Strengthening academic capacities on GHG inventory with a focus on forestry and environmental sciences

Bangladesh Forest Department
March 2017

UN-REDD PROGRAMME

Food and Agriculture Organization of the United Nations

UNDP

UN environment

The UN-REDD Programme, implemented by FAO, UNDP and UNEP, has two components: (i) assisting in developing countries to prepare and implement national REDD strategies and mechanisms; (ii) supporting the development of normative solutions and standardized approaches based on sound science for a REDD instrument linked with the UNFCCC. The programme helps empower countries to manage their REDD processes and will facilitate access to financial and technical assistance tailored to the specific needs of the countries.

The application of UNDP, UNEP and FAO rights-based and participatory approaches will also help ensure the rights of indigenous and forest-dwelling people are protected and the active involvement of local communities and relevant stakeholders and institutions in the design and implementation of REDD plans.

The programme is implemented through the UN Joint Programmes modalities, enabling rapid initiation of programme implementation and channelling of funds for REDD efforts, building on the in-country presence of UN agencies as a crucial support structure for countries. The UN-REDD Programme encourage coordinated and collaborative UN support to countries, thus maximizing efficiencies and effectiveness of the organizations' collective input, consistent with the "One UN" approach advocated by UN members.

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Suggested Citation: **Poultouchidou, A., Islam, K. M. N., Akhter, M. & Henry, M.** 2017. Strengthening academic capacities on GHG inventory with a focus on forestry and environmental sciences. Dhaka, Bangladesh Forest Department, Food and Agriculture Organization of the United Nationas.

Contents

1 Background 6
2 Objectives 8
3 Targeted Universities 8
3.1 Shahjalal University of Science and Technology 9
3.1.1 Forest Mensuration and Inventory 9
3.1.2 Watershed, Water Resources and Wetland Management 10
3.1.3 Environmental Pollution and Climate Change 11
3.1.4 Land Use Planning and Management 12
3.1.5 Remote Sensing and Geographic Information System 12
3.1.6 Internship 13
3.1.7 Forest Soil Management 13
3.2 Khulna University 14
3.2.1 Forest Mensuration and Inventory 14
3.2.2 Forest and Environmental Laws and Treaties 15
3.2.3 Aerial Photogrammetry and Remote Sensing 16
3.2.4 Soil Conservation and Watershed Management 16
3.2.5 Forest Soil and Site Productivity 17
3.3 University of Chittagong 18
3.3.1 Aerial Photogrammetry, Remote Sensing and GIS 18
3.3.2 Forest Mensuration and Inventory 18
3.3.3 Watershed Management 19
3.3.4 Land Use Planning and Management 20
3.3.5 Forest Soils 20
3.3.6 Climate Change 21
3.3.7 Internship 22
3.4 Bangabandhu Sheikh Mujibur Rahman Agricultural University 22
3.4.1 Introduction to Agroforestry and Environmental Science 23
4 Development of a new optional course for graduate students 23
4.1 GHG inventory for Agriculture, Forestry and Other land use (AFOLU) sector 23
5 References 28
6 Appendix: Current course coverage 31
6.1 Shahjalal University of Science and Technology 31

6.1.1 Forest Mensuration and Inventory 31
6.1.2 Watershed, Water Resources and Wetland Management 32
6.1.3 Environmental Pollution and Climate Change 33
6.1.4 Land Use Planning and Management 34
6.1.5 Remote Sensing and Geographic Information System 36
6.1.6 Internship 37
6.1.7 Forest Soil Management 38
6.2 Khulna University 39
6.2.1 Forest Mensuration and Inventory 39
6.2.2 Forest and Environmental Laws and Treaties 40
6.2.3 Aerial Photogrammetry and Remote Sensing 41
6.2.4 Soil Conservation and Watershed Management 42
6.2.5 Forest Soil and Site Productivity 43
6.3 University of Chittagong 44
6.3.1 Aerial Photogrammetry, Remote Sensing and GIS 44
6.3.2 Forest Mensuration and Inventory 45
6.3.3 Watershed Management 46
6.3.4 Land Use Planning and Management 48
6.3.5 Forest Soils 49
6.3.6 Climate Change 50
7 Bangabandhu Sheikh Mujibur Rahman Agricultural University 51
7.1 Introduction to Agroforestry and Environmental Science 51

