Term Information

Effective Term	Spring 2023

General Information

Course Bulletin Listing/Subject Area	Horticulture and Crop Science
Fiscal Unit/Academic Org	Horticulture & Crop Science - D1127
College/Academic Group	Food, Agric & Environ Science
Level/Career	Undergraduate
Course Number/Catalog	3586
Course Title	Digital Agriculture Laboratory
Transcript Abbreviation	DigitalAgLab
Course Description	Digital Agriculture Laboratory provides an overview of the tools used for making management decisions based on data-driven processes in agriculture and food systems. This course seeks to provide experience working with large data sets (crop, animal, weather, environment, and capital asset management models, coupled with AI) using a variety of software tools for data analysis and visualization.
Semester Credit Hours/Units	Fixed: 1

Offering Information

Length Of Course	14 Week, 12 Week
Flexibly Scheduled Course	Never
Does any section of this course have a distance education component?	No
Grading Basis	Letter Grade
Repeatable	No
Course Components	Laboratory
Grade Roster Component	Laboratory
Credit Available by Exam	No
Admission Condition Course	No
Off Campus	Never
Campus of Offering	Columbus, Lima, Mansfield, Marion, Newark, Wooster

Prerequisites and Exclusions

Prerequisites/Corequisites	AGSYSMT 2580, AGSYSMT 3585 or HCS 3585 (or concurrent)
Exclusions	AGSYSMT 3586
Electronically Enforced	Yes

Cross-Listings

Cross-Listings	AGSYSMT 3586

Subject/CIP Code

Subject/CIP Code	01.0301
Subsidy Level	Baccalaureate Course
Intended Rank	Sophomore, Junior, Senior

Requirement/Elective Designation

Sustainability

The course is an elective (for this or other units) or is a service course for other units

Course Details

Course goals or learning objectives/outcomes

- Understand the evolution of principles, theories, and methods of data-driven agriculture effects on sustainability and society.
- Gain experience with modern knowledge-based production technologies.
- Understand data-driven insights, meaningful interpretation of results, and effective ways to visualize and communicate the outcomes to the sustainable management of agriculture inputs, to the workforce and society.
- Understand the economic and environmental benefits of data driven agriculture for the producer, consumer, and society.

Content Topic List

- Data Precision, Accuracy and Outliers
- ArcGIS for mapping, analysis, and modelling
- Variable Rate Technology
- Yield Monitor Data: Cleaning and Processing
- Agricultural Machinery Data Collection, Decoding, and Processing
- Farm Data Interoperability
- Application of Google Earth in Digital Agriculture
- Remote Sensing and its application in Digital Agriculture
- Drones and their application in Digital Agriculture
- Introduction to R programming language and its application for on-farm research data analysis.
- Data Mining and Application of Big Data in Digital Agriculture
- Supply Chain Management in Digital Agriculture
- Application of Blockchain and Cryptocurrencies in Digital Agriculture

Sought Concurrence

Yes

Attachments

- HCS3585 GE justification Final_20211130.pdf: GE Justification

  (Other Supporting Documentation. Owner: Luikart,Meredith Marie)

- Course_Review_Concurrence_Animal_Sciences_AGSYSMT_HCS_3586_20211210.pdf: Concurrence

  (Concurrence. Owner: Luikart,Meredith Marie)

- Course_Review_Concurrence_Civil_Environmental_Geodetic_Engineering_AGSYSMT_HCS 3585_and_3586.pdf: Concurrence

  (Concurrence. Owner: Luikart,Meredith Marie)

- Course_Review_Concurrence_Geography_AGSYSMT_HCS_3585_and_3586.pdf: Concurrence

  (Concurrence. Owner: Luikart,Meredith Marie)

- Course_Review_Concurrence_Knowlton Schl of Architecture_AGSYSMT_HCS_3585_and_3586.pdf: Concurrence

  (Concurrence. Owner: Luikart,Meredith Marie)

- Course_Review_Concurrence_SENR_AGSYSMT_HCS_3586_20211210.pdf: Concurrence

  (Concurrence. Owner: Luikart,Meredith Marie)

- AGSYSMT_HCS_3586_Syllabus_Revised.docx: Syllabus revised

  (Syllabus. Owner: Luikart,Meredith Marie)

- AGSYSMT_HCS_3585_3586_Cover_Letter_Revised.docx: Cover letter

  (Other Supporting Documentation. Owner: Luikart,Meredith Marie)

- AGSYSMT_HCS_3585_3586_Course_Alignment_Map_Revised.docx: course alignment map

  (Other Supporting Documentation. Owner: Luikart,Meredith Marie)

Comments

- Please see Panel feedback email sent 05/17/2022. *(by Hilty,Michael on 05/17/2022 04:36 PM)*
- Revise as per COAA via email message 7 February 2022

  Revise as discussed with K. Trefz on 27 January 2022

  Revise as per discussion 19 January 2022

  Revise as per discussion 6 January 2022 *(by Osborne,Jeanne Marie on 02/07/2022 04:30 PM)*

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Luikart,Meredith Marie	12/10/2021 10:57 AM	Submitted for Approval
Approved	Barker,David John	12/13/2021 12:29 PM	Unit Approval
Revision Requested	Osborne,Jeanne Marie	01/06/2022 02:16 PM	College Approval
Submitted	Luikart,Meredith Marie	01/13/2022 02:12 PM	Submitted for Approval
Approved	Barker,David John	01/13/2022 03:14 PM	Unit Approval
Revision Requested	Osborne,Jeanne Marie	01/19/2022 02:12 PM	College Approval
Submitted	Luikart,Meredith Marie	01/25/2022 10:05 AM	Submitted for Approval
Approved	Gardner,David Sean	01/25/2022 10:10 AM	Unit Approval
Revision Requested	Osborne,Jeanne Marie	01/28/2022 10:29 AM	College Approval
Submitted	Luikart,Meredith Marie	02/02/2022 04:11 PM	Submitted for Approval
Approved	Barker,David John	02/03/2022 12:45 PM	Unit Approval
Revision Requested	Osborne,Jeanne Marie	02/07/2022 04:30 PM	College Approval
Submitted	Luikart,Meredith Marie	02/10/2022 09:42 AM	Submitted for Approval
Approved	Barker,David John	02/10/2022 01:35 PM	Unit Approval
Approved	Osborne,Jeanne Marie	02/11/2022 01:41 PM	College Approval
Revision Requested	Hilty,Michael	05/17/2022 04:36 PM	ASCCAO Approval
Submitted	Luikart,Meredith Marie	09/09/2022 05:17 PM	Submitted for Approval
Approved	Lindsey,Alexander Joseph	09/09/2022 05:47 PM	Unit Approval
Approved	Osborne,Jeanne Marie	09/12/2022 10:55 AM	College Approval
Pending Approval	Cody,Emily Kathryn Jenkins,Mary Ellen Bigler Hanlin,Deborah Kay Hilty,Michael Vankeerbergen,Bernadette Chantal Steele,Rachel Lea	09/12/2022 10:55 AM	ASCCAO Approval

THE OHIO STATE UNIVERSITY

Department of Food, Agricultural and Biological Engineering
200A Agricultural Engineering Building
590 Woody Hayes Drive
Columbus, OH 43210-1058

614.292.7284 Phone
614.292.9448 Fax

shearer.95@osu.edu

Department of Horticulture and Crop Science
202 Kottman Hall
2021 Coffey Rd
Columbus, OH 43210

614-247-6258 Phone
614-292-7162 Fax

barker.169@osu.edu

September 9, 2022

Dr. Jim Fredal, Faculty Chair of the ASCC Themes Panel
Dr. Maria Conroy, Faculty Chair of the Theme Advisory Group: Sustainability
Michael Hilty, Curriculum and Assessment Assistant
ASC Curriculum and Assessment Services
College of Arts and Sciences
The Ohio State University

We would like to thank the committee for your input on Digital Agriculture (AGSYSMT/HCS 3585) and Digital Agriculture Laboratory (AGSYSMT/HCS 3586). This letter responds to the ten (10) contingencies and four (4) recommendations mentioned in your email of May 12, 2022.

GE Theme: Sustainability – Focus on Sustainability

Contingency: The reviewing faculty saw this course as interesting but, as presented, not meeting the intention of the GE Theme: Sustainability.

> ***The focus on digital agricultural technology as a tool appears to be the focus of the course and not the consideration of how this technology could be used to look at sustainability concepts and incorporated to meet the GE Theme-specific Sustainability ELOs. They ask that the connection to the GE Theme: Sustainability be further explored and clarified.***

In general, we assumed that issues related to food production were synonymous with sustainability. We would like to thank the committee for clarifying this relationship and have revised the course and syllabus accordingly. Students will learn the impact of the existing technologies (i.e., digital agriculture) currently being used in food systems, and will evaluate their impact on sustainability and the environment.

(Syllabus 3585 – p. 2 and 3) After the course description we included the following:

- For digital agriculture, sustainability is defined as the “ability of growers to produce food efficiently and be profitable. Production practices should minimize the impact to the land, air, and water, which enhances the quality of life for local, national, and global communities.” The following sustainability concepts are addressed in this course: carbon cycling and sequestration, water quality and quantity, food production optimization and efficiency, nitrogen and phosphorus cycling and use efficiency, renewable energy, renewable materials, climate smart agriculture, food safety, and food security.”
- (Syllabus 3585 - p. 2) On page two in the official and expanded course description, sustainability and profitability are linked. This linkage is through the processes and practices of producing food, fiber, and energy. Using the data generated by farm operations that use animal and human power (traditional) through modern agricultural tractors utilizing precision agriculture technologies to controlled environment agriculture and making data-based decisions are key to sustainability. To

be sustainable, agricultural businesses must be profitable and productive by using resources efficiently, minimize environmental impact, without losing the market share.

- In the **Course Alignment Map (new document in the packet)** each lecture and laboratory topics are associated with one or more of the sustainability concepts. Each instructor will use these sustainability concepts in their lecture and laboratory connecting technology to the sustainability concepts mentioned before. For example, efficient nitrogen management in crops using remote sensing. Instructors will provide guidance on the evaluation of technologies for efficient nitrogen management and standard guidelines to be followed. The students will develop an overall appreciation and understanding of the role of data, technology and their impact on sustainability and environment.

GE Theme: Sustainability – Bibliographic Information

Contingency: The reviewing faculty ask for additional information on how the course reading materials and lectures will speak to the GE Theme: Sustainability and to provide bibliographic information surrounding the course readings.

We have added new text (required materials and/or technologies) in the syllabus and created a new document "Bibliographic information for AGSYSMT/HCS 3585 – 3586." The following bibliography will be provided to the students in Carmen and mentioned in the 3585 syllabus (see p. 7) and 3586 syllabus (see p. 5).

Required Materials

The following are general texts which provide background information. Specific chapters from these and other published materials will be assigned by the instructors. All materials are available from the OSU library. **Off-campus** access to most OSU Library resources may be obtained through these routes. Additional publications will be made available in Carmen.

Hamrita, T. K. (Ed.). (2021). Women in precision agriculture: technological breakthroughs, challenges and aspirations for a prosperous and sustainable future (Ser. Women in engineering and science). Springer. https://osu.on.worldcat.org/oclc/1187169922

Abd El-Kader, S. M., and Mohammad El-Basioni, B. M. (Eds.). (2021). Precision agriculture technologies for food security and sustainability (Ser. Advances in Environmental Engineering and Green Technologies (AEEGT) book series). Engineering Science Reference, an imprint of IGI Global. https://osu.on.worldcat.org/oclc/1156439371

Stafford, J. (Ed.). (2019). Precision agriculture for sustainability (Ser. Burleigh Dodds series in Agricultural Science, number 52). Burleigh Dodds Science Publishing. https://osu.on.worldcat.org/oclc/1078923421

Shannon, D. K., Clay, D., and Kitchen, N. R. (Eds.). (2018). Precision agriculture basics. American Society of Agronomy. https://osu.on.worldcat.org/oclc/1037150375

Lal, R., and Stewart, B. A. (Eds.). (2016). Soil-specific farming: precision agriculture (Ser. Advances in Soil Science). CRC Press, Taylor & Francis Group. https://osu.on.worldcat.org/oclc/914301013

Crawley, M. J. (2013). The R book (Second). Wiley. Retrieved July 21, 2022, https://osu.on.worldcat.org/oclc/809365744

Recommended/Optional Materials

Castrignanò Annamaria, Buttafuoco, G., Khosla, R., Mouazen, A. M., Moshou, D., & Naud, O. (Eds.). (2020). Agricultural internet of things and decision support for precision smart farming. Academic Press. https://osu.on.worldcat.org/oclc/1136962920

Pedersen, S. M., and Lind, K. M. (2017). Precision agriculture (Ser. Progress in Precision Agriculture). Springer. https://osu.on.worldcat.org/oclc/1012881350

Ess, D. R., and Morgan, M. T. (2017). The precision-farming guide for agriculturists (4th ed., Ser. Agricultural Primer Series). Deere. https://osu.on.worldcat.org/oclc/1007539133

Zhang, Q. (Ed.). (2017). Automation in tree fruit production: principles and practice. CABI. https://osu.on.worldcat.org/oclc/987909726

Zhang, Q. (Ed.). (2016). Precision agriculture technology for crop farming. CRC Press. https://osu.on.worldcat.org/oclc/908089930 [also available as ebook]

Halachmi, I. (Ed.). (2015). Precision livestock farming applications: making sense of sensors to support farm management. Wageningen Academic. https://osu.on.worldcat.org/oclc/910915968

GIS Applications in Agriculture Series. F. J. Pierce (Editor). Routledge.

Mueller, T. (2015). GIS applications in agriculture, volume four: conservation planning/ edited by Tom Mueller and Gretchen F. Sassenrath (4th ed.). https://osu.on.worldcat.org/oclc/903645674

Clay, D., and Shanahan, J. F. (2011). GIS applications in agriculture (Vol. Volume two, nutrient management for energy efficiency /, Ser. GIS applications in agriculture). CRC Press. https://osu.on.worldcat.org/oclc/231581363

Clay, S. A. (2011). GIS applications in agriculture (Vol. Volume three, invasive species / Ser. GIS applications in agriculture). CRC Press. https://doi.org/10.1201/b10597

Pierce, F. J. and Clay, D. (2007). GIS applications in agriculture (Ser. GIS applications in agriculture series). CRC Press. https://osu.on.worldcat.org/oclc/86068782

Heege, H. J. (Ed.). (2013). Precision in crop farming: site specific concepts and sensing methods: applications and results. Springer. https://osu.on.worldcat.org/oclc/852470956

Oliver, M. A., Bishop, T., and Marchant, B. (2013). Precision agriculture for sustainability and environmental protection (Ser. Earthscan food and agriculture). Taylor and Francis. https://osu.on.worldcat.org/oclc/864414805

Oliver, M. A. (2010). Geostatistical applications for precision agriculture. Springer. https://osu.on.worldcat.org/oclc/668096011

Oerke, E.-C., Gerhards, R., Menz, G., and Sikora, R. A. (Eds.). (2010). Precision crop protection - the challenge and use of heterogeneity. Springer. https://osu.on.worldcat.org/oclc/913513807

Fischer, M. M., & Getis, A. (2009). *Handbook of applied spatial analysis: software tools, methods and applications*. Springer. https://doi.org/10.1007/978-3-642-03647-7 https://link-springer-com.proxy.lib.ohio-state.edu/book/10.1007/978-3-642-03647-7

Conference proceedings

International Conference on Precision Agriculture, International Society of Precision Agriculture

Possible topics to choose from the conference

- Applications of Unmanned Aerial Systems
- Big Data, Data Mining and Deep Learning
- Geospatial Data
- Land Improvement and Conservation Practices
- On Farm Experimentation with Site-Specific Technologies
- Precision Agriculture and Global Food Security
- Precision Crop Protection
- Precision Horticulture
- Site-Specific Nutrient, Lime, and Seed Management
- Site-Specific Pasture Management
- Small Holders and Precision Agriculture
- Smart Weather for Precision Agriculture

European Conference on Precision Agriculture, International Society of Precision Agriculture

Possible topics to choose from the conference

- Precision Agriculture
- Precision Horticulture
- Precision Crop Protection
- Proximal and Remote Sensing of Soil and Crop
- Applications of Unmanned Aerial Systems
- Site-Specific Nutrient, Lime and Seed Management
- Drainage Optimization and Variable Rate Irrigation
- Geostatistics, mapping and spatial data analysis
- On Farm Experimentation with Site-Specific Technologies
- Software and mobile Apps for Precision Agriculture
- Decision Support for Precision Agriculture
- Data Mining for Precision Agriculture

European Conference on Precision Livestock Farming, European Association for Precision Livestock Farming

Possible topics to choose from the conference

- Controlling environment in animal husbandry
- Performance and welfare monitoring
- PLF approaches to enable sustainable production
- PLF to support decision-making and solutions
- Precision technology in product development, optimization, and testing
- Traceability of production
- Monitoring wildlife and companion animals

Pennsylvania Association for Sustainable Agriculture (Pasa)

- Agritourism
- Agroforestry
- Clean water
- Climate change
- Dairy Grazing
- Farm Innovations
- Farmers markets
- Food security
- Food Systems
- Fruit/Orchard

- Hemp
- Integrated pest management
- Land access
- Livestock
- Meat processing
- Organic
- Renewable energy
- Research
- Soil health
- Specialty Crops
- Urban Farming
- Vegetable production

Ohio Ecological Food and Farm Association (OEFFA)

Has YouTube video of past conference events, sessions, and workshops.

Journal articles related to the Sustainability concepts

1. Carbon Cycling and Sequestration:

Carbon Cycling and Sequestration is a whole farm approach which optimizes carbon capture by implementing sustainable practices that are known to improve the rate at which CO_2 is removed from the atmosphere and stored in plant material and/or soil organic matter. This can be achieved by following sustainable practices like residue retention, cover cropping, integrated nutrient management, minimum tillage, agroforestry, and livestock integration. Carbon farming helps with restoration of soil and environmental quality, improvement in agroecosystem resilience, and increase in social and political stability.

Selected articles focused on Carbon Cycling and Sequestration:

Abdalla, M., Hastings, A., Cheng, K., Yue, Q., Chadwick, D., Espenberg, M., . . . Smith, P. (2019). A critical review of the impacts of cover crops on nitrogen leaching, net greenhouse gas balance and crop productivity. Global Change Biology, 25(8), 2530-2543. doi:10.1111/gcb.14644

Bossio, D. A., Cook-Patton, S. C., Ellis, P. W., Fargione, J., Sanderman, J., Smith, P., . . . Griscom, B. W. (2020). The role of soil carbon in natural climate solutions. Nature Sustainability, 3(5), 391-398. doi:10.1038/s41893-020-0491-z

Chenu, C., Angers, D. A., Barre, P., Derrien, D., Arrouays, D., & Balesdent, J. (2019). Increasing organic stocks in agricultural soils: knowledge gaps and potential innovations. Soil & Tillage Research, 188, 41-52. doi:10.1016/j.still.2018.04.011

Jiang, Z., Lian, F., Wang, Z., & Xing, B. (2020). The role of biochars in sustainable crop production and soil resiliency. Journal of Experimental Botany, 71(2), 520-542. https://doi.org/10.1093/jxb/erz301

Kay, S., Rega, C., Moreno, G., Herder, M. d., Palma, J. H. N., Borek, R., . . . Herzog, F. (2019). Agroforestry creates carbon sinks whilst enhancing the environment in agricultural landscapes in Europe. Land Use Policy, 83, 581-593. doi:10.1016/j.landusepol.2019.02.025

Kopittke, P. M., Menzies, N. W., Wang, P., McKenna, B. A., & Lombi, E. (2019). Soil and the intensification of agriculture for global food security. Environment International, 132, 105078. doi:10.1016/j.envint.2019.105078

Lal, R. (2019). Accelerated soil erosion as a source of atmospheric CO2. Soil & Tillage Research, 188, 35-40. doi:10.1016/j.still.2018.02.001

Lal, R. (2018). Digging deeper: a holistic perspective of factors affecting soil organic carbon sequestration in agroecosystems. Global Change Biology, 24(8), 3285-3301. https://doi.org/10.1111/gcb.14054

Thangavel, R., Bolan, N. S., Kirkham, M. B., Wijesekara, H., Manjaiah, K., Rao, C. S., . . . Freeman, O. W., II. (2019). Soil organic carbon dynamics: impact of land use changes and management practices: a review. Advances in Agronomy, 156, 1-107. https://doi.org/10.1016/bs.agron.2019.02.001

Wiesmeier, M., Urbanski, L., Hobley, E., Lang, B., Lutzow, M. v., Marin-Spiotta, E., . . . Kogel-Knabner, I. (2019). Soil organic carbon storage as a key function of soils - a review of drivers and indicators at various scales. Geoderma, 333, 149-162. doi:10.1016/j.geoderma.2018.07.026

2. Water Quality and Quantity:
About 40 percent of the land in the United States is used for agriculture. Increased levels of nutrients from fertilizers draining into streams results in algal blooms and increased treatment cost of drinking water. Pesticides that are transported to water bodies can pose risks for aquatic life. They can impair the quality of surface water and groundwater. Transport of excess nutrients is influenced by agricultural practices, such as tillage, drainage, and the timing of application of nutrients.

