Proposed Course Layout
MS in Climate Smart Agriculture (CSA)
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University

Semester-1 (January-June)

A. Compulsory Courses (8 Cr. Hr.)

Course No.	Title of the Courses	Cr. Hr.	Marks
CSA 5101	Global Climate Change and CSA	2	100
CSA 5102	Climate Change Impact Assessment	2	100
CSA 5103	Crop Modeling	2	100
CSA 5104	Soil, Water and Environment Management	2	100

B. Elective Courses (At least 4 Cr. Hr)

Course No.	Title of the Courses	Cr. Hr.	Marks
CSA 5105	Coastal Ecosystems	2	100
CSA 5106	Remote Sensing and GIS for CSA	2	100
CSA 5107	Gender and Social Inclusion in CSA	2	100
CSA 5108	Farming Systems	2	100

C. CSA 5301: Research Work	3	Satisfactory/ Unsatisfactory

Semester-2 (July- December)

A. Compulsory Courses (8 Cr. Hr.)

Course No.	Title of the Courses	Cr. Hr.	Marks
CSA 5201	CSA Technology Development	2	100
CSA 5202	Stress Management for CSA	2	100
CSA 5203	Research Methodology	2	100
CSA 5204	Climate Information Services	2	100

B. Elective Courses (At least 4 Cr. Hr.*)

Course No.	Title of the Courses	Cr. Hr.	Marks
CSA 5205	Mitigation of Agro-emissions	2	100
CSA 5206	Climate Change and Agricultural Policy	2	100
CSA 5207	Data Management	2	100
CSA 5208	Agriculture in Changing Climate	2	100

C. CSA 5301: Research Work	3	Satisfactory/ Unsatisfactory

Semeser-3 (Thesis Semester)

Course No.	Title of the Courses	Cr. Hr.	Marks
CSA 5301	Research	2	Satisfactory/ Unsatisfactory
CSA 5302	Thesis Evaluation	5	100
CSA 5303	Thesis Defense	3	100

Grand Total 40 Cr. Hr.

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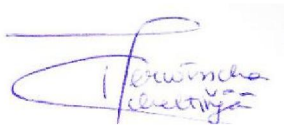

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MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course Code: CSA 5101
Course Title: Global Climate Change and Climate Smart Agriculture
Credit Hour: 2
Student Level: Level-5, Semester-1

Rationale

Human activity around the world has caused climate change, resulting in increased temperatures, altered and increasingly extreme weather patterns, rising of sea levels and the collapse of natural ecosystems, as the current speed of change is such that many forms of life have difficulty to adapt). Agricultural practices and especially rainfed agriculture, which is the most common form of agriculture in Bangladesh, can be affected by climate change enormously. Part of the solutions can be found in the application of Climate Smart Agriculture.

In this course, students learn about human induced climate change and its effects, especially on agricultural activities, as well as possible solutions, in particular Climate Smart Agriculture.

Objectives

At the end of this course, students will have gained sufficient knowledge on:

(i) The causes and effects of human induced climate change
(ii) Effects of climate change on agricultural activities (global)
(iii) Effects of climate change on agricultural activities (Bangladesh)
(iv) The principles of Climate Smart Agriculture as solution to CC
(v) Examples of CSA – both global and local

Learning Outcomes	Course Content	Teaching-Strategy	Assessment Strategy
-Define human induced climate change - Knowledge on causes and effects - Being able to name examples of climate change effects -Knowledge on solutions to climate change	**(i) Global Climate Change**: Concept of human induced climate change, specific causes, effects (global/ abroad, and for southern Bangladesh specifically) and solutions.	Lecture, Student assignment Presentation, Group Discussion	-Essay -Checklist
-Define -Describe -Analyze	**(ii) Effects of Climate Change on Agriculture (global)**:	Lecture, Reading assignment,	-Short Answer -Essay

		Group discussion	-Completion
-Define -Analyze -Prepare -Design	**(iii) Effects of Climate Change on Agriculture in Bangladesh**:	Lecture, group assignment, group discussion	-Short Answer -Practical exam -Peer rating
-Define -Evaluate	**(iv) Climate Smart Agriculture**: Concept and definition, history, major components, benefits and limitations	Lecture Discussion QA	-Short Answer -Essay
	(v) Application of Climate Smart Agriculture – global and local: …	Lecture	

Recommended Books and Publications

International Panel on Climate Change.

The Physical Science Basis, Summary for Policy Makers (IPCC, 2007)

FAO source book http://www.fao.org/climate-smart-agriculture/en/

CCAFS (CGIAR) - https://ccafs.cgiar.org First document to name 'Climate Smarte Agriculture', 2010 (paper by the Food and Agriculture Organization of the United Nations)

Aryal et al. (2020). Major Climate risks and adaptation strategies of smallholder framers in Coastal Bangladesh. https://unfccc.int/sites/default/files/resource/TNC%20Report%20%28Low%20Resolation%29%2003_01_2019.pdf

Schneider, P., Asch, F. Rice production and food security in Asian Mega deltas—A review on characteristics, vulnerabilities and agricultural adaptation options to cope with climate change (2020) Journal of Agronomy and Crop Science, 206 (4), pp. 491-503.

Hasan, M.K., Kumar, L. Perceived farm -level climatic impacts on coastal agricultural productivity in Bangladesh (2020) Climatic Change, 161 (4), pp. 617-636.

Jehan, I., Atta-ur-Rahman, Waqas, T. Assessment of meteorological drought and trend detection in Khyber Pakhtunkhwa, Pakistan (2020) Arabian Journal of Geosciences, 13 (16), art. no. 765,

Islam, M.A., Warwick, N., Koech, R., Amin, M.N., Lobry de Bruyn, L. The importance of farmers' perceptions of salinity and adaptation strategies for ensuring food security:

Evidence from the coastal rice growing areas of Bangladesh (2020) Science of the Total Environment, 727, art. no. 138674, .

Islam, R., Islam, M.M., Islam, M.N., Islam, M.N., Sen, S., Faisal, R.K. Climate change adaptation strategies: a prospect toward crop modelling and food security management (2020) Modeling Earth Systems and Environment, 6 (2), pp. 769-777. Cited 2 times.

Hasan, M.K., Kumar, L. Meteorological data and farmers' perception of coastal climate in Bangladesh (2020) Science of the Total Environment, 704, art. no. 135384

Akter, S., Ahmed, K.R. Insight and explore farming adaptation measures to support sustainable development goal 2 in the southwest coastal region of Bangladesh (2020) Environment, Development and Sustainability

Islam, A.R.M.T., Shill, B.K., Salam, R., Siddik, M.N.A., Patwary, M.A. Insight into farmers' agricultural adaptive strategy to climate change in northern Bangladesh (2020) Environment, Development and Sustainability

Hoque, M.Z., Cui, S., Xu, L., Islam, I., Tang, J., Ding, S. Assessing agricultural livelihood vulnerability to climate change in coastal Bangladesh (2019) International Journal of Environmental Research and Public Health, 16 (22)

Roy, R., Gain, A.K., Samat, N., Hurlbert, M., Tan, M.L., Chan, N.W. Resilience of coastal agricultural systems in Bangladesh: Assessment for agroecosystem stewardship strategies (2019) Ecological Indicators, 106, art. no. 105525

MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course Code: CSA 5102
Course Title: Climate Change Impact Assessment
Credit Hour: 2
Student Level: Level-5, Semester-1

Rationale: To reduce the vulnerability of agriculture to future climate change it is important to understand how students can assess the potential impacts of climate change on agriculture.

Objectives: At the end of this course, the students will gain considerable-

i) Knowledge of the potential impact of climate change on crop production, livestock, farming systems, and the agricultural sector of Bangladesh.
ii) Knowledge on how to perform a climate change impact assessment.
iii) Knowledge and the main sources of uncertainty in future climate change impacts.

Learning Outcomes	**Course Content**	**Teaching-Learning Strategy**	**Assessment Strategy**
-Understand how CO2, Temperature and precipitation change affect crop production -Understand which methods can be used to study impact on crop production - Analyse climate change impacts on plant growth	**Climate change impacts on crop production**: - Explanation of the how elevated CO2, higher temperatures affect	Lecture Reading assignment QA	-Short Answer -Essay
-Understand how climate change affects livestock. -Understand which methods can be used to study climate change impact on crop production -	**Climate Change Impacts on Livestock**: Concept of management, administration, extension administration, principles of extension administration; elements of management function: planning, organizing, staffing, directing, leading, controlling, coordinating, reporting, budgeting; Management problem in organization; Supervision, Increasing efficiency in extension administration.	Lecture Reading assignment QA	-Short Answer -Essay -Completion
	Climate change data and models for Impact assessment: Explain which	Lecture	-Short Answer

-Describe the main data sets available for climate change impacts assessment - perform a simple bias correction -assess the uncertainty of future climate change impacts	data are available and needed for climate change impact assessment - assignments on trend analyses of historical weather data - assignment on simple bias correction - assignment on analyzing and presenting uncertainty in future projections of temperature and rainfall.	Computer practical Discussion	-True-False -Matching term
-design a climate change impacts assessment on farming systems - analyse and presents the main climate change impacts of a farming system - describe the main uncertainties of future climate change impacts on farming systems.	**Perform a climate change impact assessment on a simple farming system** Group assignment were every group makes a simple assessment of climate change impacts of a particular farming system	Group assignment Presentation Report	-Short Answer -Completion -Practical exam -Peer rating

Recommended Books and Periodicals

Amjath-Babu, T.S., Krupnik, T.J., Aravindakshan, S., Arshad, M. and Kaechele, H., 2016. Climate change and indicators of probable shifts in the consumption portfolios of dryland farmers in Sub-Saharan Africa: Implications for policy. Ecological indicators, 67, pp.830-838.