Executive summary

The preparation of GHG inventory (GHG-I) is an essential element moving towards a greener economy while reducing GHG emissions and climate change. Capacity building is considered an integral part of all activities related to the preparation and maintenance of a GHG-I. A critical barrier to accurate GHG-I is the limited availability of national GHG expertise, as well as the lack of stable and skilled team that has the capacity to work on various reporting schemes including national communications, biennial updated reports, nationally determined contributions, etc.

Since 2012, FAO in collaboration with the Bangladesh Forest Department has provided capacity building support on GHG in Dhaka. Several training workshops and seminars were implemented (Akhter, 2015; Akhter & Shaheduzzaman, 2012; Birigazzi, 2016; Islam, Poultouchidou, Akhter, & Henry, 2016; Poultouchidou, Birigazzi, & Akhter, 2016) with the objective to support individuals from various government departments and academic institutions on understanding the fundamentals for the compilation of GHG-I with a focus on the AFOLU sector. All training activities followed the IPCC guidance and guidelines and are in line with international reporting requirements under the UNFCCC.

However, the capacity building efforts are not enough to ensure the sustainability of the GHG-I technical expertise and a strong consideration of the impact of different sectors and activities which contribute to GHG emissions climate change.

In order to scale up the skilled human resources on GHG-I, FAO in collaboration with the Forest Department, partners and national and international agencies and in accordance with academic institutions involved in forestry and environmental sciences, are planning activities to strengthen academic capacities on GHG-I for the AFOLU sector. This is critical, as there are greater opportunities to build capacity by integrating topics related to GHG into the curricula of universities and eventually train the future technical experts and decision makers.

This report presents suggestions for the improvement of curricula of undergraduate and graduate degree programs of four universities including Chittagong University, Khulna University, Shahjalal University of Science and Technology and Bangabandhu Sheikh Mujibur Rahman Agricultural University. In addition, the development of a new individual course - *"GHG inventory for Agriculture, Forestry and Other land use (AFOLU) sector"* - for graduate students and the description of its content is presented in the document. Finally, suggestions for implementation of internship programs are provided for universities that offer internship opportunities.

1 Background

The compilation of a greenhouse gas inventory (GHG-I) which corresponds to accurate emissions and removals is challenging especially for the Agriculture, Forestry and other land-use (AFOLU) sector, as it is the only sector with sinks and sources. The main problem is related to the lack of access to consistent, transparent, comparable, complete and accurate data as well as lack of documentation and archiving of data used in previous inventories. In addition, there is lack of experience in application of the IPCC guidance and guidelines documents (IPCC, 1996, 2003, 2006, 2014) and sufficient number of qualified GHG experts who retain over time.

In Bangladesh, the Department of Environment (DoE) under the Ministry of Environment and Forest (MoEF) is responsible for the preparation of GHG-I. The Initial National Communication which was submitted in 2002 reports that in 1994 the total CH_4 and N_2O emissions derived from agriculture was 1127.73 Gg and 14.32 Gg, respectively; while emissions from land-use change and forestry (LULUCF) sector was 7837.97 Gg of CO_2 (MoEF, 2002). According to the Second National Communication, the agricultural sector was responsible for 1215.69 Gg CH_4, and 33.94 Gg N_2O of emissions in 2005. In contrast, land-use change and forestry was a sink of 4328.78 Gg CO_2, and a source of 22533.92 Gg CO_2 emissions, representing a net emissions of 18205.52 Gg CO_2 (MoEF, 2012). However, it is worth noting that there is no consistency between the data sets used in the Initial and Second National Communication as well as no archiving or documentation. In 2015, Bangladesh submitted its Intended Nationally Determined Contribution (INDC) to the UNFCCC, but emissions from the LULUCF sector were not accounted and emission reduction targets were not reported, as was the case for transport, industry and energy sector due to difficulties in obtaining the necessary data.

