the solution of those problems and leading the digital transformation through the generation of new knowledge, technological development, innovation and entrepreneurship, in the context of rapidly evolving emerging ICT (such as Cloud Computing, Services Computing, Data Science, Artificial Intelligence), which may be applied to process of simulation, modelling development and new technologies. Furthermore, the program implements LLL approach and more flexible teaching and learning pathways and aims in turning higher education into lifelong learning institutions.

[11] Arbab Asfandiyar Khan, "SDG Indicator 2.4.1 – The Indicator's Framework", Virtual Training (September-October 2020), Food and Agriculture Organization of the United Nations https://www.fao.org/3/cb1820en/cb1820en.pdf

11. ANNEXES

11.1 Modules Framework for Master programme (separate document)

11.2 Type of lectures

11.3 Learning units and learning outcomes

11.2 Annex: Types of courses

The following types of courses are available:
(Please only offer course types included in this list from now on)

Lecture (VO)
Lectures are courses in which certain areas of a subject and the methods used in this area are imparted through didactic presentation.

Exercise course (UE)
Exercise courses are courses in which students are instructed in specific practical skills, based on theoretical knowledge.

Practical course (PR)
Practical courses are classes in which students deal with specific topics independently, based on previously acquired theoretical and practical knowledge.

Compulsory internship seminar (PP)
The compulsory internship seminar is a class in which students deal independently with topics related to their internship placements, based on previously acquired theoretical and practical knowledge.

Seminar (SE)
Seminars are courses in which students are required to work independently on the respective subject, deepen their knowledge of the topic and discuss relevant issues.

Field trips (EX)
Field trips are courses in which students have the opportunity to experience relevant fields of study in real-life practical application, to deepen their knowledge of the respective subject. Field trips can be taken to destinations both in Austria and abroad.

Master thesis seminar (MA)
Master thesis seminars are seminars intended to provide students with academic support during the thesis writing process.

Mixed-type courses:
Mixed-type courses combine the characteristics of the courses named above (with the exception of project-type courses). Integration of different course-type elements improved the didactic value of these courses.

Project course (PJ)
Project courses are characterized by problem-based learning. Under instruction, students work - preferably in small groups - on case studies, applying appropriate scientific methods.

Lecture and seminar (VS)
Lecture and exercise (VU)
Lecture and field trip (VX)
Seminar and field trip (SX)
Exercise and seminar (US)
Exercise and field trip (UX)

11.3 Annex: Learning units and learning outcomes following EQF level 7 descriptions that were adapted in line with the descriptors for learning outcomes in higher education in Europe, i.e. the Dublin descriptors

"The Dublin Descriptors are adopted as the cycle descriptors for the framework for qualifications of the European Higher Education Area. They offer generic statements of typical expectations of achievements and abilities associated with awards that represent the end of each Bologna cycle".

"Dublin Descriptors are a cross-disciplinary description of the bachelor's and master's level, which define the performance profile of students with a bachelor's or a Master's degree. This definition was developed at the European level by the Joint Quality Initiative working group.

EQF Level	Knowledge	Skills	Competences
EQF Level 7	Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research Critical awareness of knowledge issues in a field and at the interface between different fields	Specialised problem-solving skills required in research and/or innovation to develop new knowledge and procedures and to integrate knowledge from different fields	Manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches; take responsibility for contributing to professional knowledge and practice and/ or for reviewing the strategic performance of teams