Selected articles focused on Water Quality and Quantity:

Bierkens, M. F. P., & Wada, Y. (2019). Non-renewable groundwater use and groundwater depletion: a review. Environmental Research Letters, 14(6). doi:10.1088/1748-9326/ab1a5f

Duncan, E. W., Osmond, D. L., Shober, A. L., Starr, L., Tomlinson, P., Kovar, J. L., . . . Reid, K. (2019). Phosphorus and soil health management practices. Agricultural and Environmental Letters, 4(1), 190014. doi:10.2134/ael2019.04.0014

Emde, D., Hannam, K. D., Most, I., Nelson, L. M., & Jones, M. D. (2021). Soil organic carbon in irrigated agricultural systems: a meta-analysis. Global Change Biology, 27(16), 3898-3910. doi:10.1111/gcb.15680

Liu, J., & Lobb, D. A. (2021). An overview of crop and crop residue management impacts on crop water use and runoff in the Canadian prairies. Water, 13(20). doi:10.3390/w13202929

Lwin, C., Seo, B., Kim, H., Owens, G., & Kim, K. (2018). Application of soil amendments to contaminated soils for heavy metal immobilization and improved soil quality - a critical review. Soil Science and Plant Nutrition, 64(2), 156-167. doi:10.1080/00380768.2018.1440938

Ni, X., Yuan, Y., & Liu, W. (2020). Impact factors and mechanisms of dissolved reactive phosphorus (DRP) losses from agricultural fields: a review and synthesis study in the Lake Erie basin. Science of the Total Environment, 714. doi:10.1016/j.scitotenv.2020.136624

Skaalsveen, K., Ingram, J., & Clarke, L. E. (2019). The effect of no-till farming on the soil functions of water purification and retention in north-western Europe: a literature review. Soil & Tillage Research, 189, 98-109. doi:10.1016/j.still.2019.01.004

Smith, D. R., Wilson, R. S., King, K. W., Zwonitzer, M., McGrath, J. M., Harmel, R. D., . . . Johnson, L. T. (2018). Lake Erie, phosphorus, and microcystin: is it really the farmer's fault? Journal of Soil and Water Conservation (Ankeny), 73(1), 48-57. doi:10.2489/jswc.73.1.48

Souza, R. M. d., Seibert, D., Quesada, H. B., Bassetti, F. d. J., Fagundes-Klen, M. R., & Bergamasco, R. (2020). Occurrence, impacts and general aspects of pesticides in surface water: a review. Process Safety and Environmental Protection, 135, 22-37. doi:10.1016/j.psep.2019.12.035

Syafrudin, M., Kristanti, R. A., Yuniarto, A., Hadibarata, T., Rhee, J., Wedad, A. A.-O., . . . Amal, M. A.-M. (2021). Pesticides in drinking water - a review. International Journal of Environmental Research and Public Health, 18(2). doi:10.3390/ijerph18020468

Ward, M. H., Jones, R. R., Brender, J. D., Kok, T. M. d., Weyer, P. J., Nolan, B. T., . . . Breda, S. G. v. (2018). Drinking water nitrate and human health: an updated review. International Journal of Environmental Research and Public Health, 15(7), 1557. doi:10.3390/ijerph15071557

3. Food Production Optimization and Efficiency:
   Agricultural Efficiency: is defined as the input-output ratio in an agricultural operation. It reflects the impact of modern inputs and technology in production and is dependent upon the responsiveness of soil and the agricultural ecology. It measures the increase in output with a given increase in inputs, which leads to an increase in profits. This extra profit earned on agriculture is reflected by the agricultural efficiency (Source: https://lotusarise.com/agricultural-productivity-upsc/)

   Agricultural Optimization: help farmers in selecting the right crop at the right time and the optimum allocation of land and water to each of these crops to maximize the profit by taking into consideration, the market prices, climate, and irrigation facilities. It considers the case of optimization of agricultural resources. (Source: https://ieeexplore.ieee.org/document/6420815)

   Selected articles focused on Food Production Optimization and Efficiency:

Bergtold, J. S., Ramsey, S., Maddy, L., & Williams, J. R. (2019). A review of economic considerations for cover crops as a conservation practice. Renewable Agriculture and Food Systems, 34(1), 62-76. doi:10.1017/s1742170517000278

Colaco, A. F., & Bramley, R. G. V. (2018). Do crop sensors promote improved nitrogen management in grain crops? Field Crops Research, 218, 126-140. doi:10.1016/j.fcr.2018.01.007

Kleijn, D., Bommarco, R., Fijen, T. P. M., Garibaldi, L. A., Potts, S. G., & Putten, W. H. v. d. (2019). Ecological intensification: bridging the gap between science and practice. Trends in Ecology & Evolution, 34(2), 154-166. doi:10.1016/j.tree.2018.11.002

Ricciardi, V., Mehrabi, Z., Wittman, H., James, D., & Ramankutty, N. (2021). Higher yields and more biodiversity on smaller farms. Nature Sustainability, 4(7), 651-657. doi:10.1038/s41893-021-00699-2

Rosa-Schleich, J., Loos, J., Musshoff, O., & Tscharntke, T. (2019). Ecological-economic trade-offs of Diversified Farming Systems - a review. Ecological Economics, 160, 251-263. doi:10.1016/j.ecolecon.2019.03.002

4. Nitrogen and Phosphorus Cycling and Use Efficiency:

Nitrogen Cycling and Use Efficiency:

Nitrogen (N) fertilizer is required for plant growth and development. Approximately half the food produced now in the world use N fertilizer. Excessive and inefficient use of N fertilizer results in increased crop production costs and atmospheric pollution. The losses can be minimized by adopting improved sustainable agronomic practices such as optimal dosage of nitrogen, application of N by using canopy sensors, maintaining plant population, drip fertigation and legume-based intercropping.

Phosphorous Cycling and Use Efficiency:

Phosphorus (P) like nitrogen, is often the most limiting nutrient for crop production. P-loss is mainly associated with erosion and runoff. P availability can be managed by liming acid soils, using practices that increase organic matter, and proper placement of P fertilizer affecting how efficiently P is used by crops. P losses can be reduced by applying appropriate measures to reduce erosion and runoff.

Selected articles focused on Nitrogen and Phosphorus Cycling and Use Efficiency:

Abbott, L. K., Macdonald, L. M., Wong, M. T. F., Webb, M. J., Jenkins, S. N., & Farrell, M. (2018). Potential roles of biological amendments for profitable grain production - a review. Agriculture, Ecosystems & Environment, 256, 34-50. doi:10.1016/j.agee.2017.12.021

Barkha, & Ananya, C. (2021). Effect of integrated nutrient management on nutrient use efficiency of major nutrients: a review. Plant Archives, 21(1), 1084-1089. doi:10.51470/PLANTARCHIVES.2021.v21.no1.143

Carr, P. M., Cavigelli, M. A., Darby, H., Delate, K., Eberly, J. O., Gramig, G. G., . . . Woodley, A. L. (2019). Nutrient cycling in organic field crops in Canada and the United States. Agronomy Journal, 111(6), 2769-2785. doi:10.2134/agronj2019.04.0275

Colaco, A. F., & Bramley, R. G. V. (2018). Do crop sensors promote improved nitrogen management in grain crops? Field Crops Research, 218, 126-140. doi:10.1016/j.fcr.2018.01.007

Duncan, E. G., O'Sullivan, C. A., Roper, M. M., Biggs, J. S., & Peoples, M. B. (2018). Influence of co-application of nitrogen with phosphorus, potassium and sulphur on the apparent efficiency of nitrogen fertiliser use, grain yield and protein content of wheat: review. Field Crops Research, 226, 56-65. doi:10.1016/j.fcr.2018.07.010

Folina, A., Tataridas, A., Mavroeidis, A., Kousta, A., Katsenios, N., Efthimiadou, A., . . . Kakabouki, I. (2021). Evaluation of various nitrogen indices in N-fertilizers with inhibitors in field crops: a review. Agronomy, 11(3). doi:10.3390/agronomy11030418

Liu, C., Plaza-Bonilla, D., Coulter, J. A., Kutcher, H. R., Beckie, H. J., Wang, L., . . . Gan, Y. (2022). Diversifying crop rotations enhances agroecosystem services and resilience. Advances in Agronomy, 173, 299-335. doi:10.1016/bs.agron.2022.02.007

Losacco, D., Ancona, V., Paola, D. d., Tumolo, M., Massarelli, C., Gatto, A., & Uricchio, V. F. (2021). Development of ecological strategies for the recovery of the main nitrogen agricultural pollutants: a review on environmental sustainability in agroecosystems. Sustainability, 13(13). doi:10.3390/su13137163

Martinez-Dalmau, J., Berbel, J., & Ordonez-Fernandez, R. (2021). Nitrogen fertilization. A review of the risks associated with the inefficiency of its use and policy responses. Sustainability, 13(10). doi:10.3390/su13105625

Swaney, D. P., & Howarth, R. W. (2019). Phosphorus use efficiency and crop production: patterns of regional variation in the United States, 1987-2012. Science of the Total Environment, 685, 174-188. doi:10.1016/j.scitotenv.2019.05.228

Swaney, D. P., Howarth, R. W., & Hong, B. (2018). Nitrogen use efficiency and crop production: patterns of regional variation in the United States, 1987-2012. Science of the Total Environment, 635, 498-511. doi:10.1016/j.scitotenv.2018.04.027

Wang, Z., & Li, S. (2019). Nitrate N loss by leaching and surface runoff in agricultural land: a global issue (a review). Advances in Agronomy, 156, 159-217. doi: 10.1016/bs.agron.2019.01.007

5. Climate Smart Agriculture (CSA):

The most commonly used definition is provided by the Food and Agricultural Organization of the United Nations (FAO), which defines CSA as “agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes GHGs (mitigation) where possible, and enhances achievement of national food security and development goals”.

Climate Smart Agriculture (CSA) practices and technologies includes soil management, crop management, water management, livestock management, forestry, fisheries and aquaculture, and energy management. For example, precision farming, tillage, and fertilization are all CSA practices.

Selected articles focused on Climate *Smart Agriculture:*

Barasa, P. M., Botai, C. M., Botai, J. O., & Mabhaudhi, T. (2021). A review of climate-smart agriculture research and applications in Africa. Agronomy, 11(6). doi:10.3390/agronomy11061255

Gardezi, M., Michael, S., Stock, R., Vij, S., Ogunyiola, A., & Ishtiaque, A. (2022). Prioritizing climate-smart agriculture: an organizational and temporal review. Wiley Interdisciplinary Reviews: Climate Change, 13(2). doi:10.1002/wcc.755

Mizik, T. (2021). Climate-smart agriculture on small-scale farms: a systematic literature review. Agronomy, 11(6). doi:10.3390/agronomy11061096/

Sarker, M. N. I., Wu, M., Alam, G. M. M., & Islam, M. S. (2019). Role of climate smart agriculture in promoting sustainable agriculture: a systematic literature review. International Journal of Agricultural Resources, Governance and Ecology, 15(4), 323-337. doi:10.1504/ijarge.2019.104199

Thornton, P. K., Whitbread, A., Baedeker, T., Cairns, J., Claessens, L., Baethgen, W., . . . Keating, B. (2018). A framework for priority-setting in climate smart agriculture research. Agricultural Systems, 167, 161-175. doi:10.1016/j.agsy.2018.09.009

Totin, E., Segnon, A. C., Schut, M., Affognon, H., Zougmore, R. B., Rosenstock, T., & Thornton, P. K. (2018). Institutional perspectives of climate-smart agriculture: a systematic literature review. Sustainability, 10(6), 1990. doi:10.3390/su10061990

Zougmore, R. B., Laderach, P., & Campbell, B. M. (2021). Transforming food systems in Africa under climate change pressure: role of climate-smart agriculture. Sustainability, 13(8). doi:10.3390/su13084305

6. Food Safety:

It is achieved by following Good Agricultural Practices (GAPs). GAPs are measures that are adopted by farmers to prevent microbial contamination of fruits and vegetables as they are produced, packed, handled, and stored. Many other risks in the present food system, such as the long-term loss of topsoil, species diversity, natural resources, consumer choice, and opportunities for farms and rural communities have an impact on food safety.

Selected articles focused on Food Safety:

Adeyeye, S. A. O. (2020). Aflatoxigenic fungi and mycotoxins in food: a review. Critical Reviews in Food Science and Nutrition, 60(5), 709-721. doi:10.1080/10408398.2018.1548429

Anil, P., Navnidhi, C., Neelesh, S., & Sundeep, J. (2018). Role of Food Safety Management Systems in safe food production: a review. Journal of Food Safety, 38(4), e12464. doi:10.1111/jfs.12464

Chen, H., Kinchla, A. J., Richard, N., Shaw, A., & Feng, Y. (2021). Produce growers' on-farm food safety education: a review. Journal of Food Protection, 84(4), 704-716. doi:10.4315/jfp-20-320

Duchenne-Moutien, R. A., & Neetoo, H. (2021). Climate change and emerging food safety issues: a review. Journal of Food Protection, 84(11), 1884-1897. doi:10.4315/jfp-21-141

Lenzi, A., Marvasi, M., & Baldi, A. (2021). Agronomic practices to limit pre- and post-harvest contamination and proliferation of human pathogenic Enterobacteriaceae in vegetable produce. Food Control, 119. doi:10.1016/j.foodcont.2020.107486

Riggio, G. M., Wang, Q., Kniel, K. E., & Gibson, K. E. (2019). Microgreens - a review of food safety considerations along the farm to fork continuum. International Journal of Food Microbiology, 290, 76-85. doi:10.1016/j.ijfoodmicro.2018.09.027

7. Food Security:

Food security, as defined by the United Nations' Committee on World Food Security, means that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life.

In order to feed a population that is expected to grow to 9 billion people by 2050, we need to double the current food production. To meet this challenge and to achieve food security, there is a need to adopt sustainable agricultural practices which uses technology.

Selected articles focused on Food Security:

Ali, R., Ali, R., Mehmood, S. S., Zou, X., Zhang, X., Lv, Y., & Xu, J. (2019). Impact of climate change on crops adaptation and strategies to tackle its outcome: a review. Plants, 8(2), 34. doi:10.3390/plants8020034

Karthikeyan, L., Chawla, I., & Mishra, A. K. (2020). A review of remote sensing applications in agriculture for food security: crop growth and yield, irrigation, and crop losses. Journal of Hydrology (Amsterdam), 586. doi:10.1016/j.jhydrol.2020.124905

Leisner, C. P. (2020). Review: climate change impacts on food security- focus on perennial cropping systems and nutritional value. Plant Science, 293. doi:10.1016/j.plantsci.2020.110412

Ramankutty, N., Mehrabi, Z., Waha, K., Jarvis, L., Kremen, C., Herrero, M., & Rieseberg, L. H. (2018). Trends in global agricultural land use: Implications for environmental health and food security. Annual Review of Plant Biology, 69, 789-815. doi:10.1146/annurev-arplant-042817-040256

Wezel, A., Herren, B. G., Kerr, R. B., Barrios, E., Goncalves, A. L. R., & Sinclair, F. (2020). Agroecological principles and elements and their implications for transitioning to sustainable food systems. a review. Agronomy for Sustainable Development, 40(6). doi:10.1007/s13593-020-00646-z

GE Theme: Sustainability – Course Assignments

Contingency: The reviewing faculty ask that additional clarification be provided that shows how the GE Theme-specific ELOs will be engaged in the course assignments.

(3585 Syllabus p. 11-12) – ***See Grading Rubric for Homework*** *section in the syllabus and in each of the seven (7) Homeworks which clearly indicates which ELOs are in each Homework and the rubric for their evaluation. Using the* ***Course Alignment Map*** *you can also trace the ELOs through the Quizzes, Exams, Final, and the Technical Feasibility and Sustainability Study.*

Homework Set No. 1 – Sustainable Production Systems

Students will write a two-page paper overviewing a production system and key management concepts, they will conduct a literature review, provide a metadata analysis, and develop arguments to adopt or reject a technology or process based on their impact on sustainability.

Outcomes

CLO 1.1 (ELO 1.1, 3.3 – IITT 1.1.a)
CLO 2.1 (ELO 2.1 – IITT 2.1.a)
The topic you chose may also use these:
CLO 1.2 (ELO 1.1, 1.2 – IITT 1.1.b, 1.1.c, 1.2.a)]
CLO 1.3 (ELO 3.1, 3.2), CLO 1.4 (ELO 1.1, 1.2 – IITT 1.1.b, 1.1.c, 1.2.a)]
CLO 2.2 (ELO 2.1 – IITT 2.1.b), CLO 2.3 (ELO 2.2 – IITT 2.2.a), CLO 2.4 (ELO 2.2 – IITT 2.2.b),
CLO 2.5 (ELO 1.2, 2.1 – IITT 1.2.a, 2.1.a)

Homework Set No. 2 – Social Media As a "Knowledge Tool" For Sustainable Food Production

Students will select and follow thought leaders on social media centered around sustainability and digital agriculture. They will identify the thought leaders focus and how the leader influences the discussions in their social media accounts. This will change student's perspective and understanding of sustainability and technology and their interaction.

Outcomes

CLO 1.2 (ELO 1.1, 1.2 – IITT 1.1.b, 1.1.c, 1.2.a), CLO 1.4 (ELO 1.1, 1.2 – IITT 1.1.b, 1.1.c, 1.2.a)
CLO 2.4 (ELO 2.2 – IITT 2.2.b)

Homework Set No. 3 – Conferences as a "Knowledge Tool" for Digital Agriculture

Students will review conference proceedings provided by the instructor and select a topic of their interest. Students will list the key findings related to the topic and then discuss the overall impact on the societies/cultures and sustainability.

Outcomes

CLO 1.3 (ELO 3.1, 3.2), CLO 1.4 (ELO 1.1, 1.2 – IITT 1.1.b, 1.1.c, 1.2.a)
CLO 2.4 (ELO 2.2 – IITT 2.2.b)

Homework Set No. 4 – Data Interoperability in Sustainable Digital Agriculture

Students will write a one-to-two page paper on what data is available from modern farms (format, type, range, storage), contemporary with sharing data (ethics, ownership etc.), current efforts to enable data sharing, and how actionable information is extracted to guide sustainable food production.

Outcomes

CLO 2.1 (ELO 2.1 – IITT 2.1.a)

Homework Set No. 5 – Google Earth Engine (GEE) and its applications

Students will analyze how the Google Earth Engine can be used to support sustainability through access to publicly available data.

Outcomes

CLO 2.1 (ELO 2.1 – IITT 2.1.a)

Homework Set No. 6 – Ethics of Data Ownership

Students will review data ownership agreements and their implications on decision making related to production efficiency and sustainability.

Outcomes

CLO 1.3 (ELO 3.1, 3.2), CLO 1.4 (ELO 1.1, 1.2 – IITT 1.1.b, 1.1.c, 1.2.a)
CLO 2.1 (ELO 2.1 – IITT 2.1.a)

Homework Set No. 7 – Sustainability-Digital Agriculture: Thought Leader Changes Across the Semester

Students will reflect on changes in their views, thought leader views, and their impact on society, environment, and sustainability over the semester.

Objectives

CLO 2.3 (ELO 2.2 – IITT 2.2.a), ELO 2.2 – IITT 2.2.b

GE Theme: Sustainability Advanced Study

Contingency: The reviewing faculty ask that more information be added to the proposal that explains how this course is considered an advanced study of Sustainability as, while it is clear this is an advanced study on digital agriculture technology, it was unclear how Sustainability will be engaged with at the advanced level in the present proposal.

The advanced digital agriculture technologies produce terabytes of data about land, water, number and amount of the inputs used (fertilizers, seed, fuel etc.), and quality of the food, fiber or energy produced. In this course, students will learn/understand sources of data, data analysis, and effective way of communicating results to the stakeholders so that they can implement them for sustainable food production. Students must demonstrate the validity and usefulness of the data that is critical for understanding the sustainability of a practice/process and their impact on communities and the environment.

The syllabi contain sustainability concepts (3585: p. 2 and 3, 3586: p.2). The **Course Alignment Map** details the **AGSYSMT_HCS_3585_Digital Agriculture: Alignment of Sustainability Concepts** to the course objectives, module objectives, assessment, instructional materials, and activities (see p. 16 to 23) for the lecture topics, homeworks, guest lecture reflections, and the technical feasibility and sustainability study. **AGSYSMT_HCS_3586_Digital Agriculture Laboratory: Alignment of Sustainability Concepts** to the laboratory exercises (see p. 24 to 27) for the laboratory topics, and instructional materials.

AGSYSMT_HCS_3585_Digital Agriculture: Alignment of Sustainability Concepts and **AGSYSMT_HCS_3586_Digital Agriculture Laboratory: Alignment of Sustainability Concepts** maps sustainability concepts to the lecture topics, quizzes, reading materials, and lecture presentations listing the activities and interactions.

GE Theme: Repeat of bibliography information

The reviewing faculty ask for additional information on how the course reading materials and lectures will speak to the GE Theme: Sustainability and to provide bibliographic information surrounding the course readings.

This is a repeat of the fifth bullet down.

GE Theme: Sustainability - Goals

Contingency: The reviewing faculty request that GE Goals, ELOs, and a rationale that explains how the GE ELOs will be met be added to the 3586 syllabus, per a requirement of all General Education courses.