Therefore, the role of planning and implementing capacity-building activities is important in the process of conducting a GHG-I for the LULUCF and AFOLU sector. The development of skilled human resources to support corporate GHG accounting and reporting initiatives is a critical component.

Since 2012, the Forest Department with support from FAO organized five training workshops on GHG-I on the AFOLU/LULUCF sector with the objective to build human capacities on GHG-I. In total 114 participants attended the training workshops representing various organizations including Forest Department, BBS, DoE, BFRI, DLRS, MoEF, SRDI, SPARRSO and Survey of Bangladesh, Chittagong University, Khulna University and Shahjalal University of Science and Technology. Despite the number of participants who have been trained, this number needs to be scaled up to meet the national needs in developing accurate and complete emission inventories, as well as to build strong technical expertise who will guarantee the continuing accumulation of knowledge and information.

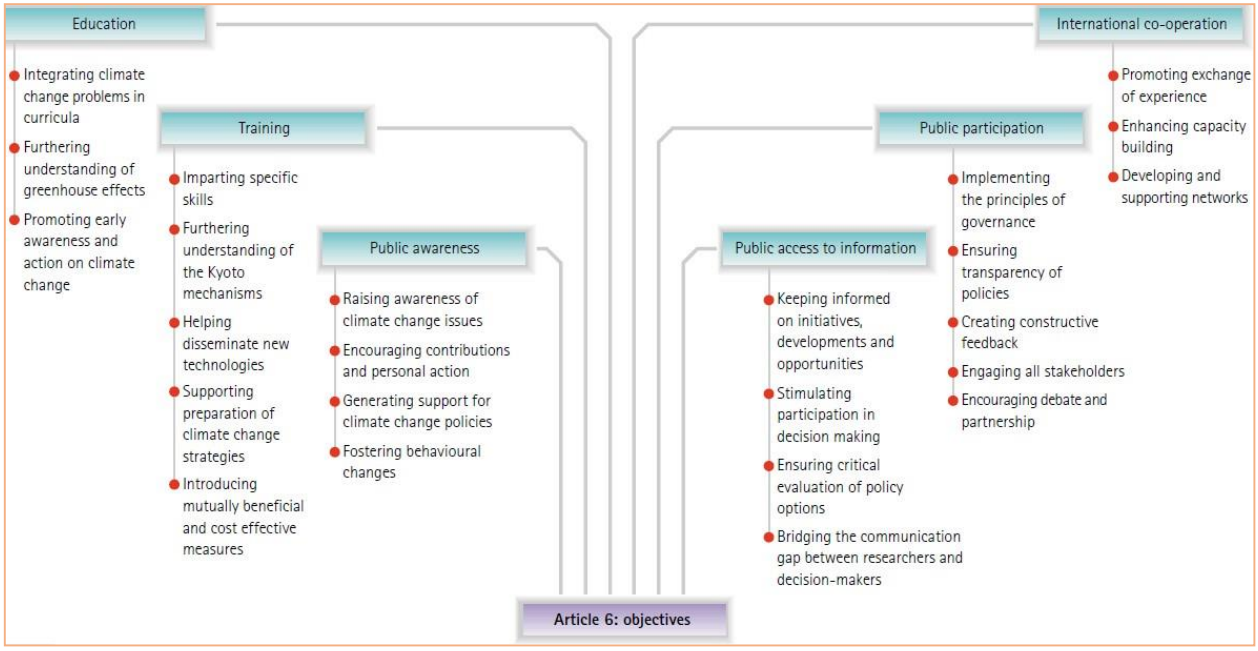

Figure 1: The objectives of Article 6 of UNFCCC – promoting public participation (UNFCCC, 2004).