Arshad, M., Amjath-Babu, T. S., Aravindakshan, S., Krupnik, T. J., Toussaint, V., Kächele, H., & Müller, K. 2018. Climatic variability and thermal stress in Pakistan's rice and wheat systems: A stochastic frontier and quantile regression analysis of economic efficiency. Ecological indicators, 89, 496-506.

Arshad, M., Amjath-Babu, T.S., Krupnik, T.J., Aravindakshan, S., Abbas, A., Kächele, H. and Müller, K., 2017. Climate variability and yield risk in South Asia's rice–wheat systems: emerging evidence from Pakistan. Paddy and water environment, 15(2), pp.249-261.

Bhuiyan, M.H. 1999. *Extension Organization and Management* Dhaka: Gulshan Publication.

Bhuiyan, M.H. and Miah, M.A.M. 1998. *Samprasaran Monobiggan(Extension Psychology)*. KishiLekak Forum, Dhaka: Colourline Printers.

Bhuyan, M. H., Miah, M. A. M., Akanda, M. G. R and Bashar, M. A. 2014. *Agricultural Extension Education.* g-Science Implementation and Publication, Dhaka.

DAE. 1999. *Agricultural Extension Manual*. Department of Agricultural Extesion> Ministry of Agriculture . Govt. of the Peoples Republic of Bangladesh, Dhaka.

Dahama, O.P. and Bhatnagar, O. P. 1980. *Education and Communication for Development* . 2nd edn. New Delhi: Oxford and IBH Publishing Co.Pvt.Ltd.

Hasanullah, M. 1995. *Managing Extension Services*. Dhaka:University Press Limited.

Kashem, M.A. 2004. *Fundamentals of Extension Education*. Mymensingh: Lima Printing Press.

Mutabazi, K.D., Amjath-Babu, T.S. and Sieber, S., 2015. Influence of livelihood resources on adaptive strategies to enhance climatic resilience of farm households in Morogoro, Tanzania: an indicator-based analysis. Regional environmental change, 15(7), pp.1259-1268.

Kelsey, L.D. amd Hearne, C.C. 1963. Cooperative Extension Work. 3rd ed. Comstock Publishing Associates, New York: Ithaca

Rao, P.L. 2008. *Enriching Human Capital through Training and Development*. New Delhi: Excel Books.

Ray, G.L. 2008. *Extension Communication and Management*. 7th edn. Kalyani Publishers, New Delhi.

Robins, S. P. 1999. *Organizational Behavior*. 8th ed. New Delhi: Prentice-Hall Pvt. Ltd.

Sahu, R.K. 2006. *Training for Development*. New Delhi: Excel Books.

MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
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Course Profile

Course code: CSA 5103
Course title: Crop Modelling
Credit hour: 2
Level of Student: Level-5, Semester-1

Rationale:
Agricultural systems in coastal Bangladesh are vulnerable for climate change. Without adaptation to these changing conditions, food production could significantly reduce, affecting food security. During this course, students will learn how to quantify the effects of climate change on crop production. First, students will analyse how changes in weather, including temperature extremes and rainfall distribution, will impact crop yield using a crop growth simulation model. The analyses will be performed in the standard WOFOST model (/), and to be more specific, for the practical Jupyter notebooks will be used (https://github.com/ajwdewit/pcse_notebooks). In the second phase of the course, we will focus on rising sea levels and salinization. The students will learn how to quantify salt accumulation in the soil and its effect on agricultural crops with the Swap-Wofost model.

Objectives: At the end of this course, the students will

(i) be able to explain the effects of climate change on agricultural production coastal Bangladesh;
(ii) be aware of existing adaptation practices and be able to explain how they may enhance agricultural production
(iii) simulate crop growth in the standard WOFOST model and the SWAP-WOFOST model;
(iv) use crop simulation models to evaluate the effects of both climate change and adaptation measures on agricultural production;
(v) interpret model results and uncertainties
(vi) visualize and communicate model results

Learning objective	Course content	Teaching Learning Strategy	Assessment tools
Describe the essential processes that are important in crop-climate interactions	Eco-physiological understanding of environmental (climate) effects on plants and crop production, including: 1) temperature, 2) water and 3) nutrients	Lecture Reading Q&A	Exam
Describe diverse adaptation options to minimize	Adaptation strategies in Bangladesh and abroad: crop choice, soil- and water management. Linking adaptation strategies	Lecture Reading Q&A	Exam

production risks in various farming contexts	to various farming- and environmental contexts.		
Analyse the impacts of climate variability and change on agricultural production systems	Simulate crop growth in the standard WOFOST model and the SWAP-WOFOST model. Evaluate the direct effects of climate change (temperature, precipitation extremes, etc.) with the standard WOFOST model. Analyse the indirect climate effects (salinization) with the SWAP-WOFOST model.	Computer practical	Assignment Exam
Analyse the effects of various adaptation measures on agricultural production systems	Incorporate adaptation measures in the crop growth simulation models. Interpret the results and the uncertainties to evaluate the effectiveness of these measures in various contexts.	Computer practical	Assignment Exam
Visualize and communicate model results	Create a scientific poster from the results of one of the assignments. Visualize the results to make them attractive and easy to understand.	Lecture Computer practical	Poster presentation

References:

https://wofost.readthedocs.io/en/latest/_downloads/3c9337e7ab23207e5a5819689c79a889/WOFOST_system_description.pdf

Diepen, C.A., van, Wolf, J. and Keulen, H., van, 1989. WOFOST: a simulation model of crop production. Soil Use and Management, 5: 16-24.

Timsina, J., Wolf, J., Guilpart, N., Van Bussel, L.G.J., Grassini, P., Van Wart, J., Hossain, A., Rashid, H., Islam, S. and Van Ittersum, M.K., 2018. Can Bangladesh produce enough cereals to meet future demand?. Agricultural systems, 163, pp.36-44.

Wit, Allard de, Hendrik Boogaard, DavideFumagalli, Sander Janssen, Rob Knapen, Daniel van Kraalingen, Iwan Supit, Raymond van der Wijngaart, and Kees van Diepen. "25 Years of the WOFOST Cropping Systems Model." Agricultural Systems 168 (January 1, 2019): 154–67.

https://www.wur.nl/en/Research-Results/Research-Institutes/Environmental-Research/Facilities-Tools/Software-models-and-databases/WOFOST.htm

https://www.wur.nl/en/Publication-details.htm?publicationId=publication-way-353232393830

https://pcse.readthedocs.io/en/stable/

MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course Code: CSA 5104
Course Title: Soil, Water and Environment Management
Credit Hour: 2
Student Level: Level-5, Semester – 1

Rationale:
Sustainable farming under changing climate is one of the stressing needs for ensuring food security of the people across the globe. For successful production of crops requires an in-depth understanding of agricultural resources and its efficient uses. The basic natural resources are soil, water and environment (light, air etc.). Therefore, students intended to follow MS in CSA should get sufficient theoretical and practical background on soil processes, nutrient dynamics in soils and nutrient budget while a comprehensive understanding on water management at crop level is equally important. In addition, CSA students need to study the efficient harvesting of environmental resources including solar radiation.

Course logistics: The course consists of 18 hours of classroom lectures, workshops, supervised practical assignments and a final exam. The remaining hours are for self-study and online testing. Course material will be made available on the digital learning platform.

Objectives: After completion of the course, the students should be able to

(i) Understand, discuss and synthesize the soil processes and functions for successful crop production.
(ii) Understand water uptake and its uses by plants, and calculate the crop water requirement.
(iii) Understand, synthesize and apply the theories related to solar radiation harvesting by plants.
(iv) Discuss the impacts of agricultural activities on soil, water and environment.
(v) Design crops or cropping for a particular situation through applying theoretical and practical knowledge of crop-soil-environment interactions.

Learning Outcomes	**Course Content**	**Teaching-Learning Strategy**	**Assessment Strategy**
Understanding soil properties, particles and their interactions in Soils	**1.Soil processes and interactions** • Physical, chemical and biological properties of soils • Soil minerals and its role in nutrient cycling • Soil texture, structure and density	Lecture Reading Assignment Presentation QA	Exam

	• Soil water and its availability to plants, soil moisture content, retention (pF curve) and flow • Soil pH, cation exchange capacity and base saturation • Soil organic matter, mineralization and its role in nutrient cycling • Soil biology- soil microorganisms and nutrient cycling • Soil salinity aspects		
Understanding nutrient dynamics and pesticides in soils	**2. Nutrient cycling and budget in soils** • Speciation of nutrients in soil • Nutrient adsorption models (Langmuir and Freundlich) • Nutrient uptake processes (Mass flow, root interception and diffusion) and models • N, P and K cycles • Nutrient budgeting/Nutrient use efficiency Calculations for different crops • Nutrient stoichiometry • Diagnosis of nutrient deficiency and toxicity in plants • Pesticide soil processes • Leaching of nutrients and pesticides	Lecture Reading Assignment Presentation QA Practical: A short experiment to examine nutrient dynamics in soil	Exam
Understanding plant water relationships	**3. Plant water relationship** • Water in soils and its uptake in plants • Water use efficiency in relation to plant/canopy architecture and weather conditions (evapotranspiration) • Crop water requirement and crop factors • Role of groundwater, capillary rise, unsaturated zone • Fresh water sources • Irrigation scheduling		Assignment Exam
Understanding plant-environment interactions	**4. Plant-environment interactions** • Solar radiation and its interception by plants • Soil temperature • Efficiency of solar radiation harvesting in relation to crop/canopy architecture, soil resources, water resource • Crop performance/management under different wind/air supply/flow		

	• Crop scheduling using heat unit calculation		
Increasing the synthesizing capacity of students for designing of crops/cropping	**5. Crop-environment interactions** • Designing crops/cropping under different resources conditions • Using the FAO AquaCrop model to model crop water demands and crop yields	Computer workshop	Assignment Presentation