The GE Goals and ELOs have been added under the General Education Goals and Expected Learning Outcomes within the 3585 (p. 3 and 4) and 3586 (p. 2 to 4) syllabi, the ELOs have been added to specific Course Learning Outcomes (CLO) and Laboratory Learning Outcomes (LLO) providing the framework and rationale for meeting the GE Goals and ELO. Additionally, this rationale is also contained in the **Course Alignment Map.** Refer to the **AGSYSMT_HCS_3585_Digital Agriculture and AGSYSMT_HCS_3586_Digital Agriculture Laboratory Course Alignment Map: Alignment of the GE Goals, ELOs, IITT Goals, and IITT ELOs** to the course lecture topics, discussions, guest speaker reflections, homeworks, laboratory exercises, and laboratory outcomes (p. 1 to 15)**.**

GE Theme: Sustainability – Mental Health

Recommendation: The reviewing faculty recommend clarifying in the syllabus who the CFAES embedded mental health counselor (as found on p. 21 of the 3585 syllabus) can be utilized by, given

this will be a course taken by students across the entire university. Can students from, say, The College of Arts and Sciences utilize David Wirt's services since they are in a CFAES course?

No, students must be in CFAES to use David Wirt's services.

All students can use the information in the first paragraph to receive help (3585 syllabus p. 21).

Only CFAES students: David Wirt, wirt.9@osu.edu, is the CFAES embedded mental health counselor. He is available for new consultations and to establish routine care. To schedule with David, please call 614-292-5766. Students should mention their affiliation with CFAES when setting up a phone screening (3585 syllabus p. 21).

GE Theme: Sustainability – Boiler plate

Recommendation: The reviewing faculty recommend removing all boilerplate language referencing distance education from the course syllabus (such as on p. 7 of the 3585 syllabus, where it mentions weekly modules are released one week ahead of time).

We agree, and it has been removed. It now reads "This course is divided into weekly modules". Students are expected to keep pace with weekly deadlines but may schedule their efforts freely within that time frame.

Recommendation: The phase (p. 21) "No matter where you are engaged in distance learning" can be changed to "No matter where you are engaged in learning" to make it more inclusive.

Changed to "No matter where you are engaged in learning"

Accessibility of Course Technology - This course requires use of Carmen Canvas Ohio State University's Learning Management System and online communication, and multimedia tools. If you need additional help to use these technologies, please request help as early as possible.

Removed the "(".

"***Contingency: The reviewing faculty request that a cover letter be provided that details all changes made to the proposal in response to the reviewing faculty's feedback and requests***."

Explained in this letter.

High Impact Practice: Interdisciplinary Team-Teaching – IITT ELOs

The reviewing faculty are unable to determine

Recommendation: how this course will meet the ELOs for the Interdisciplinary Team-Teaching High Impact Practice.

Based on Descriptions, Expected Learning Outcomes, and Rubrics for Interdisciplinary Team -Taught Courses we used the Integrative, Interdisciplinary, Team-Taught Learning ELOs and Objectives Template.

We have added the IITT ELOs (see p. 3 and 4) under the General Education Goals and Expected Learning Outcomes.

The IITT ELOs were previously listed (see p. 6 and 7) under each of the Course Learning Outcomes.

The IITT ELOs are also part of the ***Course Alignment Map*** *(see p. 1 to 16).*

Contingency: Please further elaborate and clarify on the course syllabus how the different disciplines and perspectives represented in the course will be differentiated, compared, and/or brought into dialogue with each other.

This course is taught collaboratively by two departments Food, Agricultural and Biological Engineering (FABE) and Horticulture and Crop Science, (HCS). Although, this course addresses several sustainability concepts (carbon cycling and sequestration, climate-smart agriculture, food safety, food security, food production optimization and efficiency, nitrogen and phosphorus cycling and use efficiency, and water quality and quantity), as a generalization, FABE faculty will take an engineering approach and HCS will take a biophysical approach focused on plant science to address sustainability topics. Within HCS, a range of disciplinary approaches including whole plant ecophysiology and agricultural value chain management (applied economics) will be used to address sustainability. Lectures will be conducted separately by faculty allowing the respective disciplinary approaches to be presented. The homework assignments (7), guest lecture reflections (3), and technical feasibility and sustainability study (1) will allow students to draw upon these various disciplinary approaches to the topic. For example, carbon cycling and sequestration might include an engineering component (no-tillage vs. full tillage cultivation), a biophysical component (crop selection, or fertilization to promote plant root growth), or a value chain approach (marketing of organic vs. conventional crops).

High Impact Practice: Interdisciplinary Team-Teaching - the interdisciplinary nature of the team-teaching

The reviewing faculty ask that more explanation be added to explain the interdisciplinary nature of the team-teaching taking place and what each of the two disciplines are bringing to the course.

Contingency: More explanation be added to explain the interdisciplinary nature of the team-teaching taking place.

This course addresses several sustainability concepts and will focus on i) carbon cycling and sequestration, ii) climate-smart agriculture, iii) food safety, iv) food security, v) food production optimization and efficiency, vi) nitrogen and phosphorus cycling and use efficiency, and vii) water quality and quantity. This course will be team-taught by faculty from two departments namely FABE and HCS within the CFAES. As a generalization, FABE faculty will take an engineering approach and HCS will take a biophysical approach focused on plant science to address the sustainability issues.

Contingency: What each of the two disciplines are bringing to the course

Some examples of engineering approaches to address sustainability that will be covered by FABE in this course includes mechanization and automation of equipment for crop care, robotic irrigation, crop harvesting, use of sensors for collecting data, artificial intelligence for data analytics, and spatial analyses, etc.

HCS will bring Biophysical approaches to sustainability that includes plant ecophysiology such as crop and variety selection, plant climatic responses, fertilization rates, and agricultural value chain management practices such as marketing, product differentiation and enterprise budgeting. In general, lectures will be conducted by individual faculty presenting subject matter in a traditional lecture format. Lectures will thus represent facets of each of the sustainability themes. The homework assignments (7), guest lecture reflections (3), and technical feasibility and sustainability study (1) will allow students to draw and reflect upon these various disciplinary approaches to the topic. In this course, students will learn the relationship between engineering and biophysical approaches, their interaction, and their impact on sustainability and the environment. By the end of the semester, students will understand that any impact on sustainability and environment is best understood with a multidisciplinary approach.

"***Contingency: The reviewing faculty request that a cover letter be provided that details all changes made to the proposal in response to the reviewing faculty's feedback and requests***."

Refer to this letter.

Sincerely,

Scott A. Shearer, Ph.D., P.E.
Professor and Chair, FABE

David J. Barker, Ph.D.
Professor, HCS

Course Alignment Map

AGSYSMT_HCS_3585_Digital Agriculture and AGSYSMT_HCS_3586_Digital Agriculture Laboratory Course Alignment Map: Alignment of the GE Goals, ELOs, IITT Goals, and IITT ELOs

Goals (GE, IITT, GE Sustainability)	**GE or IITT Outcomes**	**Course Outcomes in GE or IITT Outcomes** **CLO (Course Learning Outcomes)** **LLO (Laboratory Learning Outcomes)**	**Lecture Topics** **Discussion** **Guest Speakers** **Homeworks** **Laboratories**
GE Goal 1: Successful students will analyze sustainability at a more advanced and in-depth level than in the Foundations component **IITT Goa1:** GOAL 1: Successful students analyze an important topic or idea at a more advanced and in-depth level than the foundations	**ELO 1.1 (IITT ELO 1.1)** Engage in critical and logical thinking about the topic or idea of sustainability.	CLO 1.1, CLO 1.2, CLO 1.4 LLO 1.1, LLO 1.2, LLO 1.4	1 – Introduction to Digital Agriculture and its Role in Sustainability 2 – Global Navigation Satellite Systems (GNSS) in Agriculture and Natural Resource Conservation 3 – ArcGIS Applications in Agricultural Sustainability 5 – Variable Rate Technology and its Role in Long-Term Soil Health and Sustainability 6 – Soil Health Sampling and Sensing 7 – Yield Monitoring Technologies for Optimal Resource Management 8 – Historical Yield Data and its Implications for Sustainability 11 – Controller Area Networks (CAN) and Connected Machines 13 – Google Earth Applications in Production and Urban Agriculture 15 – Drone Applications in Sustainable Agriculture 22 – Precision Irrigation and Controlled Drainage for Enhance Water Quality 24 – On-Farm Research and its role in Digital Agriculture 25 – Data Analytics and Visualization for Digital Agriculture 26 – AI in Marketing and Agricultural Supply Chain Logistics 28 – Enterprise Agriculture and Sustainability HWK 1 – Sustainable Production Systems HWK 2 – Social Media As a “Knowledge Tool” For Sustainable Food Production HWK 3 – Conferences as a “Knowledge Tool” for Digital Agriculture HWK 6 – Ethics of Data Ownership L1 – Data-Driven Resource Allocation L3 – Variable Rate Technology and Soil Health L4 – Yield Monitoring for Improved Resources Utilization L5 – Connected Machines and CAN Data

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	Lecture Topics Discussion Guest Speakers Homeworks Laboratories
			L6 – Data Infrastructure to Support Economic and Ecological Outcomes L7 – Google Earth Applications in Production and Urban Agriculture L8 – Remote Sensing for Sustainability L9 – Drones for Environmental Monitoring and Sustainability L10 – Mapping, Modeling, and Data Analytics using ArcGIS L11 – Introduction to R and On-Farm Research L12 – The Role of Big Data in Sustainability L13 – Supply Chain Management and Sustainability L14 – Blockchain Applications for Traceability in the Food Supply Chain **Technical Feasibility and Sustainability Study (TFSS)**
	IITT ELO 1.1.a Critical thinking: Clearly state and comprehensively describe the issue or problem under consideration, delivering all relevant information necessary	CLO 1.1 LLO 1.1	1 – Introduction to Digital Agriculture and its Role in Sustainability 2 – Global Navigation Satellite Systems (GNSS) in Agriculture and Natural Resource Conservation 3 – ArcGIS Applications in Agricultural Sustainability 5 – Variable Rate Technology and its Role in Long-Term Soil Health and Sustainability 6 – Soil Health Sampling and Sensing 7 – Yield Monitoring Technologies for Optimal Resource Management 8 – Historical Yield Data and its Implications for Sustainability 11 – Controller Area Networks (CAN) and Connected Machines 13 – Google Earth Applications in Production and Urban Agriculture 15 – Drone Applications in Sustainable Agriculture 22 – Precision Irrigation and Controlled Drainage for Enhance Water Quality 24 – On-Farm Research and its role in Digital Agriculture 28 – Enterprise Agriculture and Sustainability <u>HWK 1 – Sustainable Production Systems</u> L1 – Data-Driven Resource Allocation L3 – Variable Rate Technology and Soil Health

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	Lecture Topics Discussion Guest Speakers Homeworks Laboratories
			L4 – Yield Monitoring for Improved Resources Utilization L5 – Connected Machines and CAN Data L6 – Data Infrastructure to Support Economic and Ecological Outcomes L9 – Drones for Environmental Monitoring and Sustainability L10 – Mapping, Modeling, and Data Analytics using ArcGIS L11 – Introduction to R and On-Farm Research L12 – The Role of Big Data in Sustainability L13 – Supply Chain Management and Sustainability **Technical Feasibility and Sustainability Study**
	IITT ELO 1.1.b Analysis: Interpret and evaluate information from multiple sources and multiple disciplinary perspectives to develop a comprehensive analysis or synthesis, and thoroughly question the viewpoints of experts and professionals	CLO 1.2, CLO 1.4 LLO 1.2, LLO 1.4	1 – Introduction to Digital Agriculture and its Role in Sustainability 3 – ArcGIS Applications in Agricultural Sustainability 5 – Variable Rate Technology and its Role in Long-Term Soil Health and Sustainability 6 – Soil Health Sampling and Sensing 7 – Yield Monitoring Technologies for Optimal Resource Management 12 – The Ethics of Data Ownership, Aggregation, and Cloud Computing 17 – Controlled Environment Agriculture 21 – Precision Livestock Farming Systems 25 – Data Analytics and Visualization for Digital Agriculture 26 – AI in Marketing and Agricultural Supply Chain Logistics 27 – Application of Blockchain Technology in Agricultural Supply Chain HWK 2 – Social Media As a “Knowledge Tool” For Sustainable Food Production HWK 3 – Conferences as a “Knowledge Tool” for Digital Agriculture HWK 6 – Ethics of Data Ownership L1 – Data-Driven Resource Allocation L3 – Variable Rate Technology and Soil Health L4 – Yield Monitoring for Improved Resources Utilization L5 – Connected Machines and CAN Data

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	Lecture Topics Discussion Guest Speakers Homeworks Laboratories
			L6 – Data Infrastructure to Support Economic and Ecological Outcomes L7 – Google Earth Applications in Production and Urban Agriculture L8 – Remote Sensing for Sustainability L9 – Drones for Environmental Monitoring and Sustainability L10 – Mapping, Modeling, and Data Analytics using ArcGIS L11 – Introduction to R and On-Farm Research L12 – The Role of Big Data in Sustainability L13 – Supply Chain Management and Sustainability L14 – Blockchain Applications for Traceability in the Food Supply Chain **Technical Feasibility and Sustainability Study**
	IITT ELO 1.1.c Critical thinking & analysis: Systematically and methodically analyze their own and others' assumptions using more than one disciplinary lens and carefully evaluate the relevance of contexts when representing a position	CLO 1.2, CLO 1.4 LLO 1.2, LLO 1.4	1 – Introduction to Digital Agriculture and its Role in Sustainability 3 – ArcGIS Applications in Agricultural Sustainability 5 – Variable Rate Technology and its Role in Long-Term Soil Health and Sustainability 6 – Soil Health Sampling and Sensing 7 – Yield Monitoring Technologies for Optimal Resource Management 12 – The Ethics of Data Ownership, Aggregation, and Cloud Computing 17 – Controlled Environment Agriculture 21 – Precision Livestock Farming Systems 25 – Data Analytics and Visualization for Digital Agriculture 26 – AI in Marketing and Agricultural Supply Chain Logistics 27 – Application of Blockchain Technology in Agricultural Supply Chain <u>HWK 2 – Social Media As a "Knowledge Tool" For Sustainable Food Production</u> <u>HWK 3 – Conferences as a "Knowledge Tool" for Digital Agriculture</u> <u>HWK 6 – Ethics of Data Ownership</u> L1 – Data-Driven Resource Allocation L2 – ArcGIS Applications in Sustainable Agricultural Production L3 – Variable Rate Technology and Soil Health

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	Lecture Topics Discussion Guest Speakers Homeworks Laboratories
			L4 – Yield Monitoring for Improved Resources Utilization L5 – Connected Machines and CAN Data L6 – Data Infrastructure to Support Economic and Ecological Outcomes L7 – Google Earth Applications in Production and Urban Agriculture L8 – Remote Sensing for Sustainability L9 – Drones for Environmental Monitoring and Sustainability L10 – Mapping, Modeling, and Data Analytics using ArcGIS L11 – Introduction to R and On-Farm Research L12 – The Role of Big Data in Sustainability L13 – Supply Chain Management and Sustainability L14 – Blockchain Applications for Traceability in the Food Supply Chain **Technical Feasibility and Sustainability Study**
	ELO 1.2 (IITT ELO 1.2) Engage in an advanced, in-depth, scholarly exploration of the topic or idea of sustainability.	CLO 1.2, CLO 1.4, CLO 2.5 LLO 1.2, LLO 1.4, LLO 2.5	1 – Introduction to Digital Agriculture and its Role in Sustainability 3 – ArcGIS Applications in Agricultural Sustainability 5 – Variable Rate Technology and its Role in Long-Term Soil Health and Sustainability 6 – Soil Health Sampling and Sensing 7 – Yield Monitoring Technologies for Optimal Resource Management 12 – The Ethics of Data Ownership, Aggregation, and Cloud Computing 17 – Controlled Environment Agriculture 21 – Precision Livestock Farming Systems 25 – Data Analytics and Visualization for Digital Agriculture 26 – AI in Marketing and Agricultural Supply Chain Logistics 27 – Application of Blockchain Technology in Agricultural Supply Chain HWK 2 – Social Media As a "Knowledge Tool" For Sustainable Food Production HWK 3 – Conferences as a "Knowledge Tool" for Digital Agriculture HWK 6 – Ethics of Data Ownership

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	Lecture Topics Discussion Guest Speakers Homeworks Laboratories
			L1 – Data-Driven Resource Allocation L2- ArcGIS and its application in sustainability L4 – Yield Monitoring for Improved Resources Utilization. L3 – Variable Rate Technology and Soil Health L5 – Connected Machines and CAN Data L6 – Data Infrastructure to Support Economic and Ecological Outcomes L7 – Google Earth Applications in Production and Urban Agriculture L8 – Remote Sensing for Sustainability L9 – Drones for Environmental Monitoring and Sustainability L10 – Mapping, Modeling, and Data Analytics using ArcGIS L11 – Introduction to R and On-Farm Research L12 – The Role of Big Data in Sustainability L13 – Supply Chain Management and Sustainability L14 – Blockchain Applications for Traceability in the Food Supply Chain **Technical Feasibility and Sustainability Study**
	IITT ELO 1.2.a Scholarly engagement: Articulate a thorough and complex understanding of the factors and contexts, including natural, social, cultural and political, contributing to an integrative understanding of the issue.	CLO 1.2, CLO 1.4, CLO 2.5 LLO 1.2, LLO 1.4, LLO 2.5	1 – Introduction to Digital Agriculture and its Role in Sustainability 3 – ArcGIS Applications in Agricultural Sustainability 5 – Variable Rate Technology and its Role in Long-Term Soil Health and Sustainability 6 – Soil Health Sampling and Sensing 7 – Yield Monitoring Technologies for Optimal Resource Management 12 – The Ethics of Data Ownership, Aggregation, and Cloud Computing 17 – Controlled Environment Agriculture 21 – Precision Livestock Farming Systems 25 – Data Analytics and Visualization for Digital Agriculture 26 – AI in Marketing and Agricultural Supply Chain Logistics 27 – Application of Blockchain Technology in Agricultural Supply Chain

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	Lecture Topics Discussion Guest Speakers Homeworks Laboratories
			HWK 2 – Social Media As a “Knowledge Tool” For Sustainable Food Production HWK 3 – Conferences as a “Knowledge Tool” for Digital Agriculture HWK 6 – Ethics of Data Ownership L1 – Data-Driven Resource Allocation L2 – ArcGIS Applications in Sustainable Agricultural Production L3 – Variable Rate Technology and Soil Health L4 – Yield Monitoring for Improved Resources Utilization L5 – Connected Machines and CAN Data L6 – Data Infrastructure to Support Economic and Ecological Outcomes L7 – Google Earth Applications in Production and Urban Agriculture L8 – Remote Sensing for Sustainability L9 – Drones for Environmental Monitoring and Sustainability L10 – Mapping, Modeling, and Data Analytics using ArcGIS L11 – Introduction to R and On-Farm Research L12 – The Role of Big Data in Sustainability L13 – Supply Chain Management and Sustainability L14 – Blockchain Applications for Traceability in the Food Supply Chain **Technical Feasibility and Sustainability Study**
GE Goal 2: Successful students will integrate approaches to sustainability by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or to work they have	**ELO 2.1 (IITT ELO 2.1)** Identify, describe and synthesize approaches or experiences as they apply to sustainability.	CLO 1.2, CLO 2.1, CLO 2.2, CLO 2.5 LLO 1.2, LLO 2.1, LLO 2.2, LLO 2.5	1 – Introduction to Digital Agriculture and its Role in Sustainability 3 – ArcGIS Applications in Agricultural Sustainability 4 – Farm Management Information Systems (FMIS) for Sustainable Management 5 – Variable Rate Technology and its Role in Long-Term Soil Health and Sustainability 6 – Soil Health Sampling and Sensing 7 – Yield Monitoring Technologies for Optimal Resource Management 8 – Historical Yield Data and its Implications for Sustainability

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	Lecture Topics Discussion Guest Speakers Homeworks Laboratories
done in previous classes and that they anticipate doing in future			9 – Artificial Intelligence Primer 10- Artificial Intelligence and Crop Care Optimization 11 – Controller Area Networks (CAN) and Connected Machines 12 – The Ethics of Data Ownership, Aggregation, and Cloud Computing 14 – Remote Sensing and Applications in Sustainable Agriculture 15 – Drone Applications in Sustainable Agriculture 16 – Precision Conservation Management 17 – Controlled Environment Agriculture 18 – Tracking Weather and Climate Change 22 – Precision Irrigation and Controlled Drainage for Enhance Water Quality 21 – Crop and Animal Modeling 21 – Precision Livestock Farming Systems 20 – Precision Pasture Management in Livestock Systems 24 – On-Farm Research and its role in Digital Agriculture 25 – Data Analytics and Visualization for Digital Agriculture 23 – Internet of Things (IoT) and Sustainability 26 – AI in Marketing and Agricultural Supply Chain Logistics 27 – Application of Blockchain Technology in Agricultural Supply Chain 28 – Enterprise Agriculture and Sustainability <u>HWK 1 – Sustainable Production Systems</u> <u>HWK 4 – Data Interoperability in Sustainable Digital Agriculture</u> <u>HWK 5 – Google Earth Engine (GEE) and its applications</u> <u>HWK 6 – Ethics of Data Ownership</u> L1 – Data-Driven Resource Allocation L2 – ArcGIS Applications in Sustainable Agricultural Production L3 – Variable Rate Technology and Soil Health L4 – Yield Monitoring for Improved Resources Utilization L5 – Connected Machines and CAN Data