UNFCCC Article 6: Education, Training, and Public Awareness

The current generation of decision-makers is the most obvious target group for building capacities on GHG. However, more emphasis needs to be put on building the capacities of other groups such as researchers, teachers and university students. This is important to build a critical mass of people equipped with the necessary knowledge and skills on GHG and to ensure the full ownership of the process by the national institutions in accordance with their mandate.

In addition, Article 6 of the United Framework Convention on Climate Change (UNFCCC) calls all Parties to promote and corporate in education, training and public awareness actions on climate change (Figure 1) and facilitate these activities at the national, regional and sub-national levels (UNFCCC, 2004). Academic institutions have the potential to develop human resources by integrating components of GHG-I in courses related to various disciplines such as forest management, agriculture, soil degradation, water resources etc. Therefore, capacity building through curriculum improvements is a key necessity for academic institutions, as it will provide the basis to train future decision-makers on how to conduct a GHG-I following the UNFCCC Guidance while meeting the national needs.

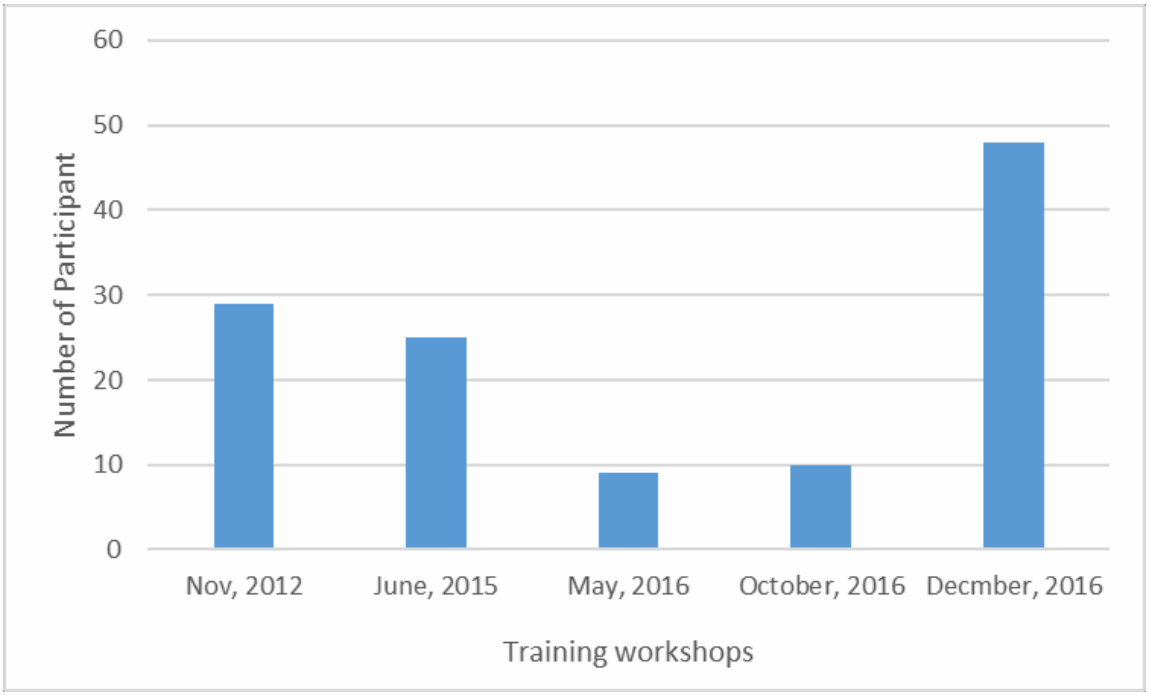

Figure 2: Number of individuals have been participated in GHG training workshops over the years.

2 Objectives

This report aims to present targeted capacity-building activities through curriculum improvements and involvement of students of academic institutions related to forestry and environmental science.