Recommended Books and Periodicals

1. Ali, H., 2011. Practices of Irrigation & On-farm Water Management: Volume 2. Springer Science & Business Media.
2. Allen, R.G., Pereira, L.S., Raes, D., Smith, M., 2000. Crop Evapotranspiration (guidelines for computing crop water requirements). FAO - Food and Agriculture Organization of the United Nations, Rome, Italy.
3. Bal et al. 2018. Advances in Crop Environment Interactions. Springer Nature.
4. Brammer H. 1996. The Geography of the Soils of Bangladesh. University Press
5. FAO, 2018. AquaCrop training handbooks: Book II: Running AquaCrop. Food & Agriculture Org.
6. Kirkham MB.2014. Principles of Soil and Plant Water Relations. Elsevier Academic Press.
7. Marschner H. 2012. Marschner's Mineral Nutrition of Higher Plants. Elsevier Academic Press.
8. Mejias, P., Piraux, M., 2017. AquaCrop, the crop water productivity model. FAO, Rome, Italy.
9. Steduto, P., C. Hsiao, T., Fereres, E., Raes, D., Land and Water Division, 2012. Crop Yield Response to Water, FAO Irrigation and Drainage Paper. FAO, Rome, Italy.
10. Tan, K.H., 2009. Environmental Soil Science. CRC Press.
11. Theivasigamani, P., Velu, G., Jeyakumar, P., 2013. Impact of Crop Heat Units on Growth and Developmental Physiology of Future Crop Production: A Review. Research & Review: Journal of Crop Science & Technology 2, 2319–3395
12. Weil R. R. and Brady N. C. 2021. The Nature and Properties of Soil. 15th Edition, Pearson publishers

Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course Code: CSA 5105
Course Title: Coastal Ecosystems
Credit Hour: 2
Student Level: Level-5, Semester-1

Rationale: Coastal Ecosystems in Bangladesh are highly vulnerable to future climate change due to sea level rise, more extreme events and changes in river sediment transport and water flows. At the same these Coastal Systems deliver important ecosystem services such as flood protection, biodiversity conservation, fisheries, wood and other plant products.

Objectives: At the end of this course, the students will gain considerable-

1) Knowledge of the how climate change affects the vulnerability of coastal ecosystems.
2) Knowledge on main ecosystem services of coastal ecosystems
3) Knowledge and how to better protects coastal ecosystems

Learning Outcomes	**Course Content**	**Teaching-Learning Strategy**	**Assessment Strategy**
- describe the processes that determine species interactions in coastal ecosystems; - demonstrate knowledge of the relationships between organisms and the environment and insight in the mechanisms that drive populations and ecosystems; - identify the principle determinants of ecosystem functioning	**Ecology of Coastal Systems** Lectures and reading assignment on the ecology of coastal ecosystems explaining – - how species interact - impacts of the environment on species interaction and ecosystems functioning and biodiversity - principle determinant of ecosystem functioning	Lecture Reading assignment QA	-Short Answer -Essay
-Explain the concept of ecosystem services -Identify the most important ecosystem services of coastal ecosystems in Bangladesh	**Ecosystem Services –** lecture and reading material on: - concept of ecosystem services - ecosystem services of coastal ecosytems Assignment on identifying key ecosystem services of coastal ecosystems	Lecture Reading assignment QA	-Short Answer -Essay -Completion

-Understand the main impacts of climate change impact on coastal ecosystems. - Describe why coastal ecosystems are very vulnerable to climate change -Identify potential adaptation options to reduce the vulnerability of coastal ecosystems	**Climate change Impact on Coastal Ecosystems** lecture and reading material on: - climate change impacts on coastal ecosystems - Vulnerability and adaptation of coastal ecosystems Assignment on identifying important adaptation options to reduce vulnerability of coastal ecosystems	Lecture Reading assignment QA	-Short Answer - essay - completion of assignment
-identify the most important species and components of coastal ecosystems - analyse future threat of coastal ecosystems (including climate change) - Design a plant for the conservation and adaptation plan for a coastal ecosystem	**Design of Coastal Ecosystem Conservation Plan** Field Trip to Coastal Ecosystem Group assignment on future conservation of a coastal ecosystem. Assignment should include: - Future climate change impacts - Other future threats (e.g. pollution, urban expansion, poaching etc.) - Identify the key ecosystem services that need to be protected - Future conservation plan which takes into account future climate change.	Field Trip Group assignment Presentation Report	-Field trip report - Group presentation Group report

Recommended books and resources:

Ahammad, Ronju, Paramesh Nandy, and Panna Husnain. "Unlocking ecosystem based adaptation opportunities in coastal Bangladesh." *Journal of coastal conservation* 17.4 (2013): 833-840.

Mehvar, Seyedabdolhossein, et al. "Climate change-driven losses in ecosystem services of coastal wetlands: A case study in the West coast of Bangladesh." *Ocean & Coastal Management* 169 (2019): 273-283.

Kibria, Golam, and AK Yousuf Haroon. "Climate change impacts on wetlands of Bangladesh, its biodiversity and ecology, and actions and programs to reduce risks." *Wetland science*. Springer, New Delhi, 2017. 189-204.

Perillo, G., Wolanski, E., Cahoon, D. R., & Hopkinson, C. S. (Eds.). (2018). *Coastal wetlands: an integrated ecosystem approach*. Elsevier.

MS in Climate Smart Agriculture
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Course Profile

Course Code: CSA 5106
Course Title: Remote Sensing and GIS for Climate Smart Agriculture (CSA)
Credit Hour: 2
Student Level: Level- 5, Semester – 1

Rationale: Students of this course are expected to learn and understand the basic concepts of GIS, spatial data and analysis techniques, and how to communicate results using a well-designed map. They will learn about remote sensing data applications and how to use them to support climate-smart agricultural practices for and improved agriculture sustainability.

Objectives: At the end of this course, the students will able to:

- Articulate basic principles of Geographic Information Systems (GIS)
- Articulate the fundamental concepts of spatial data collection and analysis methods as well generate a map out of spatial and non-spatial data using GIS software
- Be able to explain the theory behind of remote sensing and understand the basics of the electromagnetic spectrum, image enhancement and analysis, and their application
- Formulate new functions and apply what they have learned to their own research in the thematic area of CSA.

Learning Outcomes	**Course Content**	**Teaching-Learning Strategy**	**Assessment Strategy**
Understand the basic concepts of GIS. Develop fundamental skills of using, manipulating and interpreting spatial data. Develop an understanding of the underlying theory of spatial data models and to represent them visually	**Introduction**: Definition, history and nature of Geographic Information System (GIS); GI Science and GI application **Spatial data and geoinformation:** Maps; Database; Scale; Features; Representation; Generalize; Map projection; Geo-referencing; spatial database; spatial analysis. **Spatial data models and modeling:** Entity definition; Spatial data models; Spatial data structures; Vector model versus raster models of spatial data; Modeling of surfaces. **GIS data collection**: Primary geographic data capture; Secondary geographic data capture.	Lecture Reading assignment Presentation QA	-Short Answer -Essay -Checklist

	Spatial data visualization: vector data visualization (point, line and polygon features), raster data visualization, categorized vector and raster data visualization.		
Apply cartographic principles: Represent and manipulate scale, resolution, projection and data management to problems in agriculture.	**Spatial referencing and positioning:** Reference surfaces for mapping, coordinate system, map projection, coordinate transformation, satellite-based positioning and georeferencing, practical examples with data from Patuakhali mapping of mung bean.	Lecture Reading assignment Discussion QA	-Short Answer -Essay -Completion
Learn how to create spatial data and digitize GPS data	**Data Entry and Preparation:** Spatial vector data preparation, digitizing using raster data, data entry using attribute tables, collection of Global positioning system (GPS) data from farmers' fields. Application of collected data and map representation using attribute data, retrieving statistics.	Lecture Reading assignment Discussion QA	-Short Answer -True-False -Matching term
Application of spatial data manipulation and analysis	**Spatial data manipulation and analysis:** Convex hull, clipping, buffer analysis, dissolving and merging data, spatial query from attribute tables, reprojection, data conversion, extract values, reclassification, overlay and zonal statistics.	Lecture Group assignment Demonstration QA	-Short Answer -Completion -Practical exam -Peer rating
Competencies in fundamental map making	**Mapping:** component of a maps layout preparation and thematic mapping through integration of attribute tables and generation of multiple legends.	Lecture Discussion QA	-Short Answer -Essay -Matching term
Basic understanding of concepts of remote sensing Explain how electromagnetic radiation is used in remote sensing Ability to describe basic sensors and function	**Introduction to remote sensing:** What is remote sensing, electromagnetic radiationspectrum, interaction with the atmosphere, remote vs. proximal and passive vs active sensing, characteristics of remotely sensed imagery **Sensors:** location (ground, air, space), satellite types and their characteristics, pixel characteristics, resolution, cameras and aerial photography, type of sensors (multispectral, thermal and microwave)	Lecture Reading assignment Presentation QA	-Short Answer -Essay -Checklist

Ability to describe the basic elements of visual image analysis Demonstrated analytical skill in selection of the most appropriate remote sensing imagery to perform specified analysis	**Image Analysis:** visual interpretation, digital image processing: enhancement, transformation, and classification. Optional: Digital elevation model data processing and production of hill shade, slope aspect, color relief, topographic position index, topographic ruggedness index and roughness.	Lecture Reading assignment Presentation QA	-Short Answer -Essay -Checklist
Ability to work independently and with competence in basic GIS and RS analysis	**GIS and RS Applications:** Crop type mapping, crop monitoring, land use and land cover mapping, and biomass mapping Optional: flood delineation, soil moisture, land surface temperature, drought mapping, fire analysis and burn mapping, precipitation mapping, precision agriculture applications.	Lecture Reading assignment Presentation QA	-Short Answer -Essay -Checklist

Recommended Books and Periodicals

1. Ahmed, Z.U., Krupnik, T.J., Kamal, M., 2018. Introduction to basic GIS and spatial analysis using QGIS: Applications in Bangladesh. Cereal Systems Initiative for South Asia (CSISA) and the International Maize and Wheat Improvement Center, CIMMYT. Dhaka, Bangladesh. http://csisa.org/wp-content/uploads/sites/2/2018/04/QGIS_CSISA_2018.pdf

2. Huisman, Otto and de By, Rolf. (2009). Principles of geographic information systems : an introductory textbook.https://webapps.itc.utwente.nl/librarywww/papers_2009/general/principlesgis.pdf

3. Michael N. Demers (2003), Fundamentals of Geographic Information Systems, John Wiley & Sons Ltd. USA.

4. Ian Heywood, Sarah Cornelius and Steve Carver (1999), An Introduction to Geographical Information Systems; Longman, UK.