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	Lecture Topics Discussion Guest Speakers Homeworks Laboratories
			L6 – Data Infrastructure to Support Economic and Ecological Outcomes L7 – Google Earth Applications in Production and Urban Agriculture L8 – Remote Sensing for Sustainability L9 – Drones for Environmental Monitoring and Sustainability L10 – Mapping, Modeling, and Data Analytics using ArcGIS L11 – Introduction to R and On-Farm Research L12 – The Role of Big Data in Sustainability L13 – Supply Chain Management and Sustainability L14 – Blockchain Applications for Traceability in the Food Supply Chain **Technical Feasibility and Sustainability Study**
	IITT ELO 2.1.a Integration of knowledge: Connect, analyze, and extend knowledge (facts, theories, etc.) from course content to integrate their insights through construction of a more comprehensive perspective.	CLO 2.1, CLO 2.5 LLO 2.1, LLO 2.5	1 – Introduction to Digital Agriculture and its Role in Sustainability 3 – ArcGIS Applications in Agricultural Sustainability 4 – Farm Management Information Systems (FMIS) for Sustainable Management 5 – Variable Rate Technology and its Role in Long-Term Soil Health and Sustainability 6 – Soil Health Sampling and Sensing 7 – Yield Monitoring Technologies for Optimal Resource Management 8 – Historical Yield Data and its Implications for Sustainability 9 – Artificial Intelligence Primer 10- Artificial Intelligence and Crop Care Optimization 11 – Controller Area Networks (CAN) and Connected Machines 12 – The Ethics of Data Ownership, Aggregation, and Cloud Computing 14 – Remote Sensing and Applications in Sustainable Agriculture 15 – Drone Applications in Sustainable Agriculture 16 – Precision Conservation Management 18 – Tracking Weather and Climate Change 22 – Precision Irrigation and Controlled Drainage for Enhance Water Quality

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	Lecture Topics Discussion Guest Speakers Homeworks Laboratories
			21 – Crop and Animal Modeling 21 – Precision Livestock Farming Systems 20 – Precision Pasture Management in Livestock Systems 24 – On-Farm Research and its role in Digital Agriculture 25 – Data Analytics and Visualization for Digital Agriculture 23 – Internet of Things (IoT) and Sustainability 26 – AI in Marketing and Agricultural Supply Chain Logistics 27 – Application of Blockchain Technology in Agricultural Supply Chain 28 – Enterprise Agriculture and Sustainability <u>HWK 1 – Sustainable Production Systems</u> <u>HWK 4 – Data Interoperability in Sustainable Digital Agriculture</u> <u>HWK 5 – Google Earth Engine (GEE) and its applications</u> <u>HWK 6 – Ethics of Data Ownership</u> L1 – Data-Driven Resource Allocation L2 – ArcGIS Applications in Sustainable Agricultural Production L3 – Variable Rate Technology and Soil Health L4 – Yield Monitoring for Improved Resources Utilization L5 – Connected Machines and CAN Data L6 – Data Infrastructure to Support Economic and Ecological Outcomes L7 – Google Earth Applications in Production and Urban Agriculture L8 – Remote Sensing for Sustainability L9 – Drones for Environmental Monitoring and Sustainability L10 – Mapping, Modeling, and Data Analytics using ArcGIS L11 – Introduction to R and On-Farm Research L12 – The Role of Big Data in Sustainability L13 – Supply Chain Management and Sustainability L14 – Blockchain Applications for Traceability in the Food Supply Chain

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	Lecture Topics Discussion Guest Speakers Homeworks Laboratories
			Technical Feasibility and Sustainability Study
	IITT ELO 2.1.b Multiple perspectives: Evaluate and apply diverse perspectives to complex subjects from multiple cultural and disciplinary lenses as appropriate.	CLO 2.2, CLO 2.4 LLO 2.2, LLO 2.4	3 – ArcGIS Applications in Agricultural Sustainability 7 – Yield Monitoring Technologies for Optimal Resource Management 8 – Historical Yield Data and its Implications for Sustainability 11 – Controller Area Networks (CAN) and Connected Machines 17 – Controlled Environment Agriculture L3 – Variable Rate Technology and Soil Health L4 – Yield Monitoring for Improved Resources Utilization L6 – Data Infrastructure to Support Economic and Ecological Outcomes L7 – Google Earth Applications in Production and Urban Agriculture L9 – Drones for Environmental Monitoring and Sustainability L11 – Introduction to R and On-Farm Research **Technical Feasibility and Sustainability Study**
	ELO 2.2 (IITT ELO 2.2) Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts.	CLO 2.3, CLO 2.4 LLO 2.3, LLO 2.4	5 – Variable Rate Technology and its Role in Long-Term Soil Health and Sustainability 11 – Controller Area Networks (CAN) and Connected Machines 12 – Data, Ownership, Ethics, Security, Computing & Storage Discussion – Student Reflections and Student Journal <u>HWK 2 – Social Media As a “Knowledge Tool” For Sustainable Food Production</u> <u>HWK 3 – Conferences as a “Knowledge Tool” for Digital Agriculture</u> <u>HWK 7 – Sustainability-Digital Agriculture: Thought Leader Changes Across the Semester</u> L7 – Google Earth Applications in Production and Urban Agriculture

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	Lecture Topics Discussion Guest Speakers Homeworks Laboratories
			Technical Feasibility and Sustainability Study
	IITT ELO 2.2.a Self-awareness: Evaluates the impacts of cross disciplinary synthesis of the issue on themselves, the scholarly inquiry, the local and global systems and also considers the long-term impact of the work.	CLO 2.3	5 – Variable Rate Technology and its Role in Long-Term Soil Health and Sustainability 11 – Controller Area Networks (CAN) and Connected Machines 12 – Data, Ownership, Ethics, Security, Computing & Storage Discussion – Student Reflections and Student Journal HWK 7 – Sustainability-Digital Agriculture: Thought Leader Changes Across the Semester **Technical Feasibility and Sustainability Study**
	IITT ELO 2.2.b. Empathy: Interpret and explain the issue under consideration from the perspectives other than their own and more than one worldview and demonstrates openness towards others in the academic community and their perspectives	CLO 2.4	Discussion – Student Reflections and Student Journal HWK 2 – Social Media As a "Knowledge Tool" For Sustainable Food Production HWK 3 – Conferences as a "Knowledge Tool" for Digital Agriculture HWK 7 – Sustainability-Digital Agriculture: Thought Leader Changes Across the Semester **Technical Feasibility and Sustainability Study**
GE Goal 3: Successful students will analyze and explain how social and natural systems function, interact, and evolve over time; how human well-being depends on these interactions; how actions	**ELO 3.1 - SLO 1.1** Describe elements of the fundamental dependence of humans on Earth and environmental systems, and on the resilience of these systems.	CLO 1.3 LLO 1.3	4 – Farm Management Information Systems (FMIS) for Sustainable Management 21 – Crop and Animal Modeling 20 – Precision Pasture Management in Livestock Systems 27 – Application of Blockchain Technology in Agricultural Supply Chain HWK 3 – Conferences as a "Knowledge Tool" for Digital Agriculture

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	Lecture Topics Discussion Guest Speakers Homeworks Laboratories
have impacts on subsequent generations and societies globally; and how human values, behaviors and institutions impact multifaceted potential solutions across time. **Sustainability** **GES GOAL 1: Students analyze and explain how social and natural systems function, interact, and evolve over time; how human wellbeing depends on these interactions; how actions have impacts on subsequent generations and societies globally; and how human values, behaviors, and institutions impact multi-faceted, potential solutions across time.**			<u>HWK 6 – Ethics of Data Ownership</u> L1 – Data-Driven Resource Allocation L2 – ArcGIS Applications in Sustainable Agricultural Production L3 – Variable Rate Technology and Soil Health L4 – Yield Monitoring for Improved Resources Utilization L6 – Data Infrastructure to Support Economic and Ecological Outcomes L7 – Google Earth Applications in Production and Urban Agriculture L8 – Remote Sensing for Sustainability L9 – Drones for Environmental Monitoring and Sustainability L10 – Mapping, Modeling, and Data Analytics using ArcGIS L11 – Introduction to R and On-Farm Research L12 – The Role of Big Data in Sustainability L13 – Supply Chain Management and Sustainability L14 – Blockchain Applications for Traceability in the Food Supply Chain **Technical Feasibility and Sustainability Study**
	ELO 3.2 - **SLO 1.2** Describe, analyze, and critique the roles and impacts of human activity and technology on both human society and the natural world, in the past, present and future.	CLO 1.3 LLO 1.3	4 – Farm Management Information Systems (FMIS) for Sustainable Management 21 – Crop and Animal Modeling 20 – Precision Pasture Management in Livestock Systems 27 – Application of Blockchain Technology in Agricultural Supply Chain <u>HWK 3 – Conferences as a “Knowledge Tool” for Digital Agriculture</u>

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	**Lecture Topics** **Discussion** **Guest Speakers** **Homeworks** **Laboratories**
			HWK 6 – Ethics of Data Ownership L1 – Data-Driven Resource Allocation L2 – ArcGIS Applications in Sustainable Agricultural Production L3 – Variable Rate Technology and Soil Health L4 – Yield Monitoring for Improved Resources Utilization L6 – Data Infrastructure to Support Economic and Ecological Outcomes L7 – Google Earth Applications in Production and Urban Agriculture L8 – Remote Sensing for Sustainability L10 – Mapping, Modeling, and Data Analytics using ArcGIS L11 – Introduction to R and On-Farm Research L12 – The Role of Big Data in Sustainability L13 – Supply Chain Management and Sustainability L14 – Blockchain Applications for Traceability in the Food Supply Chain **Technical Feasibility and Sustainability Study**
	ELO 3.3 _ SLO 1.3 Devise informed and meaningful responses to problems and arguments in the area of sustainability based on the interpretation of appropriate evidence and an explicit statement of values.	CLO 1.1 LLO 1.1	1 – Introduction to Digital Agriculture and its Role in Sustainability 2 – Global Navigation Satellite Systems (GNSS) in Agriculture and Natural Resource Conservation 3 – ArcGIS Applications in Agricultural Sustainability 5 – Variable Rate Technology and its Role in Long-Term Soil Health and Sustainability 6 – Soil Health Sampling and Sensing 7 – Yield Monitoring Technologies for Optimal Resource Management 8 – Historical Yield Data and its Implications for Sustainability 11 – Controller Area Networks (CAN) and Connected Machines 13 – Google Earth Applications in Production and Urban Agriculture 15 – Drone Applications in Sustainable Agriculture 22 – Precision Irrigation and Controlled Drainage for Enhance Water Quality 24 – On-Farm Research and its role in Digital Agriculture

Goals (GE, IITT, GE Sustainability)	GE or IITT Outcomes	Course Outcomes in GE or IITT Outcomes CLO (Course Learning Outcomes) LLO (Laboratory Learning Outcomes)	Lecture Topics Discussion Guest Speakers Homeworks Laboratories
			28 – Enterprise Agriculture and Sustainability HWK 1 – Sustainable Production Systems L1 – Data-Driven Resource Allocation L3 – Variable Rate Technology and Soil Health L4 – Yield Monitoring for Improved Resources Utilization L6 – Data Infrastructure to Support Economic and Ecological Outcomes L7 – Google Earth Applications in Production and Urban Agriculture L10 – Mapping, Modeling, and Data Analytics using ArcGIS L11 – Introduction to R and On-Farm Research L12 – The Role of Big Data in Sustainability L13 – Supply Chain Management and Sustainability **Technical Feasibility and Sustainability Study**

AGSYSMT_HCS_3585_Digital Agriculture: Alignment of Sustainability Concepts

Module Outcomes	Sustainability Concept	Modules/Lecture Topics	Assessment and Measurement	Instructional Materials	Learner Interaction & Engagement
CLO 1.1, 1.2 CLO 2.1	Climate Smart Agriculture	1 – Introduction to Digital Agriculture and its Role in Sustainability	**Quiz 1** **Exam 1**	1. **Textbook Chapter** – 2. **PowerPoint slides** Lecture 1 – Introduction to Digital Agriculture and its Role in Sustainability	**Activities:** -Read Chapter -PowerPoint Lecture 1 -Self-check **Interaction:** -With content -With Instructor
CLO 1.1	Climate Smart Agriculture	2 – Global Navigation Satellite Systems (GNSS) in Agriculture and Natural Resource Conservation	**Quiz 1** **Exam 1**	1. **Textbook Chapter** - **PowerPoint slides** Lecture 2 – Global Navigation Satellite Systems (GNSS) in Agriculture and Natural Resource Conservation	**Activities:** -Read Chapter -PowerPoint Lecture 2 -Student Reflection, Journals -Self-check **Interaction:** -With content -With Instructor
CLO 1.1, 1.2 CLO 2.1, 2.2	Climate Smart Agriculture	3 – ArcGIS Applications in Agricultural Sustainability	**Quiz 1** **Exam 1**	1. **Textbook Chapter** - **2. Mastering ArcGIS** 3. **PowerPoint slides** Lecture 3 – ArcGIS Applications in Agricultural Sustainability	**Activities:** -Read Chapter -Read Mastering ArcGIS -PowerPoint Lecture 3 -Self-check **Interaction:** -With content -With Instructor
CLO 2.1, CLO 1.3	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity	4 – Farm Management Information Systems (FMIS) for Sustainable Management	**Quiz 1** **Exam 1**	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 4 – Farm Management Information Systems (FMIS) for Sustainable Management	**Activities:** -Read Chapter -PowerPoint Lecture 4 -Student Reflection, Journals -Submit TFSS Title to Carmen -Self-check **Interaction:** -With content -With Instructor

Module Outcomes	Sustainability Concept	Modules/Lecture Topics	Assessment and Measurement	Instructional Materials	Learner Interaction & Engagement
CLO 1.1, 1.2 CLO 2.1, 2.3	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity	5 – Variable Rate Technology and its Role in Long-Term Soil Health and Sustainability	**Quiz 2** **Exam 1** ***HWK 1 –*** Agricultural Production System Description	1. **Textbook Chapter -** 2. **Chapter 11 –** 3. **PowerPoint slides** Lecture 5 – Variable Rate Technology and its Role in Long-Term Soil Health and Sustainability	**Activities:** -Read Chapter -PowerPoint Lecture 5 -Self-check **Interaction:** -With content -With Instructor
CLO 1.1, 1.2 CLO 2.1	Carbon Cycling and Sequestration Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity	6 – Soil Health Sampling and Sensing Guest Lecture Reflection 1	**Quiz 2** **Exam 1**	1. **Textbook Chapter** - 2. **PowerPoint slides** Lecture 6 – Soil Health Sampling and Sensing	**Activities:** -Read Chapter -PowerPoint Lecture 6 -Student Reflection, Journals Submit Guest Lecture Reflection 1 to Carmen -Self-check **Interaction:** -With content -With Instructor
CLO 1.1, 1.2 CLO 2.1, 2.2	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency	7 – Yield Monitoring Technologies for Optimal Resource Management	**Quiz 2** **Exam 1**	1. **Textbook Chapter** - 2. **PowerPoint slides** Lecture 7 – Yield Monitoring Technologies for Optimal Resource Management	**Activities:** -Read Chapter -PowerPoint Lecture 7 -Student Reflection, Journals -Self-check **Interaction:** -With content -With Instructor
CLO 1.1 CLO 2.1, 2.2	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency	8 – Historical Yield Data and its Implications for Sustainability	**Quiz 2** **Exam 1**	1. **Textbook Chapter** - 2. **PowerPoint slides** Lecture 8 – Historical Yield Data and its Implications for Sustainability	**Activities:** -Read Chapter -PowerPoint Lecture 8 -Student Reflection, Journals -Submit TFSS Introduction to Carmen -Self-check **Interaction:** -With content

Module Outcomes	Sustainability Concept	Modules/Lecture Topics	Assessment and Measurement	Instructional Materials	Learner Interaction & Engagement
					-With Instructor
CLO 2.1	Climate Smart Agriculture	9 – Artificial Intelligence Primer	**Quiz 3** **Exam 1** ***HWK 2 –*** *Social Media As a "Knowledge Tool" For Sustainable Food Production*	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 9 – Artificial Intelligence Primer	**Activities:** -Read Chapter -PowerPoint Lecture 9 -Self-check **Interaction:** -With content -With Instructor
CLO 2.1	Climate Smart Agriculture	10 – Artificial Intelligence and Crop Care Optimization	**Quiz 3** **Exam 1**	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 10 – Artificial Intelligence and Crop Care Optimization	**Activities:** -Read Chapter -PowerPoint Lecture 10 -Student Reflection, Journals -Self-check **Interaction:** -With content -With Instructor
CLO 1.1 CLO 2.1, 2.2, 2.3	Climate Smart Agriculture	11 – Controller Area Networks (CAN) and Connected Machines	**Quiz 3** **Exam 1**	1. **Textbook Chapter** – 2. **PowerPoint slides** Lecture 11 – Controller Area Networks (CAN) and Connected Machines	**Activities:** -Read Chapter -PowerPoint Lecture 11 -Self-check **Interaction:** -With content -With Instructor
CLO 1.2 CLO 2.1, 2.3	Climate Smart Agriculture Food Safety Food Security	12 – The Ethics of Data Ownership, Aggregation, and Cloud Computing	**Quiz 3** **Exam 1**	1. **Textbook Chapter** – 2. **PowerPoint slides** Lecture 12 – The Ethics of Data Ownership, Aggregation, and Cloud Computing	**Activities:** -Read Chapter -PowerPoint Lecture 12 -Student Reflection, Journals -Submit TFSS References to Carmen -Self-check **Interaction:**

Module Outcomes	Sustainability Concept	Modules/Lecture Topics	Assessment and Measurement	Instructional Materials	Learner Interaction & Engagement
					-With content -With Instructor
CLO 1.1	Climate Smart Agriculture Food Production Optimization and Efficiency	13 – Google Earth Applications in Production and Urban Agriculture	**Quiz 4** **Exam 2** ***HWK 3 –*** *Conferences* as a "Knowledge Tool" for Digital Agriculture	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 13 – Google Earth Applications in Production and Urban Agriculture	**Activities:** -Read Chapter -PowerPoint Lecture 13 -Self-check **Interaction:** -With content -With Instructor
CLO 2.1	Climate Smart Agriculture Food Production Optimization and Efficiency	14 – Remote Sensing and Applications in Sustainable Agriculture Guest Lecture Reflection 2	**Quiz 4** **Exam 2**	1. **Textbook Chapter** – 2. **PowerPoint slides** Lecture 14 – Remote Sensing and Applications in Sustainable Agriculture	**Activities:** -Read Chapter -PowerPoint Lecture 14 -Student Reflection, Journals Submit Guest Lecture Reflection 2 to Carmen -Self-check **Interaction:** -With content -With Instructor
CLO 1.1 CLO 2.1	Climate Smart Agriculture Food Production Optimization and Efficiency	15 – Drone Applications in Sustainable Agriculture	**Quiz 4** **Exam 2**	1. **Textbook Chapter** – 2. **Introduction to Unmanned Aircraft Systems** 3. **PowerPoint slides** Lecture 15 – Drone Applications in Sustainable Agriculture	**Activities:** -Read Chapter -Read Introduction to Unmanned Aircraft Systems -PowerPoint Lecture 15 -Student Reflection, Journals -Self-check **Interaction:** -With content -With Instructor
CLO 2.1	Carbon Cycling and Sequestration Climate Smart Agriculture Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity	16 – Precision Conservation Management	**Quiz 4** **Exam 2**	1. **Textbook Chapter** 2. **PowerPoint slides** Lecture 16 – Precision Conservation Management	**Activities:** -Read Chapter -PowerPoint Lecture 16 -Student Reflection, Journals -Self-check

Module Outcomes	Sustainability Concept	Modules/Lecture Topics	Assessment and Measurement	Instructional Materials	Learner Interaction & Engagement
					Interaction: -With content -With Instructor
CLO 1.4 CLO 2.1	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency Food Safety Food Security Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity	17 – Controlled Environment Agriculture	**Quiz 5** **Exam 2** ***HWK 4*** *– Data Interoperability in Sustainable Digital Agriculture*	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 17 – Controlled Environment Agriculture	**Activities:** -Read Chapter -PowerPoint Lecture 17 -Self-check **Interaction:** -With content -With Instructor
CLO 2.1	Climate Smart Agriculture	18 – Tracking Weather and Climate Change. Guest Lecture Reflection 3	**Quiz 5** **Exam 2**	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 18 – Tracking Weather and Climate Change	**Activities:** -Read Chapter -PowerPoint Lecture 18 -Student Reflection, Journals Submit Guest Lecture Reflection 3 to Carmen -Self-check **Interaction:** -With content -With Instructor
CLO 1.1 CLO 2.1	Climate Smart Agriculture Water Quality and Quantity	19 – Precision Livestock Farming Systems	**Quiz 5** **Exam 2** ***HWK 5*** *– Google Earth Engine (GEE) and its applications*	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 19 – Precision Livestock Farming Systems	**Activities:** -Read Chapter -PowerPoint Lecture 19 -Self-check **Interaction:** -With content -With Instructor
CLO 2.1 CLO 1.3 CLO 2.1	Food Production Optimization and Efficiency Food Safety Food Security Nitrogen and Phosphorus Cycling and Use Efficiency	20 – Precision Pasture Management in Livestock Systems	**Quiz 5** **Exam 2**	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 20 – Precision Pasture Management in Livestock Systems	**Activities:** -Read Chapter -PowerPoint Lecture 20 -Student Reflection, Journals -Submit TFSS Draft to Carmen