Learning outcomes	**Modules in smart farming EQF level 7**
	Based on modern teaching and teaching methods through a balanced combination of theory-oriented and practice-oriented units, the modules of the LLL Master Program provide adequate learning outcomes
The graduate know to	• Identify, list, describe and name Smart Farming Technology (SFT): sensor technologies, telemetry, farm management information systems, machinery for precision agriculture, automation and robotics. • Recognize the fundamentals of smart farming approach and its purpose for achieving higher productivity physical basics for sensors, be able to design sensors concepts for future applications in agriculture and know about the errors which occur • Define and state principles of geographic information technology and remote sensing • Identify principles of GIS and know how to implement spatial data in a GIS environment • Collect and recollect of data for creation of maps and document spatial data sets • Recognize examples of specific robotic solutions for crop production processes and the potential and drawback in agriculture • Identify Farm Information Systems and their use on today's farm - data collection, data processing, data analysis and evaluation, and use of information (FIS conceptual map and the logic role of each hardware and software components, integration of each FIS components and interpretation) • Define Automated Steering & Section Control - Data sources in precision farming: -Global Navigation Satellite Systems (GPS, Galileo & Glonass) - providing the high-resolution maps of soil moisture, a method that could help farmers to take better decisions in water management; automated steering system combines digital analysis and the image processing method, cameras, and GNSS. • Select agricultural robots indoor and outdoor. • Describe the development of the PLF application from beginning to end (R&D cycle including product deployment and infrastructure maintenance) and its role in the digital transformation of smart farming • Identify Prototyping • Deep understanding of building a control system consisting of positioning and navigation modules. In addition, they are able to discuss alternative positioning technologies beyond satellite navigation, such as vision and laser distance sensors.
Being able to:	• To identify, to indicate and interpret the principles and aims of precision farming • To differentiate between precision farming and smart farming applications

	• To discover and apply the technological requirements of smart farming • To decide on the application of appropriate visualization tools and to establish actions in accordance to these results • To visualize spatial results for decision support and document the spatial data according to international metadata standards • To use the technologies and know about the data to create new solutions in “machine to machine” communication • To describe how PLF could be used to monitor, manage and control livestock production within its various branches and discuss the role of PLF in modern livestock production, • To describe principles of navigation systems of off-road vehicles • To describe the system components of off-road vehicles automation • To create small software to analyse positioning traces and post-process recorded raw data • To install and adjust corrections signal for satellite navigation systems • To design system requirements for navigation system in open field off-road vehicles • EVALUATE different technologies and tools offered on the market the potential, benefits and drawback of automated steering systems in agriculture and for precision crop farming • UNDERSTAND AND APPLICATE The functionality of existing GNSS tools to determine error corrections in agriculture (e.g. RTK) and select appropriate systems for agriculture machinery; The pros and cons about spatial data management; The technological principals of variable rate technology and know about the application accuracies to develop concepts for further innovation; Understand general concepts of cropping systems and crop simulation models, including Systems Approach, Model development, Example models and Numerical Simulation; Understand a simple crop simulation model in R, supplied from the literature, with the basic structures of a cropping system; Apply a simple crop model in R to a new problem using Parameter estimation, Model evaluation and Sensitivity analysis; Understand the potential of models to gain new systems inside in cropping systems analysis; Understand the limitations of crop models to simulate a cropping system; Understand the concept, technologies and principles of precision agriculture; Apply sensing and modeling methods to analyze soil and crop spatial variability; Understand and apply the principles for evaluation and validation of various Precision Livestock Farming-PLF applications
Being competent to	ASSESS, CREATE AND MANAGE • GIS projects and apply geodata within their field • Spatial data and have the ability to compare different GIS tools for their own field data for surface calculations and simulations as well as to implement GIS data from different sources • Create basic routines to simulate dynamic behaviour using numerical solutions

	• Create methods for carrying out modular and integrated designing of a FIS, with the capability of identifying the key components necessary to perform reliable and quality decision making processes at farms. CREATE, SYNTHESIS AND ANALYZE • Your own spatial data sets according to GIS standards • Spatial data from different sources and be able to work with different geometric and thematic layers • Analyze model uncertainty • Analyze the problems of crop growth and health using sensing and modeling methods; • Develop critical thinking ability for applying precision agriculture technologies for decision making; • Create strategies based on multidisciplinary knowledge and techniques to solve practical problems in precision agricultureture. • Analyze PLF based on biological conditions, the use of sensors, signal interpretation and processing and models for information extraction • Discuss and analyze the integration of PLF applications in modern agriculture with a focus on livestock production, and further emphasis on the interaction between human and technology from a sustainability perspective

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13. List of Figures

This document was funded by the European Erasmus+ Programme (2019-2022).

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