5. Peter A. Burrough and Rachael A. McDonnell (1998), Principles of Geographical Information Systems, Oxford University Press, UK.

6. Stan Aronoff (1995), Geographic Information Systems: A Management Approach, WDL Publications, Ottawa, Canada.

7. Christopher B. Jones (1999), Geographical Information Systems and Computer Cartography, Longmans, UK.

8. C.P. Lo & Albert K. W. Yeung (2002), Concepts and techniques of Geographic Information Systems, Prentice-Hall, New Delhi, India.

9. Principles of remote sensing: an introductory textbook. K. Tempfli, G.C. Huurneman, W.H. Bakker, L.L.F. Janssen, et al. Fourth edition. University of Twente, Nethrelands, 2009
ISBN 978-90-6164-270-1Available for on-line reading: http://www.itc.nl/Pub/Home/library/Academic_output/ITC-GIS-and-Remote-Sensing-Textbooks.html

10. Fundamentals of remote sensing. Canada Centre for Mapping and Earth Observation, Natural Resources Canada. Available as PDF: http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/9309

11. Fundamentals of Remote Sensing. NASA/ARSETPDF lectures and video recording: https://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing

12. http://glad.geog.umd.edu/Potapov/_Library/Fundamentals_RS_Session2_Land_Final.pdf

13. Principles of remote sensing. Centre for Remote Imaging, Sensing and Processing. National University of SingaporeOn-line learning materials: http://www.crisp.nus.edu.sg/~research/tutorial/rsmain.htm

14. Science Education through Earth Observation for High Schools (SEOS) Project. On-line learning materials: http://www.seos-project.eu/home.html

15. Ahmad, Firoz & Farooq, Asim &Goparaju, Laxmi & Rizvi, Javed. (2020). The Geospatial Understanding of Climate-Smart Agriculture and REDD+ Implementation: Indian Perspective. Ekologia. 39. 72-87. 10.2478/eko-2020-0006.

16. FAO. *"Climate-smart" Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation*; Food and Agriculture Organization of the United Nations: Roma, Italy, 2010.

17. Adamides, G. "A Review of Climate-Smart Agriculture Applications in Cyprus." *MDPI*,Multidisciplinary Digital Publishing Institute, 25 Aug. 2020, www.mdpi.com/2073-4433/11/9/898/htm.

MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course Code: CSA 5107
Course Title: Gender and Social Inclusion in CSA
Credit Hour: 2
Student Level: Level-5, Semester – 1

Rationale: Adoption of climate smart agriculture requires a holistic approach, which need and in-depth understanding of gender issues and social inclusion of marginalized groups. This course will help them to gain knowledge, skill and change attitude towards gender and social inclusion in the field of CSA.

Objectives: At the end of this course, the students will -

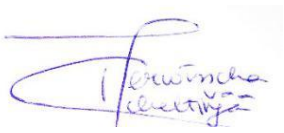
i. Gain knowledge and awareness on pressing gender issues and understand why it is important to incorporate gender in the context of climate smart agriculture;
ii. Be able to explain important concepts related to gender and social inclusion in CSA such as gender mainstreaming and equality in climate change vulnerability and resilience
iii. Gain ability to build gender sensitive teams, to conduct a gender analysis taking climate change adaptation and mitigation and design gender-responsive climate smart measures;
iv. Can develop proposal on how to mainstream gender in CSA.
v. Acquire skills such as analytical and critical thinking, group and individual work, presenting, discussing, and conveying and defending one's own opinion.

Learning Outcomes	**Course Content**	**Teaching-Learning Strategy**	**Assessment Strategy**
-Understand the concept of gender, equity and equality - Ability to explain gender sensitivity, using examples, and to build gender sensitivity in a team	**The concept of gender.** Gender; difference between sex and gender; Gender equity; Gender equality; Gender sensitivity. Gender based inequalities; Disproportionate exposure of poor women to climate change stress; Gender based violence during disasters.	Lecture Reading assignment Presentation QA	-Short Answer -Essay -Checklist
- Describe what gender analysis means - Ability to perform gender analysis and vulnerability analysis for a case study	**Gender in CSA**. Gender roles in agriculture (describing what men and women do in agriculture in Bangladesh); Application of the concepts of gender roles using practical examples; Gender analysis framework; Vulnerability assessment of men and women in the context of climate change; Gender differences in access to climate information services.	Lecture Reading assignment Discussion QA	-Short Answer -Essay -Completion

- Conceive the framework for enhancing social equity in CSA - reflect on current social inclusion based on field visit	**Social inclusion in CSA:** Framework for Enhancing Gender and Social Equity in Climate-Smart agriculture (reference WB, FAO, IFAD); Analysis of the level of inclusion. Gender and social inclusion strategies.	Lecture Reading assignment Discussion QA	-Short Answer -True-False -Matching term
- Application of gender and social inclusion in monitoring and evaluation	**Monitoring and evaluation** using gender and social inclusion in CSA; Gender specific data collection; Inclusion of gender equality in the monitoring and evaluation of climate services; M&E of gender based challenges of climate services; Gender differences in climate information relevance and capacity to act; Influence of climate services in women's participation in decision making.	Lecture Group assignment Practical assignment QA	-Short Answer -Completion -Practical exam -Peer rating
- Gain capability to mainstream gender and social inclusion in research, policy and extension work	**Mainstreaming gender and social inclusion** in research, policy and extension work. Using concepts of the earlier lectures, applying it for mainstreaming gender and social inclusion.	Lecture Discussion QA	-Short Answer -Essay -Matching term

Recommended Books and Periodicals

Sibyl Nelson and Sophia Huyer, *A Gender-responsive Approach to Climate-Smart Agriculture*, FAO, April 2016. http://www.fao.org/3/a-be879e.pdf
WB, FAO and IFAD, *Module 18, Gender in Climate Smart Agriculture*, 2015. http://www.fao.org/3/a-i5546e.pdf
Gumucio T, Huyer S, Hansen J, Simelton E, Partey S, Schwager S. 2018. *Inclusion of gender equality in monitoring and evaluation of climate services.* CCAFS Working Paper no. 249. Wageningen, Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).



MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course Code: CSA 5108
Course Title: Farming Systems
Credit Hour: 2
Student Level: Level-5, Semester 1

Rationale: Climate Smart Agriculture is a relatively new discipline, but it builds upon many older aspects of (scientific) knowledge, a major one being Farming Systems Research (FSR). In general, a system can be defined as any number of components connected and interacting, with a certain common goal or purpose. Major farming systems components are: the household, land, crops, livestock, with multiple nutrient and/or resource flows between them, such as labor, nitrogen and cash. In this course, students get familiar with the basic principles of farming systems, and the application of FSR, by learn about examples from across the world as well as from Bangladesh, in order to design and apply such research themselves.

Objectives: At the end of this course, students will have gained sufficient knowledge on:

1. The basic principles of Farming Systems Research
2. Several examples of applications of Farming Systems Research(and outcomes)
3. Apply farming systems thinking into new or ongoing research
4. Design research proposal to apply Farming Systems Research to the local context

Learning Outcomes	**Course Content**	**Teaching-Strategy**	**Assessment Strategy**
Define Systems thinking, Describe General Examples	**(i) Introduction to Systems Thinking:** Concept, definition, main aspects, and benefits	Lecture, reading, assignment, group discussion	True-false, short answer
Define FSR, Describe history, benefits, limitations, And	**(ii) Introduction to Farming Systems Research:** Concept and definition, history, major components of farming systems, system boundaries; benefits and limitations	Lecture, reading, assignment, group discussion	Multiple choice, short question
Describe Several	**(iii) Examples of FSR globally:** Learn details of the design, application and outcomes of several examples of	Lecture, reading, assignment,	Short question,

examples of FSR globally	farming systems research across the globe, discuss context-specific differences and similarities, lessons learned and options for improvement	group discussion	multiple choice
Describe Several examples of FSR in South East Asia and Bangladesh	**(iv) Examples of FSR in SEA and Bangladesh:** Learn details of the design, application and outcomes of several examples of farming systems research, applied more locally, discuss context-specific differences and similarities, lessons learned and options for improvement	Lecture, reading, assignment, group discussion	Questionnaire, short answer
Design short FSR proposal	**(v) Design of short proposal to apply FSR in Patuakhali area:**	Assignment, group discussion	Presentation

Recommended Books and Publications

Aravindakshan et al. (2020) – Multi-level socioecological drivers of agrarian change: Longitudinal evidence from mixed rice-livestock-aquaculture farming systems of Bangladesh, *Agricultural Systems* 177

Collinson (2000) – A history of farming systems research, CAB Ebook, ISBN 9780851994055 (book)

Darnhofer et al. (2012) – Farming Systems Research into the 21st Century: the new dynamic, Springer Complete Ebook (book)

Ditzler et al. (2019) – A model to examine farm household trade-offs and synergies with an application to smallholders in Vietnam, Agricultural Systems 173 (49-63)

Dixon et al. (2001) – Farming Systems and Poverty: improving farmers' livelihoods in a changing world, Springer Publishers / FAO & Worldbank, ISBN 9789251046272 (book)

Fresco & Westphal (1988) – A hierarchical classification of farming systems, *Experimental Agriculture* 24

Groot et al., (2012) – Multi-objective optimization and design of farming systems, *Agricultural Systems* 110 (63-77)

Lopez-Ridaura et al. (2018) – Climate smart agriculture, farm household typologies and food security - an ex ante assessment from Eastern India, *Agricultural Systems* 159

Tow et al. (2011) – Rainfed Farming Systems, Springer Publishers (book)

Odum (1983) – Systems ecology: an introduction, Wiley, ISBN 9780471652779 (book)

MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course Code: CSA 5201
Course Title: CSA Technology Development
Credit Hour: 2
Student Level: Level 5, Semester-2

Rationale: Climate change is a reality in Bangladesh. Therefore, technologies are needed for coping with the changing climate. The proposed course will focus on the innovation of novel technologies in agriculture while advancement of the indigenous technologies will be equally discussed. Specifically, the course will offer in-depth understanding and basic research on efficient uses of agricultural resources, e.g., soil, water and environment, climate smart cultivar development and assessment, advanced agricultural practices at a broader scale.