Module Outcomes	Sustainability Concept	Modules/Lecture Topics	Assessment and Measurement	Instructional Materials	Learner Interaction & Engagement
					-Self-check **Interaction:** -With content -With Instructor
CLO 1.4 CLO 2.1	Food Production Optimization and Efficiency Food Safety Food Security	21 – Crop and Animal Modeling	**Quiz 6** **Exam 2**	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 21 – Crop and Animal Modeling	**Activities:** -Read Chapter -PowerPoint Lecture 21 -Self-check **Interaction:** -With content -With Instructor
CLO 1.3 CLO 2.1	Food Production Optimization and Efficiency Food Safety Food Security Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity	22 – Precision Irrigation and Controlled Drainage for Enhance Water Quality	**Quiz 6** **Exam 2**	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 22 – Precision Irrigation and Controlled Drainage for Enhance Water Quality	**Activities:** -Read Chapter -PowerPoint Lecture 22 -Student Reflection, Journals -Self-check **Interaction:** -With content -With Instructor
CLO 1.1 CLO 2.1	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency Food Safety Food Security Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity	23 – Internet of Things (IoT) and Sustainability	**Quiz 6** **Exam 2** ***HWK 6** – Ethics of Data Ownership*	1. **Textbook Chapter –** 2. **PowerPoint slides** Lecture 23 – Internet of Things (IoT) and Sustainability	**Activities:** -Read Chapter -PowerPoint Lecture 23 -Self-check **Interaction:** -With content -With Instructor
CLO 1.2 CLO 1.4	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency Food Safety Food Security	24 – On-Farm Research and its role in Digital Agriculture	**Quiz 6** **Exam 2**	1. **The R Book** 2. **PowerPoint slides** Lecture 24 – On-Farm Research and its role in Digital Agriculture	**Activities:** -Read The R Book. -PowerPoint Lecture 24 -Student Reflection, Journals -Submit TFSS Final to Carmen -Self-check

Module Outcomes	Sustainability Concept	Modules/Lecture Topics	Assessment and Measurement	Instructional Materials	Learner Interaction & Engagement
	Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity				**Interaction:** -With content -With Instructor
CLO 2.1	Climate Smart Agriculture Food Production Optimization and Efficiency Food Safety Food Security	25 – Data Analytics and Visualization for Digital Agriculture Guest Lecture Reflection 4	**No Quiz – Extra Questions on Final**	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 25 – Internet of Things (IoT) and their application in digital agriculture	**Activities:** -Read Chapter -PowerPoint Lecture 25 Submit Guest Lecture Reflection 4 to Carmen -Self-check **Interaction:** -With content -With Instructor
CLO 1.2 CLO 2.1	Climate Smart Agriculture Food Production Optimization and Efficiency	26 – AI in Marketing and Agricultural Supply Chain Logistics	**No Quiz – Extra Questions on Final**	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 26 – AI in Marketing and Agricultural Supply Chain Logistics	**Activities:** -Read Chapter -PowerPoint Lecture 26 -Student Reflection, Journals -Self-check **Interaction:** -With content -With Instructor
CLO 1.2 CLO 1.3	Climate Smart Agriculture Food Production Optimization and Efficiency Food Safety Food Security	27 – Application of Blockchain Technology in Agricultural Supply Chain	**No Quiz – Extra Questions on Final**	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 27 – Application of Blockchain Technology in Agricultural Supply Chain	**Activities:** -Read Chapter -PowerPoint Lecture 27 -Self-check **Interaction:** -With content -With Instructor
CLO 1.1 CLO 2.1	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency Food Safety Food Security Nitrogen and Phosphorus	28 – Enterprise Agriculture and Sustainability	**No Quiz – Extra Questions on Final** **HWK 7 – Sustainability-** Digital Agriculture: Thought Leader	1. **Textbook Chapter -** 2. **PowerPoint slides** Lecture 28 – Enterprise Agriculture and Sustainability	**Activities:** -Read Chapter -PowerPoint Lecture 28 -Student Reflection, Journals -Self-check **Interaction:** -With content -With Instructor

Module Outcomes	Sustainability Concept	Modules/Lecture Topics	Assessment and Measurement	Instructional Materials	Learner Interaction & Engagement
	Cycling and Use Efficiency Water Quality and Quantity		Changes Across the Semester **TFSS** Presentation		

AGSYSMT_HCS_3586_Digital Agriculture Laboratory: Alignment of Sustainability Concepts

Laboratory Outcomes	Sustainability Concept	Modules	Assessment and Measurement	Instructional Materials	Learner Interaction & Engagement
LLO 1.1 LLO 1.2 LLO 1.3 LLO 1.4 LLO 2.1	Climate Smart Agriculture	L1 – Data-Driven Resource Allocation	Lab Report	1. Lab Instructions 2. Lab Manual	**Activities:** -Read Chapter -PowerPoint Lecture 1 -Self-check **Interaction:** -With content -With Instructor
LLO 1.3 LLO 1.4 LLO 2.1 LLO 2.5	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency Food Safety Food Security Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity	L2 – ArcGIS Applications in Sustainable Agricultural Production	Lab Report	1. Lab Instructions 2. Lab Manual	**Activities:** -Read Chapter -PowerPoint Lecture 2 -Self-check **Interaction:** -With content -With Instructor
LLO 1.1 LLO 1.2 LLO 1.3 LLO 1.4 LLO 2.1 LLO 2.2	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity	L3 – Variable Rate Technology and Soil Health	Lab Report	1. Lab Instructions 2. Lab Manual	**Activities:** Read Lab materials -Submit Lab Report to Carmen **Interaction:** -With content -With Instructor
LLO 1.1 LLO 1.2 LLO 1.3 LLO 1.4 LLO 2.1 LLO 2.2	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency	L4 – Yield Monitoring for Improved Resources Utilization	Lab Report	1. Lab Instructions 2. Lab Manual	**Activities:** Read Lab materials -Submit Lab Report to Carmen **Interaction:** -With content -With Instructor
LLO 1.1 LLO 1.2 LLO 1.3 LLO 1.4 LLO 2.1	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization	L5 – Connected Machines and CAN Data	Lab Report	1. Lab Instructions 2. Lab Manual	**Activities:** Read Lab materials -Submit Lab Report to Carmen

Laboratory Outcomes	Sustainability Concept	Modules	Assessment and Measurement	Instructional Materials	Learner Interaction & Engagement
	and Efficiency				**Interaction:** -With content -With Instructor
LLO 1.1 LLO 1.2 LLO 1.3 LLO 1.4 LLO 2.1 LLO 2.2 LLO 2.5	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity	L6 – Data Infrastructure to Support Economic and Ecological Outcomes	Lab Report	1. Lab Instructions 2. Lab Manual	**Activities:** Read Lab materials -Submit Lab Report to Carmen **Interaction:** -With content -With Instructor
LLO 1.2 LLO 1.3 LLO 1.4 LLO 2.1 LLO 2.2	Climate Smart Agriculture Food Production Optimization and Efficiency	L7 – Google Earth Applications in Production and Urban Agriculture	Lab Report	1. Lab Instructions 2. Lab Manual	**Activities:** Read Lab materials -Submit Lab Report to Carmen **Interaction:** -With content -With Instructor
LLO 1.2 LLO 1.3 LLO 1.4 LLO 2.1 LLO 2.5	Climate Smart Agriculture Food Production Optimization and Efficiency	L8 – Remote Sensing for Sustainability	Lab Report	1. Lab Instructions 2. Lab Manual	**Activities:** Read Lab materials -Submit Lab Report to Carmen **Interaction:** -With content -With Instructor
LLO 1.1 LLO 1.2 LLO 1.3 LLO 1.4 LLO 2.1 LLO 2.2	Climate Smart Agriculture Food Production Optimization and Efficiency	L9 – Drones for Environmental Monitoring and Sustainability	Lab Report	1. Lab Instructions 2. Lab Manual	**Activities:** Read Lab materials -Submit Lab Report to Carmen **Interaction:** -With content -With Instructor
		Spring Break			

Laboratory Outcomes	Sustainability Concept	Modules	Assessment and Measurement	Instructional Materials	Learner Interaction & Engagement
LLO 1.1 LLO 1.2 LLO 1.3 LLO 1.4 LLO 2.1	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency Food Safety Food Security Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity	L10 – Mapping, Modeling, and Data Analytics using ArcGIS	Lab Report	**1.** Lab Instructions **2.** Lab Manual	**Activities:** Read Lab materials -Submit Lab Report to Carmen **Interaction:** -With content -With Instructor
LLO 1.1 LLO 1.2 LLO 1.3 LLO 1.4 LLO 2.1 LLO 2.2	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency Food Safety Food Security Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity	L11 – Introduction to R and On-Farm Research	Lab Report	**1.** Lab Instructions **2.** Lab Manual	**Activities:** Read Lab materials -Submit Lab Report to Carmen **Interaction:** -With content -With Instructor
LLO 1.1 LLO 1.2 LLO 1.3 LLO 1.4 LLO 2.1 LLO 2.5	Carbon Cycling and Sequestration Climate Smart Agriculture Food Production Optimization and Efficiency Food Safety Food Security Nitrogen and Phosphorus Cycling and Use Efficiency Water Quality and Quantity	L12 – The Role of Big Data in Sustainability	Lab Report	**1.** Lab Instructions **2.** Lab Manual	**Activities:** Read Lab materials -Submit Lab Report to Carmen **Interaction:** -With content -With Instructor
LLO 1.1 LLO 1.2 LLO 1.3 LLO 1.4 LLO 2.1	Climate Smart Agriculture Food Production Optimization and Efficiency Food Safety Food Security	L13 – Supply Chain Management and Sustainability	Lab Report	**1.** Lab Instructions **2.** Lab Manual	**Activities:** Read Lab materials -Submit Lab Report to Carmen **Interaction:** -With content -With Instructor

Laboratory Outcomes	Sustainability Concept	Modules	Assessment and Measurement	Instructional Materials	Learner Interaction & Engagement
LLO 1.2 LLO 1.3 LLO 1.4 LLO 2.1	Climate Smart Agriculture Food Production Optimization and Efficiency Food Safety Food Security	L14 – Blockchain Applications for Traceability in the Food Supply Chain	Lab Report	1. Lab Instructions 2. Lab Manual	**Activities:** Read Lab materials -Submit Lab Report to Carmen **Interaction:** -With content -With Instructor

THE OHIO STATE UNIVERSITY

Department of Food, Agricultural and Biological Engineering
200A Agricultural Engineering Building
590 Woody Hayes Drive
Columbus, OH 43210-1058

614.292.7284 Phone
614.292.9448 Fax

shearer.95@osu.edu

Department of Horticulture and Crop Science
202 Kottman Hall
2021 Coffey Rd
Columbus, OH 43210

614-247-6258 Phone
614-292-7162 Fax

barker.169@osu.edu

Bibliographic information for AGSYSMT/HCS 3585 - 3586

Required Materials

The following are general texts which provide background information. Specific chapters from these and other published materials will be assigned by the instructors.

All materials are available from the OSU library. **Off-campus** access to most OSU Library resources may be obtained through these routes:

Additional publications will be made available in Carmen.

Hamrita, T. K. (Ed.). (2021). Women in precision agriculture: technological breakthroughs, challenges and aspirations for a prosperous and sustainable future (Ser. Women in engineering and science). Springer. https://osu.on.worldcat.org/oclc/1187169922

Abd El-Kader, S. M., and Mohammad El-Basioni, B. M. (Eds.). (2021). Precision agriculture technologies for food security and sustainability (Ser. Advances in Environmental Engineering and Green Technologies (AEEGT) book series). Engineering Science Reference, an imprint of IGI Global. https://osu.on.worldcat.org/oclc/1156439371

Stafford, J. (Ed.). (2019). Precision agriculture for sustainability (Ser. Burleigh Dodds series in Agricultural Science, number 52). Burleigh Dodds Science Publishing. https://osu.on.worldcat.org/oclc/1078923421

Shannon, D. K., Clay, D., and Kitchen, N. R. (Eds.). (2018). Precision agriculture basics. American Society of Agronomy. https://osu.on.worldcat.org/oclc/1037150375

Lal, R., and Stewart, B. A. (Eds.). (2016). Soil-specific farming: precision agriculture (Ser. Advances in Soil Science). CRC Press, Taylor & Francis Group. https://osu.on.worldcat.org/oclc/914301013

Crawley, M. J. (2013). The R book (Second). Wiley. Retrieved July 21, 2022, https://osu.on.worldcat.org/oclc/809365744

Recommended/Optional Materials

Castrignanò Annamaria, Buttafuoco, G., Khosla, R., Mouazen, A. M., Moshou, D., & Naud, O. (Eds.). (2020). Agricultural internet of things and decision support for precision smart farming. Academic Press. https://osu.on.worldcat.org/oclc/1136962920

Pedersen, S. M., and Lind, K. M. (2017). Precision agriculture (Ser. Progress in Precision Agriculture). Springer. https://osu.on.worldcat.org/oclc/1012881350

Ess, D. R., and Morgan, M. T. (2017). The precision-farming guide for agriculturists (4th ed., Ser. Agricultural Primer Series). Deere. https://osu.on.worldcat.org/oclc/1007539133

Zhang, Q. (Ed.). (2017). Automation in tree fruit production: principles and practice. CABI. https://osu.on.worldcat.org/oclc/987909726

Zhang, Q. (Ed.). (2016). Precision agriculture technology for crop farming. CRC Press. https://osu.on.worldcat.org/oclc/908089930 [also available as ebook]

Halachmi, I. (Ed.). (2015). Precision livestock farming applications: making sense of sensors to support farm management. Wageningen Academic. https://osu.on.worldcat.org/oclc/910915968

GIS Applications in Agriculture Series. F. J. Pierce (Editor). Routledge.

Mueller, T. (2015). GIS applications in agriculture, volume four: conservation planning/ edited by Tom Mueller and Gretchen F. Sassenrath (4th ed.). https://osu.on.worldcat.org/oclc/903645674

Clay, D., and Shanahan, J. F. (2011). GIS applications in agriculture (Vol. Volume two, nutrient management for energy efficiency /, Ser. GIS applications in agriculture). CRC Press. https://osu.on.worldcat.org/oclc/231581363

Clay, S. A. (2011). GIS applications in agriculture (Vol. Volume three, invasive species / Ser. GIS applications in agriculture). CRC Press. https://doi.org/10.1201/b10597

Pierce, F. J. and Clay, D. (2007). GIS applications in agriculture (Ser. GIS applications in agriculture series). CRC Press. https://osu.on.worldcat.org/oclc/86068782

Heege, H. J. (Ed.). (2013). Precision in crop farming: site specific concepts and sensing methods: applications and results. Springer. https://osu.on.worldcat.org/oclc/852470956

Oliver, M. A., Bishop, T., and Marchant, B. (2013). Precision agriculture for sustainability and environmental protection (Ser. Earthscan food and agriculture). Taylor and Francis. https://osu.on.worldcat.org/oclc/864414805

Oliver, M. A. (2010). Geostatistical applications for precision agriculture. Springer. https://osu.on.worldcat.org/oclc/668096011

Oerke, E.-C., Gerhards, R., Menz, G., and Sikora, R. A. (Eds.). (2010). Precision crop protection - the challenge and use of heterogeneity. Springer. https://osu.on.worldcat.org/oclc/913513807

Fischer, M. M., & Getis, A. (2009). *Handbook of applied spatial analysis: software tools, methods and applications*. Springer. https://doi.org/10.1007/978-3-642-03647-7 https://link-springer-com.proxy.lib.ohio-state.edu/book/10.1007/978-3-642-03647-7

Conference proceedings

International Conference on Precision Agriculture, International Society of Precision Agriculture

Possible required topics from the conference

- Applications of Unmanned Aerial Systems
- Big Data, Data Mining and Deep Learning
- Geospatial Data
- Land Improvement and Conservation Practices

- On Farm Experimentation with Site-Specific Technologies
- Precision Agriculture and Global Food Security
- Precision Crop Protection
- Precision Horticulture
- Site-Specific Nutrient, Lime, and Seed Management
- Site-Specific Pasture Management
- Small Holders and Precision Agriculture
- Smart Weather for Precision Agriculture

European Conference on Precision Agriculture

Possible required topics from the conference
Topic 01 – Precision Agriculture
Topic 02 – Precision Horticulture
Topic 04 – Precision Crop Protection
Topic 05 – Proximal and Remote Sensing of Soil and Crop
Topic 06 – Applications of Unmanned Aerial Systems
Topic 11 – Site-Specific Nutrient, Lime and Seed Management
Topic 14 – Drainage Optimization and Variable Rate Irrigation
Topic 15 – Geostatistics, mapping and spatial data analysis
Topic 22 – On Farm Experimentation with Site-Specific Technologies
Topic 23 – Software and mobile Apps for Precision Agriculture
Topic 24 – Decision Support for Precision Agriculture
Topic 25 – Data Mining for Precision Agriculture

European Conference on Precision Livestock Farming, European Association for Precision Livestock Farming

Possible required topics from the conference
Controlling environment in animal husbandry
Performance and welfare monitoring
PLF approaches to enable sustainable production
PLF to support decision-making and solutions
Precision technology in product development, optimization and testing
Traceability of production
Monitoring wildlife and companion animals

Pennsylvania Association for Sustainable Agriculture (Pasa)

- Agritourism
- Agroforestry
- Clean water
- Climate change
- Dairy Grazing
- Farm Innovations
- Farmers markets
- Food security
- Food Systems
- Fruit/Orchard
- Hemp
- Integrated pest management
- Land access
- Livestock
- Meat processing
- Organic
- Renewable energy
- Research
- Soil health
- Specialty Crops
- Urban Farming
- Vegetable production

Bibliographic information for AGSYSMT/HCS 3585 - 3586

Ohio Ecological Food and Farm Association (OEFFA)

Has YouTube video of past conference events, sessions, and workshops.

Journal articles

1. Carbon cycling and sequestration:

Carbon Farming is a whole farm approach which optimizes carbon capture by implementing sustainable practices that are known to improve the rate at which CO_2 is removed from the atmosphere and stored in plant material and/or soil organic matter. This can be achieved by following sustainable practices like residue retention, cover cropping, integrated nutrient management, minimum tillage, agroforestry, and livestock integration. Carbon farming helps with restoration of soil and environmental quality, improvement in agroecosystem resilience, and increase in social and political stability.

Carbon cycling and sequestration selected journal articles:

Abdalla, M., Hastings, A., Cheng, K., Yue, Q., Chadwick, D., Espenberg, M., . . . Smith, P. (2019). A critical review of the impacts of cover crops on nitrogen leaching, net greenhouse gas balance and crop productivity. Global Change Biology, 25(8), 2530-2543. doi:10.1111/gcb.14644

Bossio, D. A., Cook-Patton, S. C., Ellis, P. W., Fargione, J., Sanderman, J., Smith, P., . . . Griscom, B. W. (2020). The role of soil carbon in natural climate solutions. Nature Sustainability, 3(5), 391-398. doi:10.1038/s41893-020-0491-z

Chenu, C., Angers, D. A., Barre, P., Derrien, D., Arrouays, D., & Balesdent, J. (2019). Increasing organic stocks in agricultural soils: knowledge gaps and potential innovations. Soil & Tillage Research, 188, 41-52. doi:10.1016/j.still.2018.04.011

Jiang, Z., Lian, F., Wang, Z., & Xing, B. (2020). The role of biochars in sustainable crop production and soil resiliency. Journal of Experimental Botany, 71(2), 520-542. https://doi.org/10.1093/jxb/erz301

Kay, S., Rega, C., Moreno, G., Herder, M. d., Palma, J. H. N., Borek, R., . . . Herzog, F. (2019). Agroforestry creates carbon sinks whilst enhancing the environment in agricultural landscapes in Europe. Land Use Policy, 83, 581-593. doi:10.1016/j.landusepol.2019.02.025

Kopittke, P. M., Menzies, N. W., Wang, P., McKenna, B. A., & Lombi, E. (2019). Soil and the intensification of agriculture for global food security. Environment International, 132, 105078. doi:10.1016/j.envint.2019.105078

Lal, R. (2019). Accelerated soil erosion as a source of atmospheric CO2. Soil & Tillage Research, 188, 35-40. doi:10.1016/j.still.2018.02.001

Lal, R. (2018). Digging deeper: a holistic perspective of factors affecting soil organic carbon sequestration in agroecosystems. Global Change Biology, 24(8), 3285-3301. https://doi.org/10.1111/gcb.14054

Thangavel, R., Bolan, N. S., Kirkham, M. B., Wijesekara, H., Manjaiah, K., Rao, C. S., . . . Freeman, O. W., II. (2019). Soil organic carbon dynamics: impact of land use changes and management practices: a review. Advances in Agronomy, 156, 1-107. https://doi.org/10.1016/bs.agron.2019.02.001

Wiesmeier, M., Urbanski, L., Hobley, E., Lang, B., Lutzow, M. v., Marin-Spiotta, E., . . . Kogel-Knabner, I. (2019). Soil organic carbon storage as a key function of soils - a review of drivers and indicators at various scales. Geoderma, 333, 149-162. doi:10.1016/j.geoderma.2018.07.026

2. Water quality and quantity:

About 40 percent of the land in the United States is used for agriculture. Increased levels of nutrients from fertilizers draining into streams results in algal blooms and increased treatment cost of drinking water. Pesticides that are transported to water bodies can pose risks for aquatic life. They can impair the quality of surface water and groundwater. Transport of excess nutrients is influenced by agricultural practices, such as tillage, drainage, and the timing of application of nutrients.

