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# Teaching Sustainable Farming as a New Engineering Discipline

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**Abstract**

With a worldwide emphasis on sustainable farming to meet the food requirements of the growing population, there is a parallel need to develop a future workforce adept to meet the challenges in agriculture. Developing new curriculum and laboratory course projects around the theme of sustainable farming is challenging and constantly evolving. In this article, we review some of the important topics in sustainable farming that could be formatted at separate courses within a new curriculum. Some important topics on which courses have been developed are topics on soil health, soil conservation, water management, irrigation systems, energy efficiency, and biodiversity. There are interesting and valuable projects that are being taught as laboratory courses across universities, such as methods for soil analysis, soil properties measurements, assessment of irrigation systems, and socio-economic analysis of engineering systems. Data science and data management are cross-cutting topics that penetrate every sub-topic of sustainable farming. Overall, this article presents a good overview of curriculum being developed around sustainable farming which will help draw the attention of students into this field. It is expected that existing curriculum could be adapted and tailored to the vision of sustainable agriculture while also considering the student expectations and demands of the local and regional economy.

**Introduction**

Sustainable farming is related to the use of practices that maintain or improve the health of the environment, economy, and society over the long term [1-10]. There are several types and formats of best practices within sustainable farming that can be followed, such as soil health, water management, biodiversity, integrated pest management, energy efficiency, and economic viability [1-7]. In one approach for sustainable farming, soil health topic uses techniques like crop rotation, cover cropping, and reduced tillage to maintain and improve soil fertility and structure. Water management implements practices like rainwater harvesting, drip irrigation, and mulching to conserve water and reduce runoff. Biodiversity encourages a diverse range of plants and animals on your farm to improve resilience against pests and diseases and enhance ecosystem health. Integrated pest management uses a combination of biological, physical, and chemical methods to manage pests in an environmentally responsible way. [3-10] Organic practices avoid synthetic pesticides and fertilizers, and uses organic inputs and natural processes to maintain soil health and manage pests. Energy efficiency promotes the use of energy-efficient machinery and renewable energy sources to reduce the farm's carbon footprint. Economic viability ensures that farming practices are economically sustainable by balancing costs and revenues and seeking markets for sustainably produced goods. Community engagement works with local communities to support and promote sustainable practices and share knowledge [7-10].

## Soil Health as a Relevant Coursework

Creating a coursework around soil health and soil conservation involves covering a range of topics to ensure students understand both the theory and practical aspects of maintaining and improving soil health [10-14]. A basic introduction course could cover the definition and importance of soil health, along with the soil functions and key indicators of soil health. The soil functions can be related to nutrient cycling, water filtration, and support for plant growth. The next course could cover the properties of soil such as soil texture (sand, silt, clay), soil structure and its impact on soil health, soil pH and its effect on nutrient availability, and organic matter and its role in soil health. A later course can be related to soil fertility and nutrient management. This course can cover topics on essential nutrients for plant growth (macro and micronutrients). There ca be topics related to soil testing and interpretation of results, types of fertilizer (organic vs. synthetic), and techniques for nutrient management such as composting, green manures, and biofertilizers.

There can be other courses relevant to sustainable agriculture on which new coursework can be created [14-19]. On example is on soil conservation practices. This involves erosion control methods (contour plowing and terracing), learning the importance of ground cover and cover crops, and understanding the tillage practices and their impact on soil health. The course on soil water management covers soil moisture and its effect on soil health, techniques for water conservation (drip irrigation, rainwater harvesting), and managing soil drainage and reducing waterlogging. Another course could cover the biological aspects of soil health such as the role of soil microorganisms and fauna (bacteria, fungi, earthworms), enhancing soil biology through organic matter and compost, and soil health and plant-microbe interactions. A course on soil health monitoring and soil assessment could focus on the methods for assessing soil health (physical, chemical, biological indicators), tools and techniques for soil analysis, and ways of interpreting soil health data and making improvements. Similarly, a capstone course could cover case studies of successful soil health management, hands-on soil sampling and analysis, and designing a soil health improvement plan for a given scenario. The course could also look into advances in soil health research, emerging technologies and practices in soil management, and the role of policy and education in promoting soil health.