Objectives: At the end of this course, the students will gain considerable-

1) Knowledge of the agricultural technologies required to cope climate change
2) Understanding on development of novel CSA techniques
3) Knowledge to redesign indigenous technologies

Learning Outcomes	**Course Content**	**Teaching-Learning Strategy**	**Assessment Strategy**
-Understanding the field of CSA Innovation	**Chapter 1: CSA innovation: perspective and scopes** Different areas of CSA innovation, agricultural resources and their interactions between subsectors.	Lectures Reading	Assignment
-Knowledge and skill of using resources-based available CSA technologies	**Chapter 2: CSA technologies on agricultural resources** • CSA on soil, climate and water resources. • Water management (fresh water harvesting) • Salinity management (utilization of reverse osmosis for growing plants) • Agricultural inputs conservation and utilization strategies particularly during natural hazards and disasters	Lecture Visiting Demo.	Exam
Functional knowledge on crop sector CSA technologies	**Chapter 3: CSA technology in crops sector** Technologies for growing crops in difficult conditions-	Lecture Site seeing Reading	Exam Assignment

Learning Outcomes	Course Content	Teaching-Learning Strategy	Assessment Strategy
	-Sorjan cultivation -floating agriculture -bag agriculture -soilless cultivation techniques -Hanging vegetable cultivation -Quick crop establishment methods/CSAT for reduction of field duration -CAST on plant protection -CAST for quick response to crop agriculture -design of homestead for nutritional security -technologies for addressing low-lying ecosystems and short winter -crop variety development -Screening of existing cultivars under elevated temperature and CO_2.		
Functional knowledge on fisheries sector CSA technologies	**Chapter 4:CSA technology in fisheries sector** -management techniques of fishes under elevated temperature and extreme climatic events	Lecture Site seeing Reading	Exam Assignment
Functional knowledge on Livestock sector CSA technologies	**Chapter 5: CSA technology in livestock sector** -management techniques of fishes under elevated temperature and extreme climatic events	Lecture Site seeing Reading	Exam Assignment
Understanding systems level CSA technology	**Chapter 5: CSA technology at farming systems level (integration of different sub-sectors)** -Aquaculture- horticulture -Rice-fish-vegetable culture -Agroforestry	Lecture Farm and home visit	Exam Assignment
Gaining skill for CSA technologies	**Practical or research work:** Student attachment with farm families to design a CSA technology, or A short research on a suitable CSA technology development	Systemic Observation, Case study	Report and presentation

Recommended Books and Publications

Bhattacharyya et al. (2020) – Climate smart agriculture: concepts, challenges, and opportunities, Springer Publishers (book)

Deb Pal et al. (2019) – Climate Smart Agriculture in South Asia - Technologies, Policies and Institutions, Springer Publishers (book)

Food and Agriculture Organization of the United Nations (2010) – "Climate-Smart" Agriculture - Policies, Practices and Financing for Food Security, Adaptation and Mitigation (original concept document)

Food and Agriculture Organization of the United Nations (2017) – Climate Smart Agriculture source book, second edition

Hengsdijk et al. (2015) – Climate Smart Agriculture: Synthesis of case studies in Ghana, Kenya and Zimbabwe

Lipper et al. (2018) – Climate Smart Agriculture - Building Resilience to Climate Change, Springer Publishers (FAO book)

Lopez-Ridaura et al. (2018) – Climate smart agriculture, farm household typologies and food security - an ex ante assessment from Eastern India, *Agricultural Systems* 159

Steiner et al. (2020) – Actions to transform food systems under climate change, CCAFS – Wageningen

MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course Code: CSA 5202
Course Title: Stress Management in CSA
Credit Hour: 2
Student Level: Leve-5, Semester-2

Rationale:
The inexorable exposure of plants to biotic and abiotic stresses has affected the productivity and survival of crop plants worldwide, including Bangladesh. The ever changing climate may exacerbate these adverse effects of stresses on crops. Finding climate smart approaches for sustained yields under stresses has been an important goal of agricultural researchers and stakeholders while it may get momentum in the coming decades. To cope with biotic and abiotic stresses, it is of utmost importance to understand plant responses to these stresses at morpho-physiological and molecular levels, and their management strategies for achieving a high yield. Being a part of human resources development for sustainable management of crops grown under stress, this course will provide anin-depth understanding on the consequences of stresses in crop production. Importantly, the course will offer sustainable management strategies of different agricultural stresses. Therefore, the proposed course may contribute to achieving global food security.

Objectives: At the end of this course, the students will gain considerable-

(i) Understanding on the major global agricultural stresses and their impacts.
(ii) Knowledge on the stress-induced morpho-physiological and molecular responses in plants.
(iii) Competency in planning and managing crops grown in stress conditions.

Learning Outcomes	**Course Content**	**Teaching-Learning Strategy**	**Assessment Strategy**
-Understand on the major global agricultural stresses and their impacts on crop productivity -Identify the major stresses and stress-prone areas for Bangladesh agriculture	**Major agricultural stresses and their impacts in relation to global crop productivity** Lectures and reading materials on the major agricultural stresses and their impacts on crop production, especially focusing on the frequency, severity and yield losses in relation to global as well as Bangladesh context. Group assignments on major stress factors in Bangladesh and their impact on crop productions.	Lecture Reading assignment Individual writing assignment	-Short Answer -Essay
-Understand and explain stress-induced morphological, physiological and	**Morpho-physiological and molecular responses of crops under different stresses**	Lecture Individual writing assignment	-Short Answer -Essay -Completion

molecular responses in plants under stress conditions	Lectures and reading materials on the aspects of morphological, physiological and molecular responses of crops under biotic and abiotic stress conditions. Growth and yield attributes of crops, photosynthesis, respiration and source-sink activities, plant water balance, hormonal homeostasis, oxidative damages caused by stress, osmoprotectants and stress responses in plants.	QA	
-Understand the potential impacts of biotic stresses in plants -Explain management strategies in response to biotic stresses in crops for ensuring higher yields	**Major biotic stresses, their impacts and management strategies** Lectures and reading materials on important plant pathogens and insects, their mode of damages and management strategies Lectures and reading materials on weeds, their interactions with crops and management strategies. Improving biotic stress tolerance in crops. Individual/group assignments on the effects of some common biotic stresses in Bangladesh on plants and their managements.	Lecture Reading assignment Individual writing assignment	-Short Answer -Essay
-Understand the potential impacts of abiotic stresses in plants -Explain management strategies in response to various abiotic stress factors in crops for ensuring higher yields.	**Major abiotic stresses, their impacts and management strategies** Lectures and reading materials on salinity, drought, water logging, submergence and flood, high and low temperature, freezing, ultraviolet radiation, elevated CO2 and temperature, heavy metals, microplastics, antibiotics and interactions of multiple stresses. Improving abiotic stress tolerance in crops. Individual/group assignments on the frequently occurring abiotic stress in Bangladesh agriculture, their impact and management strategies.	Lecture Reading assignment Individual writing assignment	-Short Answer -Essay
-Apply the knowledge on the effects and management techniques in response to various stress factors in crops. -Assess the levels of impact of various	**A trial on impact of stresses in plants / a case study on the impact of a contemporary stress in agriculture.** Students will set a study individually or in groups, applying the acquired knowledge on the above mentioned important stress factors and practice	Field Trip Group assignment Presentation Report	-Field trip report - Individual / Group presentation and report

stresses in crop plants and recommend management strategies	different management strategies for increasing stress tolerance in plants. Alternatively, students will visit crop fields and study the impact of contemporary stresses on farmers' fields and employ management strategies improving crop productivity.		