The ultimate objective of this activity is to:

- Scale up the number of skilled human resources on GHG-I and eventually build a critical mass of people equipped with skills and knowledge on how to conduct a GHG-I for the AFOLU sector;
- Identify academic capacity gaps and needs on courses related to AFOLU GHG disciplines and recommend ways to address them;
- Improve existing curricula and provide training to teachers to integrate GHG issues into undergraduate and graduate levels across disciplines related to the AFOLU sector
- Enhance and improve understanding of issues related to GHG-I for the AFOLU sector; and
- Promote synergies among national entities involved in the preparation of GHG-I.

3 Targeted Universities

Undergraduate and graduate students from:

- The Institute of Forestry and Environmental Sciences of Chittagong University;
- The Forestry and Wood Technology Discipline, Khulna University;

- The Department of Forestry and Environmental Science, Shahjalal University of Science and Technology
- The Department of Agroforestry and Environment, Bangabandhu Sheikh Mujibur Rahman Agricultural University

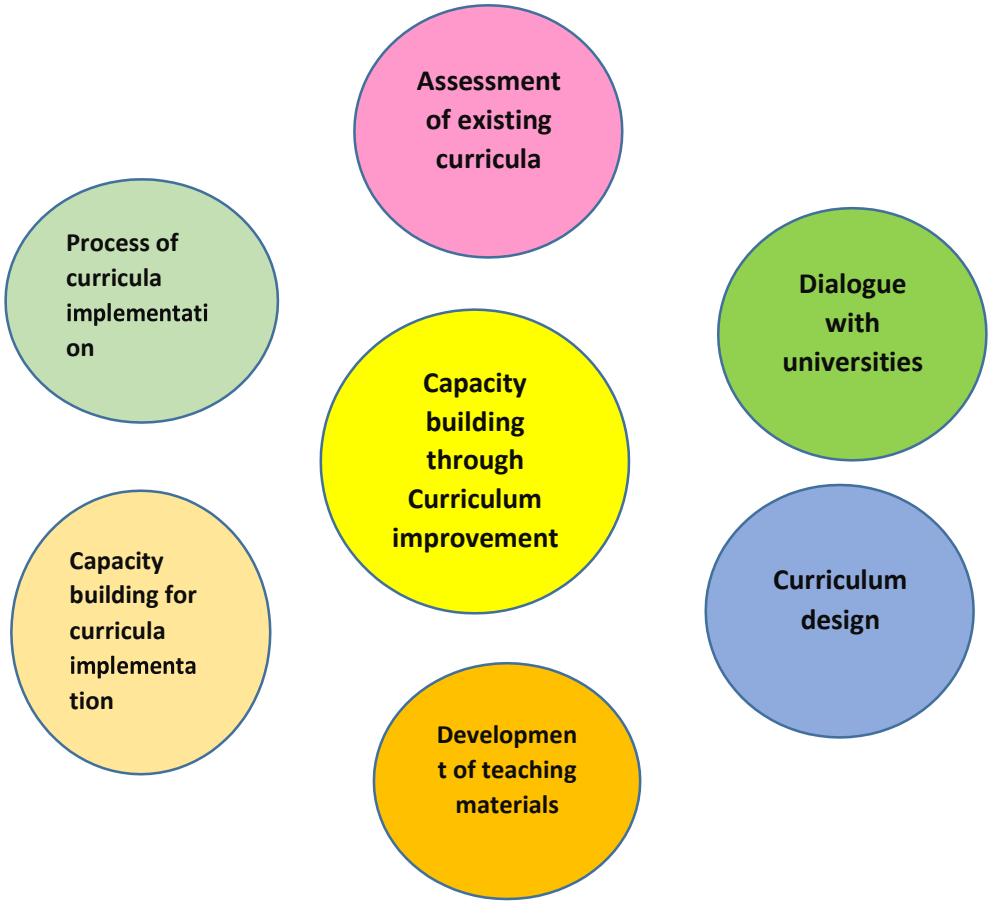

Figure 3. Building capacities on GHG inventory through curriculum improvements.