Water quality and quantity selected journal articles:

Bierkens, M. F. P., & Wada, Y. (2019). Non-renewable groundwater use and groundwater depletion: a review. Environmental Research Letters, 14(6). doi:10.1088/1748-9326/ab1a5f

Duncan, E. W., Osmond, D. L., Shober, A. L., Starr, L., Tomlinson, P., Kovar, J. L., . . . Reid, K. (2019). Phosphorus and soil health management practices. Agricultural and Environmental Letters, 4(1), 190014. doi:10.2134/ael2019.04.0014

Emde, D., Hannam, K. D., Most, I., Nelson, L. M., & Jones, M. D. (2021). Soil organic carbon in irrigated agricultural systems: a meta-analysis. Global Change Biology, 27(16), 3898-3910. doi:10.1111/gcb.15680

Liu, J., & Lobb, D. A. (2021). An overview of crop and crop residue management impacts on crop water use and runoff in the Canadian prairies. Water, 13(20). doi:10.3390/w13202929

Lwin, C., Seo, B., Kim, H., Owens, G., & Kim, K. (2018). Application of soil amendments to contaminated soils for heavy metal immobilization and improved soil quality - a critical review. Soil Science and Plant Nutrition, 64(2), 156-167. doi:10.1080/00380768.2018.1440938

Ni, X., Yuan, Y., & Liu, W. (2020). Impact factors and mechanisms of dissolved reactive phosphorus (DRP) losses from agricultural fields: a review and synthesis study in the Lake Erie basin. Science of the Total Environment, 714. doi:10.1016/j.scitotenv.2020.136624

Skaalsveen, K., Ingram, J., & Clarke, L. E. (2019). The effect of no-till farming on the soil functions of water purification and retention in north-western Europe: a literature review. Soil & Tillage Research, 189, 98-109. doi:10.1016/j.still.2019.01.004

Smith, D. R., Wilson, R. S., King, K. W., Zwonitzer, M., McGrath, J. M., Harmel, R. D., . . . Johnson, L. T. (2018). Lake Erie, phosphorus, and microcystin: is it really the farmer's fault? Journal of Soil and Water Conservation (Ankeny), 73(1), 48-57. doi:10.2489/jswc.73.1.48

Souza, R. M. d., Seibert, D., Quesada, H. B., Bassetti, F. d. J., Fagundes-Klen, M. R., & Bergamasco, R. (2020). Occurrence, impacts and general aspects of pesticides in surface water: a review. Process Safety and Environmental Protection, 135, 22-37. doi:10.1016/j.psep.2019.12.035

Syafrudin, M., Kristanti, R. A., Yuniarto, A., Hadibarata, T., Rhee, J., Wedad, A. A.-O., . . . Amal, M. A.-M. (2021). Pesticides in drinking water - a review. International Journal of Environmental Research and Public Health, 18(2). doi:10.3390/ijerph18020468

Ward, M. H., Jones, R. R., Brender, J. D., Kok, T. M. d., Weyer, P. J., Nolan, B. T., . . . Breda, S. G. v. (2018). Drinking water nitrate and human health: an updated review. International Journal of Environmental Research and Public Health, 15(7), 1557. doi:10.3390/ijerph15071557

3. Food production optimization and efficiency:

Agricultural efficiency is defined as the input-output ratio in an agricultural operation. It reflects the impact of modern inputs and technology in production and is dependent upon the responsiveness of soil and the agricultural ecology. It measures the increase in output with a given increase in inputs, which leads to an increase in profits. This extra profit earned on agriculture is reflected by the Agricultural Efficiency (Source: https://lotusarise.com/agricultural-productivity-upsc/)

Agricultural optimization: help farmers in selecting the right crop at the right time and the optimum allocation of land and water to each of these crops to maximize the profit by taking into consideration, the market prices, climate, and irrigation facilities. It considers the case of optimization of agricultural resources. (Source: https://ieeexplore.ieee.org/document/6420815)

Food production optimization and efficiency selected journal articles*:*

Bergtold, J. S., Ramsey, S., Maddy, L., & Williams, J. R. (2019). A review of economic considerations for cover crops as a conservation practice. Renewable Agriculture and Food Systems, 34(1), 62-76. doi:10.1017/s1742170517000278

Colaco, A. F., & Bramley, R. G. V. (2018). Do crop sensors promote improved nitrogen management in grain crops? Field Crops Research, 218, 126-140. doi:10.1016/j.fcr.2018.01.007

Kleijn, D., Bommarco, R., Fijen, T. P. M., Garibaldi, L. A., Potts, S. G., & Putten, W. H. v. d. (2019). Ecological intensification: bridging the gap between science and practice. Trends in Ecology & Evolution, 34(2), 154-166. doi:10.1016/j.tree.2018.11.002

Ricciardi, V., Mehrabi, Z., Wittman, H., James, D., & Ramankutty, N. (2021). Higher yields and more biodiversity on smaller farms. Nature Sustainability, 4(7), 651-657. doi:10.1038/s41893-021-00699-2

Rosa-Schleich, J., Loos, J., Musshoff, O., & Tscharntke, T. (2019). Ecological-economic trade-offs of Diversified Farming Systems - a review. Ecological Economics, 160, 251-263. doi:10.1016/j.ecolecon.2019.03.002

4. Nitrogen and phosphorus cycling and use efficiency:

Nitrogen cycling and use efficiency:

Nitrogen fertilizer is required for plant growth and development. Approximately half the food produced now in the world use N fertilizer. Excessive and inefficient use of N fertilizer results in increased crop production costs and atmospheric pollution. The losses can be minimized by adopting improved sustainable agronomic practices such as optimal dosage of nitrogen, application of N by using canopy sensors, maintaining plant population, drip fertigation and legume-based intercropping.

Phosphorous cycling and use efficiency:

Phosphorus (P) like nitrogen, is often the most limiting nutrient for crop production. P-loss is mainly associated with erosion and runoff. P availability can be managed by liming acid soils, using practices that increase organic matter, and proper placement of P fertilizer affecting how efficiently P is used by crops. P losses can be reduced by applying appropriate measures to reduce erosion and runoff.

Nitrogen and phosphorus cycling and use efficiency selected journal articles:

Abbott, L. K., Macdonald, L. M., Wong, M. T. F., Webb, M. J., Jenkins, S. N., & Farrell, M. (2018). Potential roles of biological amendments for profitable grain production - a review. Agriculture, Ecosystems & Environment, 256, 34-50. doi:10.1016/j.agee.2017.12.021

Barkha, & Ananya, C. (2021). Effect of integrated nutrient management on nutrient use efficiency of major nutrients: a review. Plant Archives, 21(1), 1084-1089. doi:10.51470/PLANTARCHIVES.2021.v21.no1.143

Carr, P. M., Cavigelli, M. A., Darby, H., Delate, K., Eberly, J. O., Gramig, G. G., . . . Woodley, A. L. (2019). Nutrient cycling in organic field crops in Canada and the United States. Agronomy Journal, 111(6), 2769-2785. doi:10.2134/agronj2019.04.0275

Colaco, A. F., & Bramley, R. G. V. (2018). Do crop sensors promote improved nitrogen management in grain crops? Field Crops Research, 218, 126-140. doi:10.1016/j.fcr.2018.01.007

Duncan, E. G., O'Sullivan, C. A., Roper, M. M., Biggs, J. S., & Peoples, M. B. (2018). Influence of co-application of nitrogen with phosphorus, potassium and sulphur on the apparent efficiency of nitrogen fertiliser use, grain yield and protein content of wheat: review. Field Crops Research, 226, 56-65. doi:10.1016/j.fcr.2018.07.010

Folina, A., Tataridas, A., Mavroeidis, A., Kousta, A., Katsenios, N., Efthimiadou, A., . . . Kakabouki, I. (2021). Evaluation of various nitrogen indices in N-fertilizers with inhibitors in field crops: a review. Agronomy, 11(3). doi:10.3390/agronomy11030418

Liu, C., Plaza-Bonilla, D., Coulter, J. A., Kutcher, H. R., Beckie, H. J., Wang, L., . . . Gan, Y. (2022). Diversifying crop rotations enhances agroecosystem services and resilience. Advances in Agronomy, 173, 299-335. doi:10.1016/bs.agron.2022.02.007

Losacco, D., Ancona, V., Paola, D. d., Tumolo, M., Massarelli, C., Gatto, A., & Uricchio, V. F. (2021). Development of ecological strategies for the recovery of the main nitrogen agricultural pollutants: a review on environmental sustainability in agroecosystems. Sustainability, 13(13). doi:10.3390/su13137163

Martinez-Dalmau, J., Berbel, J., & Ordonez-Fernandez, R. (2021). Nitrogen fertilization. A review of the risks associated with the inefficiency of its use and policy responses. Sustainability, 13(10). doi:10.3390/su13105625

Swaney, D. P., & Howarth, R. W. (2019). Phosphorus use efficiency and crop production: patterns of regional variation in the United States, 1987-2012. Science of the Total Environment, 685, 174-188. doi:10.1016/j.scitotenv.2019.05.228

Swaney, D. P., Howarth, R. W., & Hong, B. (2018). Nitrogen use efficiency and crop production: patterns of regional variation in the United States, 1987-2012. Science of the Total Environment, 635, 498-511. doi:10.1016/j.scitotenv.2018.04.027

Wang, Z., & Li, S. (2019). Nitrate N loss by leaching and surface runoff in agricultural land: a global issue (a review). Advances in Agronomy, 156, 159-217. doi: 10.1016/bs.agron.2019.01.007

5. Climate-Smart Agriculture (CSA):

The most commonly used definition is provided by the Food and Agricultural Organization of the United Nations (FAO), which defines CSA as "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes GHGs (mitigation) where possible, and enhances achievement of national food security and development goals".

Climate-smart agriculture (CSA) practices and technologies includes soil management, crop management, water management, livestock management, forestry, fisheries and aquaculture, and energy management. For example, precision farming, tillage, and fertilization are all CSA practices.

Climate-Smart Agriculture selected journal articles:

Barasa, P. M., Botai, C. M., Botai, J. O., & Mabhaudhi, T. (2021). A review of climate-smart agriculture research and applications in Africa. Agronomy, 11(6). doi:10.3390/agronomy11061255

Gardezi, M., Michael, S., Stock, R., Vij, S., Ogunyiola, A., & Ishtiaque, A. (2022). Prioritizing climate-smart agriculture: an organizational and temporal review. Wiley Interdisciplinary Reviews: Climate Change, 13(2). doi:10.1002/wcc.755

Mizik, T. (2021). Climate-smart agriculture on small-scale farms: a systematic literature review. Agronomy, 11(6). doi:10.3390/agronomy11061096/

Sarker, M. N. I., Wu, M., Alam, G. M. M., & Islam, M. S. (2019). Role of climate smart agriculture in promoting sustainable agriculture: a systematic literature review. International Journal of Agricultural Resources, Governance and Ecology, 15(4), 323-337. doi:10.1504/ijarge.2019.104199

Thornton, P. K., Whitbread, A., Baedeker, T., Cairns, J., Claessens, L., Baethgen, W., . . . Keating, B. (2018). A framework for priority-setting in climate smart agriculture research. Agricultural Systems, 167, 161-175. doi:10.1016/j.agsy.2018.09.009

Totin, E., Segnon, A. C., Schut, M., Affognon, H., Zougmore, R. B., Rosenstock, T., & Thornton, P. K. (2018). Institutional perspectives of climate-smart agriculture: a systematic literature review. Sustainability, 10(6), 1990. doi:10.3390/su10061990

Zougmore, R. B., Laderach, P., & Campbell, B. M. (2021). Transforming food systems in Africa under climate change pressure: role of climate-smart agriculture. Sustainability, 13(8). doi:10.3390/su13084305

6. Food safety:

It is achieved by following Good Agricultural Practices (GAPs). GAPs are measures that are adopted by farmers to prevent microbial contamination of fruits and vegetables as they are produced, packed, handled, and stored. Many other risks in the present food system, such as the long-term loss of topsoil, species diversity, natural resources, consumer choice, and opportunities for farms and rural communities have an impact on food safety.

Food availability: Food availability means that enough food is physically present for the entire population. It is a function of supply chains and food reserves.

Food safety selected journal articles:

Adeyeye, S. A. O. (2020). Aflatoxigenic fungi and mycotoxins in food: a review. Critical Reviews in Food Science and Nutrition, 60(5), 709-721. doi:10.1080/10408398.2018.1548429

Anil, P., Navnidhi, C., Neelesh, S., & Sundeep, J. (2018). Role of Food Safety Management Systems in safe food production: a review. Journal of Food Safety, 38(4), e12464. doi:10.1111/jfs.12464

Chen, H., Kinchla, A. J., Richard, N., Shaw, A., & Feng, Y. (2021). Produce growers' on-farm food safety education: a review. Journal of Food Protection, 84(4), 704-716. doi:10.4315/jfp-20-320

Duchenne-Moutien, R. A., & Neetoo, H. (2021). Climate change and emerging food safety issues: a review. Journal of Food Protection, 84(11), 1884-1897. doi:10.4315/jfp-21-141

Lenzi, A., Marvasi, M., & Baldi, A. (2021). Agronomic practices to limit pre- and post-harvest contamination and proliferation of human pathogenic Enterobacteriaceae in vegetable produce. Food Control, 119. doi:10.1016/j.foodcont.2020.107486

Riggio, G. M., Wang, Q., Kniel, K. E., & Gibson, K. E. (2019). Microgreens - a review of food safety considerations along the farm to fork continuum. International Journal of Food Microbiology, 290, 76-85. doi:10.1016/j.ijfoodmicro.2018.09.027

7. Food security:

Food security, as defined by the United Nations' Committee on World Food Security, means that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life.

In order to feed a population that is expected to grow to 9 billion people by 2050, we need to double current food production. To meet this challenge and to achieve food security, there is a need to adopt sustainable agricultural practices which uses technology.

Food security selected journal articles:

Ali, R., Ali, R., Mehmood, S. S., Zou, X., Zhang, X., Lv, Y., & Xu, J. (2019). Impact of climate change on crops adaptation and strategies to tackle its outcome: a review. Plants, 8(2), 34. doi:10.3390/plants8020034

Karthikeyan, L., Chawla, I., & Mishra, A. K. (2020). A review of remote sensing applications in agriculture for food security: crop growth and yield, irrigation, and crop losses. Journal of Hydrology (Amsterdam), 586. doi:10.1016/j.jhydrol.2020.124905

Leisner, C. P. (2020). Review: climate change impacts on food security- focus on perennial cropping systems and nutritional value. Plant Science, 293. doi:10.1016/j.plantsci.2020.110412

Ramankutty, N., Mehrabi, Z., Waha, K., Jarvis, L., Kremen, C., Herrero, M., & Rieseberg, L. H. (2018). Trends in global agricultural land use: Implications for environmental health and food security. Annual Review of Plant Biology, 69, 789-815. doi:10.1146/annurev-arplant-042817-040256

Bibliographic information for AGSYSMT/HCS 3585 - 3586

Wezel, A., Herren, B. G., Kerr, R. B., Barrios, E., Goncalves, A. L. R., & Sinclair, F. (2020). Agroecological principles and elements and their implications for transitioning to sustainable food systems. a review. Agronomy for Sustainable Development, 40(6). doi:10.1007/s13593-020-00646-z

Digital Agriculture Laboratory Syllabus

AGSYSMT/HCS 3586 Spring 2023

Course Information

Course times and location: Labs will meet once a week on Tuesdays; time and location: TBD
Credit hours: 1
Mode of delivery: In Person

Instructors

Department of Food, Agricultural and Biological Engineering:

Name: Dr. Scott A. Shearer
Email: shearer.95@osu.edu (preferred)
Phone: 614-292-7284
Office location: 590 Woody Hayes Drive
Office hours: TBD.

Department of Horticulture and Crop Science:

Name: Dr. David Barker
Office location: 226 Kottman Hall
E-mail: barker.169@osu.edu (preferred)
Phone: (614) 247-6258
Office Hours: TBD

Name: Dr. Alex Lindsey
Office location: 312A Kottman Hall
E-mail: lindsey.227@osu.edu (preferred)
Phone: (614) 292-3864
Office Hours: TBD

Name: Dr. Guilherme Signorini
Office location: 225 Howlett Hall
E-mail: signorini.2@osu.edu (preferred)
Phone: no phone
Office Hours: TBD

Course Coordinator

Department of Horticulture and Crop Science:
Name: Dr. Ramarao Venkatesh
301 Kottman Hall
E-mail: venkatesh.1@osu.edu (preferred)
Phone: (614) 688-4204
Office Hours: TBD

Preferred contact method:

First contact with any instructor should be at Ohio State email address. Student will receive a response within **24 hours**.
Class-wide communications will be sent through the Announcements tool in CarmenCanvas. Please check your notification preferences (go.osu.edu/canvas-notifications) to be sure you receive these messages.

Course Prerequisites

AGSYSMT 2580, AGSYSMT 3585 or HCS 3585 (or concurrent)

Course Exclusions

None

Course Description

Catalog Description: Digital Agriculture Laboratory provides an overview of the tools used for making management decisions based on data-driven processes in agriculture and food systems. Simply stated, "digital agriculture" is the "generation and analysis of large data sets to produce actionable information." This course seeks to provide students with experience of using a variety of analytical tools to extract and present actionable management information from a variety of large, complex data sets generated in food systems.

Extended Description: Digital Agriculture Laboratory provides an overview of the tools used for making management decisions based on data-driven processes in agriculture and food systems. The advancement of digital tools and analytics seeks to combine large data sets and sources with crop, animal, weather, environment, and capital asset management models, coupled with AI, to produce actionable information to enhance the sustainability and profitability of the food supply chain. Simply stated, "digital agriculture" is the "generation and analysis of large data sets to produce actionable information." This course seeks to provide students with experience using a variety of tools extract and present actionable management information from a variety of large, complex data sets common in food systems.

For digital agriculture, sustainability is defined as the ability of growers to have agricultural production systems that are efficient and profitable, that minimizes the impact to the land, air, and water, and that enhances the quality of life for local, national, and global communities. The following are some of the sustainability concepts covered in this course: Carbon Cycling and Sequestration, Water Quality and Quantity, Food Production Optimization and Efficiency, Nitrogen and Phosphorus Cycling and Use Efficiency, Climate Smart Agriculture, Food Safety and Food Security.

General Education Goals and Expected Learning Outcomes

As part of the Sustainability Theme of the General Education curriculum, this course is designed with the following Goals and Expected Learning Outcomes:

GE Goal 1: Successful students will analyze sustainability at a more advanced and in-depth level than in the Foundations component.

Expected Learning Outcomes (ELO)

- ELO 1.1 (IITT ELO 1.1) Engage in critical and logical thinking about the topic or idea of sustainability. LLO 1.1, LLO 1.2, LLO 1.4
    - IITT ELO 1.1.a Critical thinking: Clearly state and comprehensively describe the issue or problem under consideration, delivering all relevant information necessary
    - IITT ELO 1.1.b Analysis: Interpret and evaluate information from multiple sources and multiple disciplinary perspectives to develop a comprehensive analysis or synthesis, and thoroughly question the viewpoints of experts and professionals.
    - IITT ELO 1.1.c Critical thinking & analysis Systematically and methodically analyze their own and others' assumptions using more than one disciplinary lens and carefully evaluate the relevance of contexts when representing a position
- ELO 1.2 (IITT ELO 1.2) Engage in an advanced, in-depth, scholarly exploration of the topic or idea of sustainability. LLO 1.2, LLO 1.4, LLO 2.5
    - IITT ELO 1.2.a Scholarly engagement: Articulate a thorough and complex understanding of the factors and contexts, including natural, social, cultural and political, contributing to an integrative understanding of the issue.

GE Goal 2: Successful students will integrate approaches to sustainability by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or to work they have done in previous classes and that they anticipate doing in future.

Expected Learning Outcomes

- ELO 2.1 (IITT ELO 2.1) Identify, describe and synthesize approaches or experiences as they apply to sustainability. LLO 1.2, LLO 2.1, LLO 2.2, LLO 2.5
    - IITT ELO 2.1.a Integration of knowledge: Connect, analyze, and extend knowledge (facts, theories, etc.) from course content to integrate their insights through construction of a more comprehensive perspective.
    - IITT ELO 2.1.b Multiple perspectives: Evaluate and apply diverse perspectives to complex subjects from multiple cultural and disciplinary lenses as appropriate.
- ELO 2.2 (ITC ELO 2.2) Demonstrate a developing sense of self as a learner through reflection, self-assessment and creative work, building on prior experiences to respond to new and challenging contexts. LLO 2.3, LLO 2.4

- IITT ELO 2.2.a Self-awareness: Evaluates the impacts of cross disciplinary synthesis of the issue on themselves, the scholarly inquiry, the local and global systems and also considers the long-term impact of the work.

- IITT ELO 2.2.b. Empathy: Interpret and explain the issue under consideration from the perspectives other than their own and more than one worldview and demonstrates openness towards others in the academic community and their perspectives.

GE Goal 3: Successful students will analyze and explain how social and natural systems function, interact, and evolve over time; how human well-being depends on these interactions; how actions have impacts on subsequent generations and societies globally; and how human values, behaviors and institutions impact multifaceted potential solutions across time.

Expected Learning Outcomes

- ELO 3.1 Describe elements of the fundamental dependence of humans on Earth and environmental systems, and on the resilience of these systems. LLO 1.3

- ELO 3.2 Describe, analyze, and critique the roles and impacts of human activity and technology on both human society and the natural world, in the past, present and future. LLO 1.3

ELO 3.3 Devise informed and meaningful responses to problems and arguments in the area of sustainability based on the interpretation of appropriate evidence and an explicit statement of values. LLO 1.1

This 1-credit AGSYSMT/HCS 3586 laboratory supports ALL of the Goals and ALL Expected Learning Outcomes fulfilled by AGSYSMT/HCS 3585 for the Sustainability Theme category.