Recommended Books and Periodicals

1. Hall A.E., 2001. Crop responses to environment. CRC, Boca Raton
2. Shame, S. Goyal, S.K. Sharma, D.W., 2003. Crop Production in Saline Environment: Global and Integrative Perspectives. Haworth Press. New York, USA.
3. Masood, A. 2006.Drought Management: Strategies for pulse Crops. Udaipur,165-E,Kamla Nagar, New Delhi.
4. Nilsen, E.T. and Orcutt, D.M., 1996. Physiology of plants under stress. Abiotic factors. *Physiology of plants under stress. Abiotic factors.*
5. Hale, M.G. and Orcutt, D.M., 1987. The physiology of plants under stress. John Wiley & Sons.
6. Jones, H.G., Flowers, T.J. and Jones, M.B., 2008. Plants under stress: biochemistry, physiology and ecology and their application to plant improvement. Cambridge University Press.
7. Nilsen, E.T.O. and David, M., The physiology of plants under stress: abiotic factors/Erik T. Nilsen, David M. Orcutt.
8. Orcutt, D.M. and Nilsen, E.T., 2000. *Physiology of plants under stress: Soil and biotic factors* (Vol. 2). John Wiley & Sons.
9. Iqbal M. Khan R. and Singh A., 2020. Improving Abiotic Stress Tolerance in Plants.
10. Shanker, A. and Shanker, C. eds., 2016. Abiotic and Biotic Stress in Plants: Recent Advances and Future Perspectives.
11. Hasanuzzaman, M., Hakeem, K.R., Nahar, K. and Alharby, H.F. eds., 2019. *Plant abiotic stress tolerance: Agronomic, molecular and biotechnological approaches*. Springer.
12. Shamim, M. and Singh, K.N. eds., 2017. *Biotic stress management in rice: molecular approaches*. CRC Press.
13. Shinwari, Z.K., Tanveer, F. and Iqrar, I., 2019. Role of Microbes in Plant Health, Disease Management, and Abiotic Stress Management. In *Microbiome in Plant Health and Disease* (pp. 231-250). Springer, Singapore.
14. Dresselhaus, T. and Hückelhoven, R. eds., 2019. *Biotic and abiotic stress responses in crop plants*. MDPI.
15. Tripathi, D.K., Singh, V.P., Chauhan, D.K., Sharma, S., Prasad, S.M., Dubey, N.K. and Ramawat, N. eds., 2020. *Plant Life Under Changing Environment: Responses and Management*. Academic Press.
16. Poltronieri, P. and Hong, Y. eds., 2019. *Applied Plant Biotechnology for Improving Resistance to Biotic Stress*. Academic Press.
17. Ahmad, P. and Prasad, M.N.V. eds., 2011. Environmental adaptations and stress tolerance of plants in the era of climate change. Springer Science & Business Media.
18. Singh, H.P., Batish, D.R. and Kohli, R.K. eds., 2006. *Handbook of sustainable weed management*. CRC Press.
19. Tuteja, N. and Singh, G.S. eds., 2012. Plant acclimation to environmental stress. Springer Science & Business Media.
20. Ahmad, P., 2016. *Plant metal interaction: emerging remediation techniques*. Elsevier.

21. Ratnadewi, D. ed., 2018. *Plant Growth and Regulation: Alterations to Sustain Unfavorable Conditions*. BoD–Books on Demand.

MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course Code: CSA 5203
Course Title: Research Methodology
Credit Hour: 2
Student Level: Level-5, Semester– 2

Rationale: Students of MS in CSA have to accomplish a mandatory research followed by thesis writing. This course will help them to accomplish that task efficiently. In addition, the graduates will work in different development organizations where they need to develop research proposals, accomplish field works and present results. This course will help prepare them in this regard.

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

i. Develop the situation and research problem and accomplish literature review of their research
ii. Design and test research hypothesis, and perform meta-analysis
iii. Understand the principles of quantitative and qualitative research
iv. Develop research proposal, perform field work and present results

Learning Outcomes	Course Content	Teaching-Learning Strategy	Assessment Strategy
The students will be able to select suitable situational problem and research problem and efficiently perform literature search	Defining the situational problem and research problem and applying and reviewing literature existing literature to their problem statement	Lecture Reading assignment Group discussion	Short questions Assignments Presentation
The students acquire skill in designing research, test hypothesis and perform meta-analysis	Compare and contrast descriptive and inferential research; Identifying and labeling variables; Sampling; Reliability and validity: Research design; Constructing hypothesis; Testing hypothesis: t-test, chi-square, correlation, regression ANOVA (one-way and two-way); Meta-analysis	Lecture Reading assignment Workshop	Quiz Short questions Problem solving
Understand and perform qualitative and quantitative research	Compare and construct qualitative and quantitative research; Constructivism and Epistemology; Qualitative research methods: observational method, interviews, focus group discussion, participatory methods; validity and triangulation in qualitative research, sampling and qualitative data analysis	Lecture Group discussion Workshop	Written Quiz Structure draft proposal

The students can develop research proposal, write thesis and perform proper citation of research documents and sources	Research Proposal development; research report and thesis writing; Research Ethics; Reference writing- APA, MLA	Lecture Reading Assignment Workshop Peer feedback	Structure draft proposal Presentation

Recommended Books and Journals:

Glesne, C. (2016). Becoming Qualitative Researchers: An Introduction, 5th Edition

Recommended Books and Periodicals. Pearson

Neuman, W.L. (2014). Social Research Methods: Qualitative and Quantitative Approaches, 7th Edition, Pearson

Creswell, J.W. and Creswell, J.D. (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches 5th Edition. SAGE Publications

Machi, L. A., & McEvoy, B. T. (2016). The literature review: Six steps to success(3rded).London: Corwin Press.

SHADISH, W.S. , Shadish, William R. , Cook, Thomas D. and Campbell, Donald Thomas. (2002). Experimental and Quasi-experimental Designs for Generalized Causal Inference. Houghton Mifflin Company

Leeuwis, C. (2013). *Communication for rural innovation: rethinking agricultural extension*. John Wiley & Sons.

May, T. (2011). *Social research*. McGraw-Hill Education (UK).

Babel Vinck and Karssenberg (2019) - Decision-making in model construction: Unveiling habits

Lahtinen Guillaume and Hamalainen (2017) - Why pay attention to paths in practise of environmental modelling?

Melsen et al. (2019) - Subjective modeling decisions can significantly impact the simulation of flood and drought events

MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course Code: 5204
Course Title: Climate Information Services
Credit Hour: 2
Student Level: Level-5, Semester-2

Rationale: graduates in scientific and professional field require knowledge on the theoretical design principles of climate services and how to apply those concepts into a scientific proposal; this course will help prepare them in this regard.

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

i. Understand general data, concepts and methods for large-n comparative climate change adaptation policy research and apply the to identify adaptation challenges in Bangladesh;
ii. Comprehend and de construct the concepts, categories and processes involved in design a climate information services by exploring theory and real case examples;
iii. Identify potential users and related decisions and link it to relevant climatic data for a scientific proposal

Learning Outcomes	**Course Content**	**Teaching-Learning Strategy**	**Assessment Strategy**
Understand general data, concepts and methods for large-n comparative climate change adaptation policy research and apply the to identify adaptation challenges in Bangladesh;	**General introduction to adaptation:** Climate change impacts, socio-economic and gas scenarios, vulnerability and risk assessment into policy research for adaptation	Lectures Reading material Assignment	Assignment
Comprehend and de construct the concepts, categories and processes involved in design a climate information services by exploring theory and real case examples;	**Introduction to Climate services:** definition of climate services, categorization of climate services, co-production and co-creation and identification to user needs and decisions., usability gaps. Examples of real climate services around the globe	Lecture Guest lectures Reading material Assignment Peer feedback	Assignment

Identify potential users and related decisions and link it to relevant climatic data sources and temporal and spatial climate data for a scientific proposal	**Linking decisions to relevant data:** introduction to climate data on types and sources and process chain. Climatic indices for agriculture. Relation of data and type of decisions.	Lecture Reading material Assignment Presentations	Assignment (Draft Proposal) Presentation

Recommended Books and Periodicals

Biesbroek, R., L. Berrang-Ford, J. D. Ford, A. Tanabe, S. E. Austin, and A. Lesnikowski. 2018.Data, concepts and methods for large-n comparative climate change adaptation policy research: A systematic literature review. *Wiley Interdisciplinary Reviews: Climate Change* 9(6):e548.

Denton, F., T.J.Wilbanks, A. C. Abeysinghe, I. Burton, Q. Gao, M. C. Lemos, T. Masui, K. L. O'Brien, and K. Warner. 2014. Climate-resilient pathways: adaptation, mitigation, and sustainable development. Pages 1101-1131 *in* C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, and L.L.White, editors. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kok, K., S. Pedde, M. Gramberger, P. A. Harrison, and I. P. Holman. 2019. New European socio-economic scenarios for climate change research: operationalising concepts to extend the shared socio-economic pathways. *Regional Environmental Change* 19(3):643–654.

Kok, K., M. van Vliet, I. Barlund, A. Dubel, and J. Sendzimir. 2011. Combining participative backcasting and explorative scenario development: Experiences from the SCENES project. *Technological Forecasting and Social Change* 78(5):835-851.

Biesbroek, R., L. Berrang-Ford, J. D. Ford, A. Tanabe, S. E. Austin, and A. Lesnikowski. 2018. Data, concepts and methods for large-n comparative climate change adaptation policy research: A systematic literature review. *Wiley Interdisciplinary Reviews: Climate Change* 9(6):e548.

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MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course Code: CSA 5205
Course Title: Mitigation of Agro-emissions
Credit Hour: 2
Student Level: Level-5, Semester–2

Rationale: Students of this course are expected to understand and enrich knowledge about climate smart agriculture (CSA) concepts, pillars and portfolios for CSA interventions. They will learn concepts related to mitigation of greenhouse gas (GHG) emission in agriculture their importance, impacts, and potential mitigation strategies with a focus on Bangladesh and South Asia.

Objectives: At the end of this course, the students will able to:

- Articulate basic concepts of CSA and its pillars.
- Show competence in how CSA can be applied to mitigate emissions in agricultural productions systems.
- Describe CSA portfolio interventions and their relevance.
- Formulate the potential GHG mitigation strategies for local adaptation.
- Describe tools and methods for measuring mitigation.
- Demonstrate knowledge of IPCC and UNFCCC commitments and in country policy implications.