3.1 Shahjalal University of Science and Technology

Department of Forestry and Environmental Science

Undergraduate level

3.1.1 Forest Mensuration and Inventory

(Third Year, Semester 1, 3 Hours/Week, 3.0 Credits)

Suggested topics to be considered
Forest GHG-I: Definition, importance and benefits of conducting a GHG-I for the forestry sector Forest as a net source or sink of greenhouse gases
How to stratify forests into similar forest classes?

Which are the forest carbon pools and how they affect the carbon cycle and carbon fluxes?
How to estimate carbon stocks in biomass using stand volume equations
Basic approaches for estimating carbon stock changes (Gain-loss and carbon stock change method)
REDD+ in the context of UNFCCC and National Forest Monitoring System
Key Resources
1. Watson, R., Noble, I., Bolin, B., & Ravindranath, N. (2000). Land use, land-use change and forestry. Summary for policymakers: Intergovernmental Panel on Climate Change (IPCC). 2. IPCC. (2001). Chapter 3: The Carbon Cycle and Atmospheric Carbon Dioxide. In Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (Hewson)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 3. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter 1: Introduction, Chapter 2: Generic Methodologies applicable to multiple land-use categories, Chapter3: Consistent Representation of Lands, Chapter 4: Forest Land. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan. 4. IPCC. (2003). Chapter 2: Basis for Consistent Representation of Land Areas, Chapter 3: LUCF Sector Good Practice Guidance. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan. 5. UN-REDD. (2013). National Forest Monitoring Systems: Monitoring and Measurement, Reporting and Verification (M & MRV) in the context of REDD+ Activities. 6. Wageningen University, G.-G., World Bank FCPF. (2015). REDD+ training materials. Retrieved from http://www.gofcgold.wur.nl/redd/Training_modules.php 7. Larjavaara, M., Kanninen, M., Alam, S. A., Mäkinen, A., & Poeplau, C. (2017). CarboScen: a tool to estimate carbon implications of land-use scenarios. Ecography, n/a-n/a. doi:10.1111/ecog.02576 8. Krisnawati, H., Imanuddin, R., Adinugroho, W. C., & Hutabarat, S. (2015). Estimation of Annual Greenhouse Gas Emissions from Forest and Peat Lands in Central Kalimantan. Bogor, Indonesia: Research and Development Center for Conservation and Rehabilitation, Forestry Research and Development Agency.

3.1.2 Watershed, Water Resources and Wetland Management

(Third Year, Semester 2, 2 Hours/Week, 2.0 Credits)

Suggested topics to be considered
IPCC definition of managed and unmanaged wetlands
How does wetland management can affect the GHG emissions and removals?
What are the greenhouse gases associated with wetlands?
Wetland classification based on the IPCC guidance
Basic approaches to estimate emissions and removals from Wetlands Remaining Wetlands and Land Converted to Wetlands
Key Resources
1. IPCC. (2003). Chapter 3.5: Wetlands. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K.,

Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan.
2. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter 7: Wetlands. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan.
2. IPCC. (2014). 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, [Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G. (Hewson).]. IPCC, Switzerland.
3. Krisnawati, H., Imanuddin, R., Adinugroho, W. C., & Hutabarat, S. (2015). Estimation of Annual Greenhouse Gas Emissions from Forest and Peat Lands in Central Kalimantan. Bogor, Indonesia: Research and Development Center for Conservation and Rehabilitation, Forestry Research and Development Agency.
4. Strack, M. (2008). Peatlands and climate change. Jyväskylä: International Peat Society.