When 1-credit AGSYSMT/HCS 3586 is taken in combination with the 3-credit AGSYSMT/HCS 3585 lecture, together these 4-credits (i.e., 3-credit lecture + 1-credit laboratory) meet the expectations of the integrative, interdisciplinary, team-taught practice. The subject matter encompasses social, biological, engineering, and economic scales that are too broad or complex to be adequately dealt by a single discipline or profession.

This course is taught by a multi-disciplinary team comprising of six faculty from two departments (Food, Agricultural and Biological Engineering, and Horticulture and Crop Science) in the College of Food, Agricultural, and Environmental Sciences (CFAES).

Students will work with large scale complex problems throughout the entire course centered on food system operations (small holder vs corporate) that have an impact on the profitability, environment, sustainability, how technology impacts food, fuel, fiber, energy production practices, logistics, and careers (current and future). Students will have opportunities to revisit, analyze, and synthesize the material taught in the course. Students' can compare their knowledge and understanding of the complex issues of data driven food, fuel, and fiber production systems and chart how their knowledge and understanding has changed across time. The content and procedures learned in this course will not only provide the basis for completing class assignments and activities but can be applied to future courses and employment.

Note: AGSYSMT/HCS 3586 (1 hr.) cannot be taken alone, nor fulfill GE credit without AGSYSMT/HCS 3585.

AGSYSMT 3586
Digital Agriculture Laboratory

This laboratory course supports and reenforces AGSYSMT/HCS 3585's fulfillment of ALL of the Sustainability Theme Learning Goals and Expected Learning Outcomes.

- The laboratory supplies additional real-world applications of the lecture topics.
- Data, data sets, analysis, and data visualization are core components of the lab reports.
- Students make informed decisions using their academic/life experiences, results generated by data analysis, impact of production practices on sustainability, environment, and on humans (individuals, society/culture).

Laboratory Goals and Laboratory Learning Outcomes (LLO)

Laboratory Goal 1. Students will analyze sustainability at a more advanced and in-depth level.

LLO 1.1 *Develop* responses to problems and arguments in the area of sustainability based in data, definitions, principles, and theories. ELO 1.1, 3.3 – IITT 1.1.a

LLO 1.2 Analyze how multiple sources and disciplines, expert viewpoints, and technologies impact sustainability using the sustainability concepts. Show their impacts on the environment, political, natural, cultural, and social aspects. ELO 1.1, 1.2 – IITT 1.1.b, 1.1.c, 1.2.a

LLO 1.3 *Describe*, *analyze*, and *critique* the roles and impacts of human activity and technology on the society and the natural world, in the past, present, and future. ELO 3.1, 3.2

LLO 1.4 Data collection, analysis, interpretation of results and effective communication of results to growers/workforce that helps to plan their farm operations. ELO 1.1, 1.2 – IITT 1.1.b, 1.1.c, 1.2.a

Course Goal 2. Successful students will integrate approaches to sustainability by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or to work they have done in previous classes and that they anticipate doing in future

LLO 2.1 *Compare* the technologies (Applied IoT, Artificial Intelligence, Blockchain, Controlled Environments Agriculture, Data Mining, Enterprise Agriculture, On-Farm Research, Variable Rate Application, RFID) used in digital agriculture and food systems as they impact sustainability, environment, and society in the world around us. ELO 2.1 – IITT 2.1.a

LLO 2.2 *Evaluate* impact of digital agriculture on sustainability under different disciplinary lenses, multi-cultural, diverse perspectives applied to complex subjects of sustainability concepts. ELO 2.1 – IITT 2.1.b

LLO 2.3 *Examine* how your concepts, scholarly approach, knowledge has changed within the course. ELO 2.2 – IITT 2.2.a

LLO 2.4 Using the sustainability concepts *Create* your own definition of, and the role of digital agriculture then *Create* a second definition and role from a different person's perspective. Explain the similarities and differences based on the two perspectives. ELO 2.2 – IITT 2.2.b

LLO 2.5 Categorize how data is generated, stored, ownership, privacy, security, ethics, and technologies influence the sustainability (plant, animal, and soil environments). ELO 1.2, 2.1 – IITT 1.2.a, 2.1.a

How This Course Works

Mode of delivery: In Person

Pace of activities: This course is divided into **weekly modules**. Students are expected to keep pace with weekly deadlines but may schedule their efforts freely within that time frame.

Credit hours and work expectations: This is a 1 credit-hour multi-disciplinary team-taught laboratory course. According to Ohio State bylaws on instruction (go.osu.edu/credit hours), students should expect around 1 hour per week of time spent on direct instruction (instructor content and Carmen activities, for example), an additional 1 hour of laboratory time, and in addition to 2 hours of laboratory and homework activities (reading and assignment preparation, for example) to receive a grade of C average.

Please note: This includes studying, reviewing, and editing notes, discussing with fellow students, etc. and does not equate to assignments and homework activities.

Attendance and participation requirements:

Research shows that regular participation is one of the highest predictors of success. With that in mind, the instructor has the following expectations for everyone's participation:

- **Attendance:** You are expected to attend all classes.
- **Participation:** Your participation in class is essential to your success. Participation includes Answering questions in class when called upon; sharing relevant insights of examples from your experiences; Asking questions if you do not understand the material
- In case of emergencies and other circumstances that prevent you from attending, please contact the instructor as soon as possible by email. Official documentation (e.g., from a doctor's office or hospital, or interviewer, etc.) must be provided. If you miss a lab session, please discuss how to make up the lab with the instructor in a different time.

Course Materials, Fees, and Technologies

Required Materials and/or Technologies

The following are general texts which provide background information. Specific chapters from these and other text may be assigned by the instructors.

All materials are available from the OSU library. **Off-campus** access to most OSU Library resources may be obtained through these routes.

Additional publications and materials are available in Carmen

- Hamrita, T. K. (Ed.). (2021). Women in precision agriculture: technological breakthroughs, challenges and aspirations for a prosperous and sustainable future (Ser. Women in engineering and science). Springer. https://osu.on.worldcat.org/oclc/1187169922
- Abd El-Kader, S. M., and Mohammad El-Basioni, B. M. (Eds.). (2021). Precision agriculture technologies for food security and sustainability (Ser. Advances in Environmental Engineering and Green Technologies (AEEGT) book series). Engineering Science Reference, an imprint of IGI Global. https://osu.on.worldcat.org/oclc/1156439371
- Stafford, J. (Ed.). (2019). Precision agriculture for sustainability (Ser. Burleigh Dodds series in Agricultural Science, number 52). Burleigh Dodds Science Publishing. https://osu.on.worldcat.org/oclc/1078923421

   - Shannon, D. K., Clay, D., and Kitchen, N. R. (Eds.). (2018). Precision agriculture basics. American Society of Agronomy. https://osu.on.worldcat.org/oclc/1037150375
   - Lal, R., and Stewart, B. A. (Eds.). (2016). Soil-specific farming: precision agriculture (Ser. Advances in Soil Science). CRC Press, Taylor & Francis Group. https://osu.on.worldcat.org/oclc/914301013
   - Crawley, M. J. (2013). The R book (Second). Wiley. Retrieved July 21, 2022, https://osu.on.worldcat.org/oclc/809365744
- Computer: current Mac (OS X or PC (Windows 10 or higher with high-speed internet connection
- Webcam: built-in or external webcam, fully installed and tested
- Microphone: built-in laptop or tablet mic or external microphone

Recommended/Optional Materials and/or Technologies

- The instructors will provide you with supplementary reading materials periodically and will be announced during the lecture. They will be uploaded to Canvas.
- The course instructors will update additional material/sources for students during individual lectures. Digital agriculture area is dynamic and new research is published on an ongoing basis. Instructors will be interacting with Dr. Florian Diekman, science liaison librarian, throughout the semester. He serves as Head of the Food, Agricultural, and Environmental Sciences Library at The Ohio State University. Florian provides research and teaching support for the students, faculty, staff, and alumni of the College of Food, Agricultural, and Environmental Sciences, and members of the public.

Fees and/or Additional Requirements

- None

Required Equipment

- **Computer:** current Mac (MacOS) or PC (Windows 10) with high-speed internet connection
- **Webcam:** built-in or external webcam, fully installed and tested
- **Microphone:** built-in laptop or tablet microphone or external microphone
- **Other:** a mobile device (smartphone or tablet to use for BuckeyePass authentication

  If you do not have access to the technology you need to succeed in this class, review options for technology and internet access at go.osu.edu/student-tech-access.

You can use any electronic device to access the course in CarmenCanvas and perform all of the function needed to complete the course. There may be additional directions or restrictions for some of the activities as noted in those activities.

Required Software

- **Microsoft Office 365:** All Ohio State University students are now eligible for free Microsoft Office 365 ProPlus through Microsoft's Student Advantage program. Full instructions for downloading and installation is found Office 365 - Installation of Office for Windows/Mac for Students.

- **Zotero:** You also need to install the ASABE style by going to Zotero Style Repository then select American Society of Agricultural and Biological Engineers or, ZoteroBib to build bibliography without downloading the app and style. Instructions are found ZoteroBib FAQ.
- **ArcGIS Desktop**: Will be used in the labs and you need to download it to a Windows machine from go.osu.edu/esri. Go to the ArcGIS Desktop Get started with ArcMap and follow the instructions.
- "R"- **What is R?** You will be using R in lab for statics. You can download R for free from the R Project for Statistical Computing using a USA CRAN server such as Case Western Reserve University Mirror.

CarmenCanvas Access

You will need to use BuckeyePass (buckeyepass.osu.edu multi-factor authentication to access your courses in Carmen. To ensure that you are able to connect to Carmen at all times, it is recommended that you do each of the following:

- Register multiple devices in case something happens to your primary device. Visit the BuckeyePass - Adding a Device (go.osu.edu/add-device) help article for step-by-step instructions.
- Request passcodes to keep as a backup authentication option. When you see the Duo login screen on your computer, click **Enter a Passcode** and then click the **Text me new codes** button that appears. This will text you ten passcodes good for 365 days that can each be used once.
- Install the Duo Mobile application (go.osu.edu/install-duo) on all of your registered devices for the ability to generate one-time codes in the event that you lose cell, data, or Wi-Fi service.

If none of these options will meet the needs of your situation, you can contact the IT Service Desk at 614-688-4357 (HELP) and IT support staff will work out a solution with you.

Technology Skills Needed for This Course

- Basic computer and web-browsing skills
- Navigating CarmenCanvas (go.osu.edu/canvasstudent)
- CarmenZoom virtual meetings (go.osu.edu/zoom-meetings)
- Recording a slide presentation with audio narration and recording, editing and uploading video (go.osu.edu/video-assignment-guide)

Technology Support

For help with your password, university email, CarmenCanvas, or any other technology issues, questions, or requests, contact the IT Service Desk, which offers 24-hour support, seven days a week.

- **Self Service and Chat**: go.osu.edu/it
- **Phone:** 614-688-4357 (HELP)
- **Email:** servicedesk@osu.edu

Grading and Faculty Response

Assignment Category	Percentage
Lab Reports (14)	**100%**
Total	**100%**

Descriptions of Laboratory Course Assignments

Description: There are 14 Laboratory Report each with a procedure, objectives, data, and results. There is a rubric for each Laboratory Report. **See page 10 for the Late Assignments.**

Goal 1 [LLO 1.1 (ELO 1.1, 3.3 – IITT 1.1.a); LLO 1.2 (ELO 1.1, 1.2 – IITT 1.1.b, 1.1.c, 1.2.a); LLO 1.3 (ELO 3.1, 3.2); LLO1.4 (ELO 1.1, 1.2 – IITT 1.1.b, 1.1.c, 1.2.a)]

Goal 2 [LLO 2.1 (ELO 2.1 – IITT 2.1.a); LLO 2.2 (ELO 2.1 – IITT 2.1.b); LLO 2.3 (ELO 2.2 – IITT 2.2.a); LLO 2.4 (ELO 2.2 – IITT 2.2.b); LLO 2.5 (ELO 1.2, 2.1 – IITT 1.2.a, 2.1.a)]

Sample Grading Rubric for Laboratory Reports

General Laboratory Report Rubric	
Grading Scale 4-point scale – 4 (exceeds expectations - >90%), 3 (meets expectations - 80-90%), 2 (meets $^2/_3$ of the expectations 70-80%), 1 (meets $^1/_3$ of the expectations - 60-70%), and 0 (unsatisfactory - <60%)	**Score**
Report Requirements	**0 to 4 pts.**
A. Write out the objective of the report, do not include any irrelevant details	
B. Demonstrate thorough understanding of topic using complete and accurate information	
C. Present information in a knowledgeable manner	
D. Use three or more referenced resources to gather information including speaking with stakeholders and experts	
E. Use appropriate resources (peer reviewed publications, trade publications, websites, videos etc. using the ASABE Style Guide	
Subtotal	
Report Organization	**0 to 4 pts.**
1. Visual appeal and clarity, figures and maps are neatly done with proper labeling	
2. Legible, neatness, and creativity	
3. Homework is complete and on time	
4. Successfully meet the objective(s) of the assignment	
5. Written assignment without any typos and clearly written	
Subtotal	
Total (0 to 40 pts.)	

Students will have 14 laboratory reports to complete. Be sure you understand the specifics of the report and respond accordingly. Laboratory reports will count for **100% of your final grade**. A total of 14 reports will be given during the entire duration of the course.

We are training you to become professionals. With this in mind, your work should be of high quality. Your laboratory assignments should be organized and meet the requirements mentioned in the "general" rubric above. But, for each laboratory assignment we will provide you with a specific rubric relevant to the assigned homework assignment. Partial credit will be given.

Grading Scale

Grade	Range
A	100 % to 93.0%
A-	< 93.0 % to 90.0%
B+	< 90.0 % to 87.0%
B	< 87.0 % to 83.0%
B-	< 83.0 % to 80.0%
C+	< 80.0 % to 77.0%
C	< 77.0 % to 73.0%
C-	< 73.0 % to 70.0%
D+	< 70.0 % to 67.0%
D	< 67.0 % to 60.0%
E	< 60.0 % to 0.0%

Academic integrity and collaboration:

Your laboratory reports should be your own original work. In formal reports, you should follow ASABE style to cite the key words and references of your research sources. You are encouraged to ask a trusted person to proofread your assignments before you turn them in but no one else should revise or rewrite your work.

Reusing Past Work

In general, you are prohibited in university courses from turning in work from a past class to your current class, even if you modify it. If you want to build on past research or revisit a topic you have explored in previous courses, please discuss the situation with me.

Falsifying Research or Results

All research you will conduct in this course is intended to be a learning experience; you should never feel tempted to make your results or your library research look more successful than it was.

Collaboration and Informal Peer-Review

The course includes many opportunities for formal collaboration with your classmates. While study groups and peer-review of major written projects is encouraged, remember that comparing answers on a quiz or assignment is not permitted. If you are unsure about a particular situation, please feel free just to ask ahead of time.

Late Assignments

Please refer to Carmen for due dates. Due dates are set to help you to stay on pace and to allow timely feedback that will help you complete subsequent assignments.

- Late work will have 20% of the total points deleted for each day it is late. Five (5) days late you will receive zero (0 points). This is based on the timestamp in Carmen, anything after the deadline is the next day and 20% off. In the case of documented emergency or illness, please contact the Course Coordinator as soon as possible to discuss accommodations, which will be determined on a case-by-case basis.

Instructor Feedback and Response Time

I am providing the following list to give you an idea of my intended availability throughout the course. Remember that you can call 614-688-4357 (HELP) at any time if you have a technical problem.

- **Preferred contact method:** If you have a question, please contact me first through my Ohio State email address. I will reply to emails within **24 hours on days when class is in session at the university**.
- I am providing the following list to give you an idea of my intended availability throughout the course. Remember that you can call 614-688-HELP at any time if you have a technical problem.
- **Class announcements:** I will send all important class-wide messages through the Announcements tool in CarmenCanvas. Please check your notification preferences (go.osu.edu/canvas-notifications) to ensure you receive these messages.
- **Discussion board:** I will check and reply to messages in the discussion boards once mid-week and once at the end of the week.
- **Grading and feedback:**
    - For large weekly assignments, you can generally expect feedback within 7 school days.

Other Course Policies

Discussion and Communication Guidelines

The following are my expectations for how we should communicate as a class. Above all, please remember to be respectful and thoughtful.

- Writing style: While there is no need to participate in class discussions as if you were writing a research paper, you should remember to write using good grammar, spelling, and punctuation. A more conversational tone is fine for non-academic topics.
- Tone and civility: Let's maintain a supportive learning community where everyone feels safe and where people can disagree amicably. Remember that sarcasm doesn't always come across online. The instructors will provide you with specific guidance for discussions on controversial or personal topics.

- Citing your sources: When we have academic discussions, please cite your sources to back up what you say. For the textbook or other course materials, list at least the title and page numbers. For online sources, include a web link.
- Backing up your work: Consider composing your academic posts in a word processor, where you can save your work, and then copying it into the Carmen discussion.

Academic Integrity Policy

See Descriptions of Major Course Assignments for specific guidelines about collaboration and academic integrity in the context of this online class.

Ohio State's Academic Integrity Policy

Academic integrity is essential to maintaining an environment that fosters excellence in teaching, research, and other educational and scholarly activities. Thus, The Ohio State University and the Committee on Academic Misconduct (COAM) expect that all students have read and understand the university's Code of Student Conduct (studentconduct.osu.edu) and that all students will complete all academic and scholarly assignments with fairness and honesty. Students must recognize that failure to follow the rules and guidelines established in the university's Code of Student Conduct and this syllabus may constitute "Academic Misconduct."

The Ohio State University's *Code of Student Conduct* (Section 3335-23-04) defines academic misconduct as: "Any activity that tends to compromise the academic integrity of the university or subvert the educational process." Examples of academic misconduct include (but are not limited to plagiarism), collusion (unauthorized collaboration), copying the work of another student, and possession of unauthorized materials during an examination. Ignorance of the university's *Code of Student Conduct* is never considered an excuse for academic misconduct, so I recommend that you review the *Code of Student Conduct* and, specifically, the sections dealing with academic misconduct.

If the instructors suspect that a student has committed academic misconduct in this course, they are obligated by university rules to report their suspicions to the Committee on Academic Misconduct. If COAM determines that you have violated the university's Code of Student Conduct (i.e., committed academic misconduct, the sanctions for the misconduct could include a failing grade in this course and suspension or dismissal from the university.
If you have any questions about the above policy or what constitutes academic misconduct in this course, please contact me.

Other sources of information on academic misconduct (integrity to which you can refer include:

- Committee on Academic Misconduct (go.osu.edu/coam)
- Ten Suggestions for Preserving Academic Integrity (go.osu.edu/ten-suggestions)
- Eight Cardinal Rules of Academic Integrity (go.osu.edu/cardinal-rules)

Copyright for Instructional Materials

The materials used in connection with this course may be subject to copyright protection and are only for the use of students officially enrolled in the course for the educational purposes associated with the course. Copyright law must be considered before copying, retaining, or disseminating materials outside of the course.

Creating an Environment Free from Harassment, Discrimination, and Sexual Misconduct

The Ohio State University is committed to building and maintaining a community to reflect diversity and to improve opportunities for all. All Buckeyes have the right to be free from harassment, discrimination, and sexual misconduct. Ohio State does not discriminate on the basis of age, ancestry, color, disability, ethnicity, gender, gender identity or expression, genetic information, HIV/AIDS status, military status, national origin, pregnancy (childbirth, false pregnancy, termination of pregnancy, or recovery therefrom), race, religion, sex, sexual orientation, or protected veteran status, or any other bases under the law, in its activities, academic programs, admission, and employment. Members of the university community also have the right to be free from all forms of sexual misconduct: sexual harassment, sexual assault, relationship violence, stalking, and sexual exploitation.

To report harassment, discrimination, sexual misconduct, or retaliation and/or seek confidential and non-confidential resources and supportive measures, contact the Office of Institutional Equity:

1. Online reporting form at equity.osu.edu,
2. Call 614-247-5838 or TTY 614-688-8605,
3. Or email equity@osu.edu

The university is committed to stopping sexual misconduct, preventing its recurrence, eliminating any hostile environment, and remedying its discriminatory effects. All university employees have reporting responsibilities to the Office of Institutional Equity to ensure the university can take appropriate action:

- All university employees, except those exempted by legal privilege of confidentiality or expressly identified as a confidential reporter, have an obligation to report incidents of sexual assault immediately.
- The following employees have an obligation to report all other forms of sexual misconduct as soon as practicable but at most within five workdays of becoming aware of such information: 1. Any human resource professional (HRP; 2. Anyone who supervises faculty, staff, students, or volunteers; 3. Chair/director; and 4. Faculty member.

Counseling and Consultation Services/Mental Health

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. No matter where you are engaged in learning, The Ohio State University's Student Life Counseling and Consultation Service (CCS) is here to support you. If you find yourself feeling isolated, anxious or overwhelmed, on-demand mental health resources (go.osu.edu/ccsondemand) are available. CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You can reach an on-call counselor when CCS is closed at 614- 292-5766**. 24-hour emergency help** is available through the 24/7 National Suicide Prevention Lifeline website (suicidepreventionlifeline.org) or by calling 1-800-273-8255(TALK). The Ohio State Wellness app (go.osu.edu/wellnessapp) is also a great resource.