Learning Outcomes	**Course Content**	**Teaching-Learning Strategy**	**Assessment Strategy**
Introduction to the problem of GHG Emissions Understand the basic concepts of CSA and pillars of CSA. Understand CSA based mitigation concepts and principles.	**Introduction**: Introduction to climate and agriculture, climate change, role of GHG emissions. Carbon cycles and relevance of nitrogen and methane. Definition, background and history, and concepts; The three pillars of CSA Clarification of GHG emissions, background; importance of mitigation in climate change; Sources of agricultural emissions, with emphasis on livestock and agriculture; Relationship between climate change and agricultural productions systems; Impacts of business-as-usual (current) agricultural practices on agricultural productions systems and climate change.	Lecture Reading assignment Presentation QA	-Short Answer -Essay -Checklist
Enrich basic knowledge of CSA	CSA portfolios; Define the six “S” agricultural GHG mitigation concepts	Lecture	-Short Answer

portfolios interventions for sustainably agricultural production systems	(water smart, nutrient smart, carbon smart, energy smart, weather smart and knowledge smart).	Reading assignment Presentation Discussion QA	-Essay -Completion
Formulate and develop potential technological solutions and Agro-emissions mitigation strategies for local adaptation	Understand local challenges and limitations in agricultural production systems; Assessment the reasons of for high in business-as-usual (current) agricultural practices. Identify the key options to mitigate GHG emissions for crops and agriculture. **Efficient water management options:** Precise laser land leveling, alternate wetting and drying irrigation, improved nutrient use efficiency, tensiometer based irrigation, crop demand-based irrigation, micro-irrigation systems, fuel efficiency in production and post-harvest operations, etc. **Nutrient management:** soil test based nutrient recommendation, decision supported guided tool based nutrient management (LCC, NDVI), crop response based nutrient management, adjusting nutrient rates with yield targets, etc. **Carbon sequestration:** conservation agriculturally based practices, crop residue and organic farm waste management, sustainable crop diversification and intensification, integration with livestock and farming systems etc. **Energy efficient:** Minimum tillage based practices, optimize cropping and farming systems; appropriate mechanization. **Weather forecast:** Weather forecast information for short- and medium-term decisions, Long-term climate based soil and crop simulations information for guiding the decision process. **Knowledge awareness and skill development:** Agro-advisory services based on weather and market, high yield varieties and suitable crops, inclusive decision process of women and youth, business models for agricultural services	Lecture Reading assignment Discussion QA	-Short Answer -True-False -Matching term

	Salinity and acidity management: understand the problems; salt movement and mechanism, technological solutions for salt and pH management **Livestock:** livestock feeding strategies, substitution of high-methane producing animals with low GHG emission sources, discussion on dietary considerations and meat preferences		
Increase knowledge on decision and measuring tools of Agro-emissions mitigation.	**Methods of emissions measurements** Laboratory analysis: Equipment's for laboratory analysis, sample collection process and requirements; setup of sample collection chambers; process samples and analysis of samples; calculation and interpretations. Input based measurements and quantification: Describe models and tools for emissions quantification, data requirements, data collections, inputting and process the data, interpretation of data outcomes. Explore the science based evidence for emissions alternatives and reduction	Lecture Group assignment Demonstration Practical QA	-Short Answer -Completion -Practical exam -Peer rating
Enrich knowledge on IPCC and UNFCCC commitments and mitigation country goal and country policy for mitigation of Agro-emissions	Understand the importance of IPCC and UNFCCC commitments to climate change and emissions mitigations; Scenario and status of agricultural-based emissions globally and countrywide and contribution to total emission, Bangladesh goal to reduce the emissions, Current polies to mitigate agricultural GHG emissions, Institutional changes needed toachieve mitigation.	Lecture Reading assignment Presentation QA	-Short Answer -Essay -Matching term

Recommended Books and Periodicals

Smil, V. 2000 : *Cycles of Life: Civilization and the Biosphere*, *Scientific American Library*, New York, x + 221 p.

Smil, V. 2013 : *Should We Eat Meat? Evolution and Consequences of Modern Carnivory* Wiley *ISBN* 978-1118278727

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Gathala, M.K., Laing, A.M., Tiwari, T.P., Timsina, J., Rola-Ruzben, F., Islam, S., Maharjan, S., Browm, P.R., Das, K.K., Pradhan, K., Chowdhury, A.K., Kumar, R., Datt, R., Anwar, M., Hossain, S., Kumar, U., Adhikari, S., Magar, D.B.T., Sapkota, B.K., Shrestha, H.K., Islam, R., Rashid, M., Hossain, I., Hossain, A., Brown, B., Gerard, B., 2020. Improving smallholder farmers' gross margins and labor-use efficiency across a range of cropping systems in the Eastern Gangetic Plains. *World Development*. 138: 105266. https://doi.org/10.1016/j.worlddev.2020.105266

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MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course code: CSA 5206

Course title: Climate Change and Agricultural Policy

Credit hour: 2; Total Lecture: 32

Student Level: Level-5, Semester-2

Rationale: Agricultural policies play a key role in climate mitigation and adaptation connecting scales and, by determining and using different natural resources endowments, different sectoral developments. Students will gain an understanding of the way national level agricultural policies link to adaptation and mitigation of climate change action through farm level production and international trade and agreements.

Learning Objectives: At the end of this course, the students will gain considerable-

(i) Knowledge of existing linkages between agricultural policies and climate change action
(ii) Knowledge on how the agricultural sector can contribute to achieve climate change goals
(iii) Knowledge of the main approaches and experiences to promote agricultural contribution to climate change goals in the global south
(iv) Knowledge of the narratives and linkages between national and international policies and agreements regarding the role of agricultural policies in climate change goals

Learning Outcomes	**Course content**	**Teaching-Learning Strategies**	**Assessment tools**
Analyse agricultural policies linkages to climate change	Setting the stage: Introduction to agricultural policies of related to inputs (water, labor, fertilizers, extension, pesticides, etc.), outputs (food trade) and their relation to climate change mitigation and adaptation objectives. Definition of agricultural policies, brief overview of paradigm shifted from production focus to system perspective and the linkages to climate change adaptation and mitigation.	Lecture Reading assignment Presentation QA	-Short Answer -Checklist -Essay
Understand the importance of systemic	Analytical system-focused frameworks linking agricultural policies with climate relevant social and environmental	Lecture Reading assignment Presentation	-Short Answer -Checklist -Essay

perspective applied to agricultural policies to address climate change objectives	objectives. Overview of narratives on system perspective relevant for climate change adaptation and mitigation in the agricultural policy context (e.g. food systems, ecosystem services, nutrition, public health, poverty alleviation)	QA	
Understand the relevance of agricultural policies for reducing greenhouse gases emissions in different types of food value chains	Agricultural policies and mitigation of climate change. Overview of the concepts of greenhouse gas mitigation in a value chains perspective (e.g. Life Cycle Assessment), the importance of the land use sector in the global south	Lecture Group discussion Presentation QA	-Short Answer -Checklist -Essay -Report presentation
Understand the relevance of agricultural policies for reducing the risks and vulnerability of different types of producers	Agricultural policy and adaptation to climate change (e.g. to minimize the climate risks, increase adaptive capacity, reduce vulnerability). Overview of the concepts of risk, adaptation, vulnerability, sensitivity and exposure in the context of agricultural sector of the global south.	Lecture Group discussion Presentation QA	-Short Answer -Checklist -Essay -Report presentation
Analyse the relevance of lessons learned around the global south on linking agricultural policies and action with climate change objectives	Innovations in linking agricultural policy and climate change mitigation and adaptation. Overview of case studies and lessons learned from experiences in the global south agricultural private and public policy innovations on food trade, payment for ecosystem services, sustainable food certification, etc.)	Lecture Group discussion Presentation QA	-Short Answer -Checklist -Essay -Report presentation
Understand the existing	International climate change targets, policies linked to agricultural production.	Lecture Reading assignment	-Short Answer -Checklist

narratives on how agricultural policies are linked to climate change objectives	Overview of UNFCCC Koronivia process, Multi-lateral Agreements, the Global Alliance of Climate Smart Agriculture, etc.	Presentation QA	-Essay -Report presentation

Reference books/ Literature sources

Aryal, J.P., Sapkota, T.B., Rahut, D.B., Krupnik, T.J., Shahrin, S., Jat, M.L. and Stirling, C.M., 2020. Major climate risks and adaptation strategies of smallholder farmers in coastal Bangladesh. Environmental management, 66, pp.105-120.

Ayers, J., 2011. Resolving the adaptation paradox: Exploring the potential for deliberative adaptation policy-making in Bangladesh. Global Environmental Politics, 11(1), pp.62-88.

Ayers, J.M. and Huq, S., 2009. The value of linking mitigation and adaptation: a case study of Bangladesh. Environmental Management, 43(5), pp.753-764.

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Bangladeshi Nationally Determined Contribution report to the UNFCCC. It would be useful to highlight how is agriculture is framed and discuss with students so they can apply the concepts they learned and think of the implications and opportunities when promoting CSA.

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de Brauw, A., Kramer, B. and Murphy, M., 2021. Migration, labor and women's empowerment: Evidence from an agricultural value chain in Bangladesh. World Development, 142, p.105445.

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de França Doria, M., Boyd, E., Tompkins, E.L. and Adger, W.N., 2009. Using expert elicitation to define successful adaptation to climate change. Environmental Science & Policy, 12(7), pp.810-819.

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Donatti, C.I., Harvey, C.A., Martinez-Rodriguez, M.R., Vignola, R. and Rodriguez, C.M., 2019. Vulnerability of smallholder farmers to climate change in Central America and Mexico: current knowledge and research gaps. Climate and Development, 11(3), pp.264-286.

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Herrero, M., Thornton, P.K., Mason-D'Croz, D., Palmer, J., Benton, T.G., Bodirsky, B.L., Bogard, J.R., Hall, A., Lee, B., Nyborg, K. and Pradhan, P., 2020. Innovation can accelerate the transition towards a sustainable food system. Nature Food, 1(5), pp.266-272.

Ingwersen, W.W., Garmestani, A.S., Gonzalez, M.A. and Templeton, J.J., 2014. A systems perspective on responses to climate change. Clean Technologies and Environmental Policy, 16(4), pp.719-730.

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The role of social learning processes in rural India, Bolivia and Mali. Journal of rural studies, 23(1), pp.23-37.
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Vignola, R., Oosterveer, P., Bene, C., 2021. Conceptualising food system governance and its present challenges. Sustainability Science.
Vogel, C., Moser, S.C., Kasperson, R.E. and Dabelko, G.D., 2012. Linking vulnerability, adaptation and resilience science to practice: Pathways, players and partnerships. Integrating Science and Policy, pp.117-148.
Yamin, F., Rahman, A. and Huq, S., 2005. Vulnerability, adaptation and climate disasters: a conceptual overview.

MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course Code: CSA 5207
Course Title: Data Management
Credit Hour: 2
Student Level: Level-5, Semester – 2

Rationale: Students of this course are expected to learn and understand the major concepts of data management, processing, data governance, and basic data mining techniques with emphasis and consideration on climate smart agriculture (CSA)

Objectives: At the end of this course, students should able to:

- Understand the data management challenges and solutions
- Understand principles of data management
- Gain technical expertise on data collection, storage, processing and representation.
- Acquire knowledge on data interpretation and inference
- Apply these knowledge on domain specific data (e.g. Agronomic/Life science/Business data)

Learning Outcomes	**Course Content**	**Teaching-Learning Strategy**	**Assessment Strategy**
Basic concepts of Data & Information Overview of Data Management	**Introduction**: Definition, differences between data and information, types of data (structured, unstructured) and metadata, data formats, types of data sources in agriculture and CSA **Data Management:** Data management services, data stewardship, research lifecycle (, hypothesis and objective seting, discovery &planning, data collection, data organization and processing, data analysis and representation, data publication and sharing, long-term management of data)	Lecture Reading assignment Presentation QA	-Short Answer -Essay -Checklist
Statistical Learning for Data Management (pre-requisite before diving deep into data management details)	**Descriptive Statistics:** Definition, measures of central tendency (mean, median, mode), measures of asymmetry (skewness, kurtosis), measures of variability (variance, standard deviation, coefficient of variation), measures of relationship between variables (covariance and correlation)	Lecture Reading Discussion Assignment QA	-Short Answer -True-False -Completion -Checklist

	Inferential Statistics: Definition, Common data distribution types (Bernoulli/ Uniform/ Binomial/ Normal/ Poisson Distribution etc.), Central limit theorem, Hypothesis testing, Confidence intervals, Z-scores.		
Data Visualization Techniques (pre-requisite before diving deep into data management details)	**Categorical Data Visualization:** Frequency distribution tables, bar and column charts, Pie charts, Pareto diagrams, cross tables/contingency tables **Numerical Data Visualization:** Frequency distribution tables with intervals, Histograms, Box plots, Scatter plots, Line charts	Lecture Presentation Demonstration QA	-Assignment -Practical Exam
Deep Dive in Data Management	**Discovery and planning:** Data management plans (DMPs), Identify area of interest, stakeholders based on research and business potential, Resource management **Data Collection:** Data collection methods, Survey methods, Questionnaire design, Demonstration on popular data collection toolkits (ODK, Kobo, Google form etc.) **Data Organization and Processing:** Data file formats, Data sorting& grouping, Data cleaning process, Outlier identification, Missing value imputation techniques, Data transformation strategies (Smoothing, Aggregation, Generalization, Normalization, Discretization, Attribute Construction) **Data Analysis and Representation:** Understanding data distribution, Application of statistical learning on acquired data, Application of visualization techniques for proper data visualization and representation. **Data Publication and Sharing:** Data documentation levels, Data citation Data privacy, Data licensing, Data sharing protocols, Data access levels, Embargos, Technological access restrictions, Data use agreements. **Long-term Management:**	Lecture Reading Discussion Demonstration Assignment QA	-Short Answer -Essay -Presentation -Completion -Practical Exam

	Data storage and storage facility, Data encryption, Data versioning, Data backup, Cloud storage management, Data modularity.		
More details on Outlier Detection Techniques:	**Outlier Detection Methods:** Supervised, Semi-supervised, Unsupervised methods, Statistical methods, Mahalanobis distance, Box and whisker method etc. **Outlier Replacement Methods:** Mean/Median/Mode replacement, Model based replacement (knn, glm, mice etc)	Lecture Reading Discussion Demonstration Assignment QA	-Problem solving -Assignment -Completion
Basic Concepts of Data Mining	**Overview:** Data mining definition, Types of data pattern problems (Regression, Classification, Clustering), Parametric, Non-parametric methods. **Regression:** Linear regression, Non-linear regression, Interpolation and extrapolation, Polynomial regression, Bayesian regression **Classification:** Logistic regression, Decision tree, Bayes classifier, Support vector machine **Clustering:** k-means, k-nearest neighbors, Probabilistic hierarchical clustering, DBSCAN	Lecture Reading assignment Discussion QA	-Short Answer -True-False -Problem solving
Data Management in Agricultural and Agronomic domain	**Overview:** Scopes and stakeholder search, Structuring and planning projects, Ways to gather data (direct or passive), Survey design for direct data collection, Finding data source for passive data collection, Procedures of data collection, validation and quality check, application of gathered knowledge of data lifecycles on the acquired data	Lecture Group assignment Demonstration QA	-Completion -Project -Peer rating -Presentation

Recommended Books and Resources

1. Multi-Domain Master Data Management: Advanced MDM and Data Governance in Practice (https://www.elsevier.com/books/multi-domain-master-data-management/allen/978-0-12-800835-5)

2. Research Data Management and Sharing (https://www.coursera.org/learn/data-management)
3. Data Stewardship: An Actionable Guide to Effective Data Management and Data Governance (https://www.elsevier.com/books/data-stewardship/plotkin/978-0-12-822132-7)

4. Data Mining: Concepts and Techniques
http://myweb.sabanciuniv.edu/rdehkharghani/files/2016/02/The-Morgan-Kaufmann-Series-in-Data-Management-Systems-Jiawei-Han-Micheline-Kamber-Jian-Pei-Data-Mining.-Concepts-and-Techniques-3rd-Edition-Morgan-Kaufmann-2011.pdf
5. Think Stats - Probability and Statistics for Programmers
(http://greenteapress.com/thinkstats/thinkstats.pdf)
6. Statistics and probability
(https://www.khanacademy.org/math/statistics-probability)
7. Pattern Recognition and Machine Learning
(https://www.springer.com/gp/book/9780387310732)
8. Data Visualization with R
(https://www.analyticsvidhya.com/blog/2015/07/guide-data-visualization-r/)
9. Data Visualization with Python
(https://www.coursera.org/learn/python-for-data-visualization)
10. Data Visualization in R
(https://www.dataquest.io/course/r-data-viz/)

MS in Climate Smart Agriculture
Institute of Climate Smart Agriculture
Patuakhali Science and Technology University, Dumki, Patuakhali

Course Profile

Course Code: CSA 5208
Course Title: Agriculture in a Changing Climate
Credit Hour: 2
Student Level: Level-5, Semester-2

Rationale: Agriculture in Bangladesh will face enormous challenges in the coming century. Climate will have far reaching consequences on agriculture and food systems. In addition, the demand of food will increase while the variety of food items will also change in the coming decade. Specifically, people will search for a more nitrous, healthier diet. Since climate change is inevitable and will have negative consequences on food production, any government including Bangladesh need to design its future agriculture well ahead of the start of climate induced consequences. As part of the human resources development for facing the challenges in climate change in agriculture, the course will look at the long term consequences of climate change on agriculture in Bangladesh taking a broad look at the future. We will not only look at impact of crops and farms but at how whole food systems need to change to adapt to future challenges.

Objectives: At the end of this course, the students will gain considerable-

(i) Knowledge of the long term impact of climate and socio-economic change on agriculture in Bangladesh
(ii) Knowledge on future scenarios for agriculture in Bangladesh.
(iii) Knowledge and possible strategic changes in food systems in Bangladesh.

Learning Outcomes	**Course Content**	**Teaching-Learning Strategy**	**Assessment Strategy**
-Understand the potential impacts of long term climate change on food systems and the agricultural sector in Bangladesh -Explain the different between first order and higher order impact of climate change on the different components of the food systems	**Long term impact of climate change on Agriculture in Bangladesh** Lectures and reading assignment on the long term impact of climate on agriculture especially focusing on higher level impacts, such as, impact on whole food systems, including trade, food security and the impacts on changes in diet. Discussing potential large ranging impacts such as consecutive cyclones, large floods, long term droughts and large scale salt water intrusions. Individual writing assignment on potential long term impacts of climate	Lecture Reading assignment Individual writing assignment	-Short Answer -Essay

	change on a component of the food supply chain		
-Understand how future socio-economic change affects the future of agriculture in Bangladesh -Design scenarios for future Agriculture in Bangladesh	**Scenarios for future agriculture in Bangladesh** Lectures and reading on RCP-SSP scenario framework of the IPCC. Future socio-economic scenarios for Bangladesh. And how future socio-economic interact with climate change impacts on agriculture. Group Assignment on developing scenarios for future the of agriculture in Bangladesh	Lecture Reading assignment QA	-Short Answer -Essay -Completion
-understand the different autonomous, incremental and transformative adaptation. - design a plan for transformative adaptation for an agricultural system	**Transformative Adaptation of Agriculture** Lectures and reading material on the difference between autonomous, incremental and transformative adaptation. Lecture and reading material on the need for transformative adaptation and limits to adaptation Individual/group assignment on designing a plan for transformative adaptation of an agricultural system	Field Trip Group assignment Presentation Report	-Field trip report - Group presentation Group report

Recommended Books and Resources

Alam, G. M. M., K. Alam, and S. Mushtaq. 2017. Climate change perceptions and local adaptation strategies of hazard-prone rural households in Bangladesh. Climate Risk Management 17:52-63.

Hossain, M.S., Qian, L., Arshad, M., Shahid, S., Fahad, S. and Akhter, J. (2019), "Climate change and crop farming in Bangladesh: an analysis of economic impacts", International Journal of Climate Change Strategies and Management, Vol. 11 No. 3, pp. 424-440. https://doi.org/10.1108/IJCCSM-04-2018-0030

Dinar, Ariel, and Robert O. Mendelsohn, eds. *Handbook on climate change and agriculture*. Edward Elgar Publishing, 2011.