3.1.3 Environmental Pollution and Climate Change

(Fourth Year, Semester 1, 3 Hours/Week, 3.0 Credits)

Suggested topics to be considered
Development of an individual course on climate change or addition of the following topics to the existing course:
The Need for an International Climate Change Agreement
Objectives and Principles under the UNFCCC, the Kyoto Protocol and the Paris Agreement
GHG Reporting requirements (e.g. national communications, BUR, FREL/FRL)
Climate change mitigation documents at the national level: NAMAs, CDMs, INDC, NDC, FREL/FRL
Climate change adaptation and vulnerability documents at the national level: NAPAs
Climate change finance (e.g. GCF, GEF etc.) and Developing and transferring technologies
Key Resources

1. IPCC. (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (Hewson)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. (Vol. 4): Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
2. IPCC. (2014). Summary for policymakers. In: 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 Field, C.B., 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 (Hewson)]: Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.
3. IPCC. (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (Hewson)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

4. IPCC. (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (Hewson)]. . Retrieved from IPCC, Geneva, Switzerland:
5. Secretariat, U. (2015). Synthesis Report on the Aggregate Effect of the Intended Nationally Determined Contributions. Paper presented at the Bonn, Germany: United Nations Framework Convention on Climate Change.
6. Secretariat, U. (2016). Climate Action Now: Summary for Policymakers 2016.
7. Secretariat, C. C. (2002). A guide to the climate change convention process. Preliminary 2nd edition. Bonn.
8. Iversen P., L. D., and Rocha M., (2014). Understanding Land Use in the UNFCCC, Summary for Policymakers.
9. UNFCC. (2016). UN Climate Change Newsroom. Retrieved from http://newsroom.unfccc.int/
10. UNDP. (2012). Country papers: Preparation of National Communications from Non-Annex I Parties to the UNFCCC: A Compilation of Lessons Learned and Experiences from selected countries. Retrieved from http://www.unfccc.org.mk/content/Documents/INVENTORY/Country%20papers%20Final%20Version_1.pdf
11. UNFCCC. (2009). UNFCCC Resource Guide: Resource Guide for preparing the national communications of non-Annex I Parties. Module 1: The process of national communications from non-Annex I Parties.

3.1.4 Land Use Planning and Management

(Fourth Year, Semester II, 2 Hours/Week, 2.0 Credits)

Suggested topics to be considered
Land use categories based on the IPCC Guidance
Approaches for representing land areas based on the IPCC Guidance and uncertainties associated with approaches
Land stratification - Examples of land stratification - Land stratification for Bangladesh
Brief overview of land-use databases development: Use of Data Prepared for Other Purposes, and new data collection using remote sensing (RS) techniques and surveys.
Key Resources
1. IPCC. (2003). Chapter 2: Basis for Consistent Representation of Land Areas. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan. 2. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter3: Consistent Representation of Lands. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan.

3.1.5 Remote Sensing and Geographic Information System

(Third Year, Semester I, 3 Hours/Week, 3.0 Credit)

Suggested topic to be considered

Bangladesh national land representation system developed by Bangladesh Forest Department and how to use the system
Developing simplified land-use change matrix using IPCC land class
Key Resources
1. IPCC. (2003). Chapter 2: Basis for Consistent Representation of Land Areas. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan. 2. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter3: Consistent Representation of Lands. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan. 3. Akhter, M., Aziz, T., Costello, L., Di Gregorio, A., Hadi, M. A., Henry, M., Hossain, M. A., Iqbal, M. Z., Islam, M. S., Islam, M. R., Jalal, R., Mahboob, M. G., Rahman, M. S., Shahrin, F., Sumon, F. R., Tasnim, K. Z. & Udita, T. S., (2016). National Land Representation System of Bangladesh. Bangladesh Forest Department and Food and Agricultural Organization of the United Nations, Dhaka, Bangladesh.

3.1.6 Internship

(Fourth Year, Semester II, 2 Hours/Week, 1.0 Credit)

Suggestions for implementation of internships programs
Support the Forest Department (BFD) and/or Department of Environment (DoE) in archiving and improved management and archiving of documents using a reference management software (e.g. EndNote)
Support the development of emission factor database for Bangladesh with country-specific values for the IPCC land categories
Support FD and/or DoE to update their websites
Support FD with activities related to BFI
Support FD and/or DoE with data collection, archiving and documentation.