For CFAES students they can contact David Wirt, wirt.9@osu.edu, is the CFAES embedded mental health counselor. He is available for new consultations and to establish routine care. To schedule with David, please call 614-292-5766. Students should mention their affiliation with CFAES when setting up a phone screening.

Accessibility Accommodations for Students with Disabilities

Requesting Accommodations

The university strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability including mental health, chronic or temporary medical conditions, please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services (SLDS. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. In light of the current pandemic, students seeking to request COVID-related accommodations may do so through the university's request process, managed by Student Life Disability Services.

Disability Services Contact Information

- Phone: 614-292-3307
- Website: slds.osu.edu
- Email: slds@osu.edu
- In person: Baker Hall 098, 113 W. 12th Avenue

Accessibility of Course Technology

This online course requires use of CarmenCanvas (Ohio State's learning management system and other online communication and multimedia tools. If you need additional services to use these technologies, please request accommodations as early as possible.

- CarmenCanvas accessibility (go.osu.edu/canvas-accessibility)
- Streaming audio and video
- CarmenZoom accessibility (go.osu.edu/zoom-accessibility)
- Overview of Accessibility at OSU and OSU Privacy

Specific course software's accessibility privacy statements

Vendor Accessibility	Vendor Privacy
(ArcGIS Desktop) ArcMap	ArcGIS Privacy
Carmen (Canvas accessibility)	Carmen (Canvas/Infrastructure Privacy
CarmenZoom accessibility	CarmenZoom Privacy
Adobe Connect (Carmen Connect Accessibility)	Adobe Privacy Policy
MediaSite Accessibility Statement	MediaSite Privacy
Microsoft Office Accessibility	Microsoft Office 365 Privacy

Proctorio Accessibility
Top Hat Accessibility

Proctorio Privacy
Top Hat Privacy

Course Schedule

Lab/ Week No.	Due Date	Laboratory/ Exercises	LLO
1		Data-Driven Resource Allocation	LLO 1.1 LLO 1.2 LLO 1.3 LLO 2.1
2		ArcGIS Applications in Sustainable Agricultural Production	LLO 1.3 LLO 2.1
3		Variable Rate Technology and Soil Health	LLO 1.1 LLO 1.2 LLO 1.3 LLO 2.1
4		Yield Monitoring for Improved Resources Utilization	LLO 1.1 LLO 1.2 LLO 1.3 LLO 2.1
5		Connected Machines and CAN Data	LLO 1.1 LLO 1.2 LLO 1.3 LLO 2.1
6		Data Infrastructure to Support Economic and Ecological Outcomes	LLO 1.1 LLO 1.2 LLO 1.3 LLO 2.1
7		Google Earth Applications in Production and Urban Agriculture	LLO 1.2 LLO 1.3 LLO 2.1
8		Remote Sensing for Sustainability	LLO 1.2 LLO 1.3 LLO 2.1
9		Drones for Environmental Monitoring and Sustainability	LLO 1.1 LLO 1.2 LLO 1.3 LLO 2.1
10		Spring Break	
11		Mapping, Modeling, and Data Analytics using ArcGIS	LLO 1.1 LLO 1.2 LLO 1.3 LLO 2.1
12		Introduction to R and On-Farm Research	LLO 1.1 LLO 1.2 LLO 1.3 LLO 2.1
13		Role of Big Data in Sustainability	LLO 1.1 LLO 1.2 LLO 1.3 LLO 2.1
14		Supply Chain Management and Sustainability	LLO 1.1 LLO 1.2 LLO 1.3 LLO 2.1
15		Blockchain Applications for Traceability in the Food Supply Chain	LLO 1.2 LLO 1.3 LLO 2.1

GE THEME COURSES

Overview

Courses that are accepted into the General Education (GE) Themes must meet two sets of Expected Learning Outcomes (ELOs): those common for all GE Themes and one set specific to the content of the Theme. This form begins with the criteria common to all themes and has expandable sections relating to each specific theme.

A course may be accepted into more than one Theme if the ELOs for each theme are met. Courses seeing approval for multiple Themes will complete a submission document for each theme. Courses seeking approval as a 4-credit, Integrative Practices course need to complete a similar submission form for the chosen practice. It may be helpful to consult your Director of Undergraduate Studies or appropriate support staff person as you develop and submit your course.

Please enter text in the boxes to describe how your class will meet the ELOs of the Theme to which it applies. Please use language that is clear and concise and that colleagues outside of your discipline will be able to follow. You are encouraged to refer specifically to the syllabus submitted for the course, since the reviewers will also have that document Because this document will be used in the course review and approval process, you should be *as specific as possible*, listing concrete activities, specific theories, names of scholars, titles of textbooks etc.

Course subject & number AGSYSMT 3585/HCS 3585

General Expectations of All Themes

GOAL 1: Successful students will analyze an important topic or idea at a more advanced and in-depth level than the foundations.

Please briefly identify the ways in which this course represents an advanced study of the focal theme. In this context, "advanced" refers to courses that are e.g., synthetic, rely on research or cutting-edge findings, or deeply engage with the subject matter, among other possibilities. *(50-500 words)*

AGSYSMT 3585/HCS 3585 has a prerequisite of a Foundational Data Analysis course ("HCS 2260, ANIMSCI 2260, or any entry level statistics course approved by the instructor"). AGSYSMT 3585/HCS 3585 course will be using advanced data analysis and interpretation tools in the context of agricultural and food systems. This is accomplished by using software packages such as ArcGIS, R, Excel, SAS, Tableau, and Minitab.

Course subject & number AGSYSMT 3585/HCS 3585

ELO 1.1 Engage in critical and logical thinking about the topic or idea of the theme. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. (50-700 words)

Goals 3-5 and Lab Goals require critical and logical thinking related to sustainable agricultural and food systems. In Goal 3/Lab Goal 3, students will learn and interpret data-driven technologies, and effective ways to visualize and communicate the outcomes of sustainable management of food, fuel, and fiber production, to the workforce and society. In Goal 4/Lab Goal 4, students will understand the economic and environmental benefits of data driven agriculture and food systems for the producer, consumer, and society. In Goal 5 students will understand how data generated from various technologies is collated and analyzed to produce actionable management information (e.g., Enterprise Agriculture) to make agriculture and food systems more sustainable.

ELO 1.2 Engage in an advanced, in-depth, scholarly exploration of the topic or idea of the theme. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Students will gain experience in advanced technologies described in Course Goal 2/Lab Goal 2; for example:
a) (2.1, LLO 2.1) Compare technologies used in data driven agriculture and food systems as they impact sustainability, environmental quality, and society;
b) (2.2, LLO 2.2) precision agriculture technologies (e.g., GNSS, VRT, yield monitoring, and remote sensing) in edge and cloud computing for food, fuel, and fiber production;
c) (2.3, LLO 2.3) geospatial technologies, intelligent networks, RFID, blockchain, data mining, applied IoT, and artificial intelligence used in data driven agriculture and food systems to achieve sustainability and to improve environmental quality;
d) (2.4, LLO 2.4) on-farm research design and protocols that influence sustainability, environmental quality; and
e) (2.5, LLO 2.5) automation of food, fuel, and fiber production, processing, and distribution systems;
f) (2.6) AI is being used in data driven agriculture and food systems to make food, fiber, and fuel production more sustainable;

Course subject & number AGSYSMT 3585/HCS 3585

GOAL 2: Successful students will integrate approaches to the theme by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or to work they have done in previous classes and that they anticipate doing in future.

ELO 2.1 Identify, describe, and synthesize approaches or experiences as they apply to the theme. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Students will draw on their own practical experiences: such as internships, work, or other personal experiences related to their major, and will be able to apply these to interpretation and application of data-driven technologies in the context of sustainable agricultural production. In Course Goal 4 and Lab Goal 4, students will examine how data-driven agriculture and food systems improve profitability while simultaneously improving environmental quality to benefit society. In Course Goal 5, students will model data flow and outputs in enterprise agriculture for their impact on sustainability, environmental quality, and benefits to society.

ELO 2.2 Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

All students begin the course with some level of understanding of Biobased products such as food, fuel, and fiber; as well as some understanding of environmental issues such as climate, air, water, and nutrient pollution. Goal 4/Lab Goal 4 and the related learning outcome allows students to develop this basic knowledge into formalized, qualitative analysis and interpretation. Students will complete 7 assignments (6 Homeworks and the Technical Feasibility Study), in which they relate and apply their own experiences to the HWK subject matter. Guest lectures are accompanied by a reflective report, which elicits student's views, and critiques the expert's presentation in relation to their impact on them as an individual.

Course subject & number AGSYSMT 3585/HCS 3585

Specific Expectations of Courses in Sustainability

GOAL 1: Students analyze and explain how social and natural systems function, interact, and evolve over time; how human wellbeing depends on these interactions; how actions have impacts on subsequent generations and societies globally; and how human values, behaviors, and institutions impact multi-faceted, potential solutions across time.

1.1 Describe elements of the fundamental dependence of humans on Earth and environmental systems and on the resilience of these systems. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Goal 2/Lab Goal 2 describes experiences with modern knowledge-based food/fuel/fiber production technologies such as (2.2, LLO 2.2) precision farming, (2.3, LLO 2.3) geospatial technologies, intelligent networks, RFID, blockchain, data mining, applied IoT, 2.6 artificial Intelligence, (2.4, LLO 2.4) on-farm research design and protocols and (2.5, LLO 2.5) automation of agricultural and livestock production. Course materials develop the relationship between these technologies, processing, and distribution systems and sustainability, and their effects on the environment and society.

Course subject & number AGSYSMT 3585/HCS 3585

1.2 Describe, analyze and critique the roles and impacts of human activity and technology on both human society and the natural world, in the past, currently, and in the future. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Goals 4/Lab Goal 4 and Goal 5: integrate and apply fundamental knowledge (Goal 1/Lab Goal1) and analytical technologies (Goal 2/Lab Goal 2) to quantitative interpretation of the allocation (management) of resources such as plant/animal genetics, fertilizer, crop protection, production practices, etc. within a production system; to optimize the output of food, fuel, and fiber to use at local, national, and international scales.

1.3 Devise informed and meaningful responses to problems and arguments in the area of sustainability based on the interpretation of appropriate evidence and an explicit statement of values. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

This course uses modern principles, theories, and methods of data-driven agriculture and food systems (Goal 1/Lab Goal 1) and quantitative technologies (Goal 2, Lab Goal 2) to develop and evaluate informed and meaningful responses to resource allocation (plant/animal genetics, fertilizer, crop protection, production practices, etc.) within a production system (farm) with the objective of sustainable production systems. Sustainability is defined as the ability to produce a product that is efficient and profitable; that minimizes the impact to the land, air, and water; and that enhances the quality of life for local, national, and international communities.

Interdisciplinary Team-Taught Course Inventory

Overview

The GE allows students to take a single, 4+ credit course to satisfy a particular GE Theme requirement if that course includes key practices that are recognized as integrative and high impact. Courses seeking one of these designations need to provide a completed Integrative Practices Inventory at the time of course submission. This will be evaluated with the rest of the course materials (syllabus, Theme Course submission document, etc). Approved Integrative Practices courses will need to participate in assessment both for their Theme category and for their integrative practice.

Please enter text in the boxes below to describe how your class will meet the expectations of Interdisciplinary Team-Taught courses. It may be helpful to consult the Description & Expectations document for this pedagogical practice or to consult your Director of Undergraduate Studies or appropriate support staff person as you complete this Inventory and submit your course.

Please use language that is clear and concise and that colleagues outside of your discipline will be able to follow. You are encouraged to refer specifically to the syllabus submitted for the course, since the reviewers will also have that document Because this document will be used in the course review and approval process, you should be *as specific as possible*, listing concrete activities, specific theories, names of scholars, titles of textbooks etc.

Accessibility

If you have a disability and have trouble accessing this document or need to receive it in another format, please reach out to Meg Daly at daly.66@osu.edu or call 614-247-8412.

Pedagogical Practices for Interdisciplinary Team-Taught Courses

Course subject & number: AGSYSMT/HCS3585 and AGSYSMT/HCS 3586

Performance expectations set at appropriately high levels (e.g. Students investigate large, complex problems from multiple disciplinary perspectives). Please link this expectation to the course goals, topics and activities and indicate *specific* activities/assignments through which it will be met. *(50-500 words)*

Students will investigate large complex problems from multiple disciplinary perspectives like Carbon Cycling and Sequestration, Climate Smart Agriculture, Food Production Optimization and Efficiency, Food Safety, Food Security, Nitrogen and Phosphorus Cycling and Use Efficiency, and Water Quality and Quantity which forms foundation for Sustainability in Digital Agriculture. Digital agriculture technologies produce large scale data sets. Large scale complex problems are used as examples throughout the entire course centered on food system operations (small holder vs corporate) that have an impact on sustainability. Laboratories will provide students an opportunity to work with these large scale complex issues. Labs: L1- Data-Driven Resource Allocation, L3- Variable Rate Technology and Soil Health, L4- Yield Monitoring for Improved Resources Utilization, L5- Connected Machines and CAN Data, L6- Data Infrastructure to Support Economic and Ecological Outcomes, L8- Remote Sensing for Sustainability, L9- Drones for Environmental Monitoring and Sustainability, L11- Introduction to R and On-Farm Research, L12- Role of Big Data in Sustainability, L14- Blockchain Applications for Traceability in the Food Supply Chain.

The Guest Speaker Reflections address how technology impacts food, fuel, fiber, energy production practices, logistics, careers (current and future), profitability, sustainability, the environmental issues, and effective way to communicate with stakeholders and experts. The Technical Feasibility and Sustainability Study focuses on the implication of a new technology or practices on sustainability and its potential for adoption. Students will provide a thoughtful analysis of how technology will impact sustainability, and role of private sector in developing new sustainable technologies based on a review of the existing literature and/or other external sources of information.

Significant investment of time and effort by students over an extended period of time (e.g., engage the issue iteratively, analyzing with various lenses and seeking to construct an integrative synthesis). Please link this expectation to the course goals, topics and activities and indicate *specific* activities/assignments through which it will be met. *(50-500 words)*

The 1) Technical Feasibility and Sustainability Study, 2) Guest Speaker Reflections, and 3) Laboratory Activities provide students with opportunities to revisit, analyze, and synthesize the material taught in the course. Students can compare their knowledge and understand the complex issues of data driven food, fuel, and fiber production systems and reflect on how their knowledge and understanding has changed over the semester. Each of the three above activities span the semester and the students have the option to pursue their interest in sustainability. The Technical Feasibility and Sustainability Study looks at adopting new data-driven technologies and production practices. Guest Speaker Reflections provides students with the current state of data driven food systems and possible career opportunities in the area of sustainable digital agriculture. Planned laboratory activities provide hands on experience to the students on the topics covered in AGSYSMT/HCS 3585.

Interactions with faculty and peers about substantive matters including regular, meaningful faculty mentoring and peer support about conducting interdisciplinary inquiry. Please link this expectation to the course goals, topics and activities and indicate *specific* activities/assignments through which it will be met. *(50-500 words)*

This course is taught by a multi-disciplinary team comprising of four faculty from two departments (Food, Agricultural and Biological Engineering [FABE] and Horticulture and Crop Science [HCS]). Faculty in the College of Food, Agricultural, and Environmental Sciences (CFAES) have a philosophy of close interaction, faculty mentoring, and peer support of students that will continue in this interdisciplinary course.

The course was designed by and will be team taught. Feedback will be given to students in a timely manner on the Homeworks, Lab Reports, and Guest Speaker Reflections. Beyond feedback on these, in addition to office hours, students will have an opportunity to interact with instructors daily (via Carmen or OSU email). After the exams and quizzes, instructors will also provide feedback to the students. Complex sustainability concepts covered in this course like water quality, managing global nitrogen cycle, climate change and others will encourage students to interact with each other, with instructors, and guest speakers to get a better understanding of the concepts. Self-Checks will be incorporated in the course by creating sample Question Banks for the Lecture topics which will allow the students to test their understanding of concepts and topics covered in the course in a non-graded format. This will encourage students to reflect (check) their understanding of sustainability concepts.

Students will get frequent, timely, and constructive feedback on their work, scaffolding multiple disciplinary perspectives and integrative synthesis to build over time. Please link this expectation to the course goals, topics and activities and indicate *specific* activities/assignments through which it will be met. *(50-500 words)*

We will give six quizzes [one every two weeks] and seven homework assignments [one every two weeks] during the semester. In addition, instructors will provide timely and constructive feedback to students on Technical Feasibility and Sustainability Study [six sections with deadlines], quizzes, homeworks, and the guest speaker reflections during the semester. The quizzes will be graded by Carmen providing immediate feedback to the students. The quiz questions will also be used for the self-checks allowing students to review their knowledge. The homeworks will be returned in the following week with instructor's feedback. The technical feasibility and sustainability study will be developed by the students over the entire semester. Students will also incorporate information and ideas from the guest speaker reflections into the technical feasibility and sustainability study.

Periodic, structured opportunities to reflect and integrate learning (e. g. students should work to integrate their insights and construct a more comprehensive perspective on the issue). Please link this expectation to the course goals, topics and activities and indicate *specific* activities/assignments through which it will be met. *(50-500 words)*

Reflections and integrated learning are key components of the Laboratory Activities, Guest Speaker Reflections, and the Technical Feasibility and Sustainability Study. Questions are designed to elicit students' views, their critique of the presentations, and classroom activities. Students reflect on and critique their impact on them as an individual and their potential career opportunities. In addition, they will reflect on their impact on food systems, the environment, and the society at local, national, and global scales. The activities (Labs, Guest Speakers, and Feasibility Study) are planned throughout the semester. The instructors will provide feedback on the activities to the students encouraging them to develop more comprehensive views on sustainable digital agriculture.

Opportunities to discover relevance of learning through real-world applications and the integration of course content to contemporary global issues and contexts. Please link this expectation to the course goals, topics and activities and indicate *specific* activities/assignments through which it will be met. *(50-500 words)*

Real-world learning has been incorporated into Lecture topics, Guest Speaker Reflections, Laboratory Activities, and Technical Feasibility and Sustainability Study. Lecture topics in the course encompasses the following issues: environmental impact of different production practices, food security/safety/traceability, climate change/extreme weather impacts, sustainability, carbon sequestration, viability of rural communities (profit, labor availability, etc.), and water quality and quantity. The Guest Speakers/invited speakers are current experts who will speak about their careers and opportunities in sustainable digital agriculture, future of food systems, and the current sustainability issues. The Laboratory Activities are hands on, but they also allow the students to incorporate the content/knowledge from the Guest Speakers and apply it to that exercise. The Technical Feasibility and Sustainability Study provides an opportunity for the students to integrate course materials, faculty feedback, and expert opinions.

Public Demonstration of competence, such as a significant public communication of their integrative analysis of the issue. Please link this expectation to the course goals, topics and activities and indicate *specific* activities/assignments through which it will be met. *(50-500 words)*

Technical Feasibility and Sustainability Study presentation - Each student will create a 90 to 120 second video based on their Technical Feasibility and Sustainability Study. The video will be uploaded to a Carmen Discussion area. Other students will review the posted video and make their comments via Discussion. The student who created the video must respond to comments and questions

Students will also make a live presentation in the class with Q&A to follow after their presentation. The instructors and other students will participate. The presenter will be expected to lead the Q&A.

The instructor will provide a detailed presentation guideline. This will help students to plan their presentation.

Experiences with diversity wherein students demonstrate intercultural competence and empathy with people and worldview frameworks that may differ from their own. Please link this expectation to the course goals, topics and activities and indicate *specific* activities/assignments through which it will be met. *(50-500 words)*

Data-driven agriculture and food systems have global scope. Agriculture can represent different cultures: such as i) small holder vs corporate, ii) urban rural interface, iii) organic vs conventional, iv) "Plain clothes cultures", and v) USA vs international. Students investigate these viewpoints within the context of data-driven agriculture and food systems. Students consider how new and current practices or technologies impact various populations and cultures. They will be encouraged to consider Technical Feasibility and Sustainability Study topics from other cultures/regions or how topics are influenced by other cultures. Homeworks (1, 3, 4, and 7) have international components - social media or technology developed for and in conjunction with people and worldview frameworks.

Explicit and intentional efforts to promote inclusivity and a sense of belonging and safety for students, e.g. universal design principles, culturally responsive pedagogy, structured development of cultural self-awareness. Please link this expectation to the course goals, topics and activities and indicate *specific* activities/assignments through which it will be met. *(50-500 words)*

The lecture topics in this course are designed to encompass different student populations. All students, including those familiar with agriculture and food systems, engineering, agronomy, horticulture, and controlled environment agriculture, as well as students with more diverse backgrounds and experience (e.g. sustainability, environment, social issues) will find a place in the course. Each Homework is designed to expose students to cultures outside their experiences. Some technologies are developed outside of the student's own culture. As part of the homeworks, students are asked to consider how their technology of choice impacts their culture and other cultures via online communication/discussion.

Homeworks (1, 3, 4, and 7) expose students to other ideas, cultures, methods of communication all within the university environment in a structured methodology. Feedback from their classmates and faculty provide students with a safe environment to adjust their writing reflecting different views and their awareness of other people, cultures, and methodologies.

Clear plans to promote this course to a diverse student body and increase enrollment of typically underserved populations of students. Please link this expectation to the course goals, topics and activities and indicate *specific* activities/assignments through which it will be met. *(50-500 words)*

This course is open for enrollment to students from all backgrounds, views, and cultures. Diverse views will be respected and encouraged. The teaching team includes instructors from Brazil, New Zealand, and USA. Guest Speakers will be industry professionals from diverse backgrounds who bring their own work/cultural experiences to the classroom.