## Irrigation and Water Management as a Topical Coursework

Designing coursework on irrigation and water management involves teaching the principles, techniques, and technologies used to efficiently use water resources in agriculture [5-17]. A basic course can focus on the introduction to the topic covering the importance of water in agriculture, overview of global water resources and challenges, and basic hydrology related to the water cycle, precipitation, evaporation, and transpiration. To understand the relationships between soil, water, and plants, another course can focus on the soil moisture and its measurement, plant water needs and transpiration, field capacity, wilting point, and available water, and water use efficiency and factors affecting it. Yet another course can cover the types of irrigation systems, including surface irrigation (furrow, border, and basin irrigation), sprinkler irrigation (types and design considerations), drip irrigation (components, advantages, and limitations), and subsurface irrigation and its applications. New system designs could be developed for assessing water needs based on crop type, climate, and soil, calculating irrigation requirements and scheduling designing irrigation systems for efficiency and sustainability, and providing a cost-benefit analysis of different irrigation methods. Advanced topics in irrigation could cover remote sensing and GIS in water management, smart irrigation systems (sensors, automation, and control systems), and precision agriculture and its role in irrigation management. It is also important to understand the environmental and socio-economic aspects of water, irrigation systems, and sustainable water use along with policy, regulation and community engagement.

**Laboratory Coursework in Sustainable Farming Curriculum**

Laboratory coursework in sustainable farming can provide hands-on experience with various techniques and tools used in sustainable agriculture [10-20]. This type of coursework helps students understand practical applications, analyze data, and develop problem-solving skills. Any laboratory course starts with learning the safety protocols and lab etiquette, providing an overview of laboratory equipment and tools, and an introduction to experimental design and data analysis.

Laboratory coursework on soil health and management could focus on soil sampling and analysis techniques such as techniques for collecting soil samples, and laboratory analysis of soil texture, pH, organic matter, and nutrient content [15-20]. The labs could also teach methods for culturing and identifying soil microorganisms, and ways to assess microbial activity (e.g., soil respiration tests). A laboratory component on water quality and water management could focus on water testing for the analysis of water pH, electrical conductivity, dissolved oxygen, and contaminants, along with testing and optimizing irrigation systems and measuring soil moisture with sensors and probes.

Within the topic of plant health and crop management, laboratory components could focus on studying plant nutrition using leaf tissue analysis for nutrient deficiencies or toxicities, and experiments on nutrient uptake and fertilization methods [25-31]. Pest and disease management labs could help study the identification of common pests and diseases and perform laboratory tests for pest resistance or disease control efficacy [22-32]. Within the topic of waste management, experiments can be conducted on setting up composting experiments with different organic materials, monitoring composting parameters (temperature, moisture, pH), setting up and maintaining worm bins for vermicomposting, and the analysis of vermicompost quality and nutrient content.

Within the topic of crop diversity and crop rotation, experiments can be conducted on seed germination rates under various conditions, and testing seed viability and vigor. Furthermore, we can design crop rotation plans based on soil health and pest management data, along with analysis of the impact of crop rotation on soil fertility [35-41]. Within the topic of agricultural biodiversity, experiments can help in the identification and study of beneficial insects and setting up experiments to attract and support pollinators. For energy efficiency and waste management, experiments can be proposed with solar panels, wind turbines, or biogas systems while calculating energy savings and efficiency. One can analyze farm waste and develop recycling or reuse strategies.

## Data Analytics in Sustainable Farming Curriculum

All the lab components and projects would train students in data collection, statistical analysis, and report writing including techniques for accurate data recording and statistical analysis, writing scientific reports and presenting findings, and discussing implications of results for sustainable farming practices. This outline provides a comprehensive approach to teaching sustainable farming practices through curriculum and laboratory coursework. Each section discussed in this article can be expanded with specific experiments, case studies, and hands-on activities tailored to the students' level and the resources available. We understand that there cannot be a generalized, standard plan of action to implement sustainable farming curriculum in existing academic framework, and every university needs to adapt the curriculum to meet the needs of their students and local industry [40-45].

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