Graduate level

3.1.7 Forest Soil Management

(First Year, Semester I, 4 Hours/Week, 4 Credits)

Suggested topics to be considered
Soil types in Bangladesh based on FAO-UNESCO, USDA
Conversion of soil classes from one classification system to the IPCC soil classes
Basic approaches for assessing soil carbon stock changes using the IPCC methodology
Key Resources
1. Huq, S. I. S., Jalaluddin Md. (2013). The soils of Bangladesh: Springer Netherlands. 2. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter3: Consistent Representation of Lands, Annex 3A.5 Default climate and soil classifications. Chapter 2.3.3.1: Soil carbon estimation methods. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan.

3. IPCC. (2003). Chapter 3.3.2.2: Change in carbon stocks in soils. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan.
4. Poultouchidou, A., Chowdhury, S., Hoque, S., MN, H., Haque, A., Akther, M.,Henry, M. (2016). Mapping the soil carbon stocks of Bangladesh. Retrieved from Dhaka:
5. Corsi, S., Friedrich, T., Kassam, A., Pisante, M., & Sà, J. d. M. (2012). Soil organic carbon accumulation and greenhouse gas emission reductions from conservation agriculture: a literature review: Food and Agriculture Organization of the United Nations (FAO).
6. Jahn, R., Blume, H. P., Asio, V. B., Spaargaren, O., & Schad, P. (2006). Guidelines for soil description, 4th edition. Rome: FAO.
7. Group, I. W. (2014). World reference base for soil resources 2014 international soil classification system for naming soils and creating legends for soil maps. FAO, Rome.

3.2 Khulna University

Forestry and Wood Technology Discipline

Undergraduate level

3.2.1 Forest Mensuration and Inventory

(Third Year, Term I, 3hours/week, 3credits)

Suggested topics to be considered
Forest GHG-I: Definition, importance and benefits of conducting a GHG-I for the forestry sector Forest as a net source or sink of greenhouse gases
How to stratify forests into similar forest classes?
Which are the forest carbon pools and how they affect the carbon cycle and carbon fluxes?
How to estimate carbon stocks in biomass using stand volume equations
Basic approaches for estimating carbon stock changes (Gain-loss and carbon stock change method)
REDD+ in the context of UNFCCC and National Forest Monitoring System
Key Resources
9. Watson, R., Noble, I., Bolin, B., & Ravindranath, N. (2000). Land use, land-use change and forestry. Summary for policymakers: Intergovernmental Panel on Climate Change (IPCC). 10. IPCC. (2001). Chapter 3: The Carbon Cycle and Atmospheric Carbon Dioxide. In Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (Hewson)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 11. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter 1: Introduction, Chapter 2: Generic Methodologies applicable to multiple land-use categories, Chapter3: Consistent Representation of Lands, Chapter 4: Forest Land. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan. 12. IPCC. (2003). Chapter 2: Basis for Consistent Representation of Land Areas, Chapter 3: LUCF Sector Good Practice Guidance. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T.,

Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan.
13. UN-REDD. (2013). National Forest Monitoring Systems: Monitoring and Measurement, Reporting and Verification (M & MRV) in the context of REDD+ Activities.
14. Wageningen University, G.-G., World Bank FCPF. (2015). REDD+ training materials. Retrieved from http://www.gofcgold.wur.nl/redd/Training_modules.php
15. Larjavaara, M., Kanninen, M., Alam, S. A., Mäkinen, A., & Poeplau, C. (2017). CarboScen: a tool to estimate carbon implications of land-use scenarios. Ecography, n/a-n/a. doi:10.1111/ecog.02576
16. Krisnawati, H., Imanuddin, R., Adinugroho, W. C., & Hutabarat, S. (2015). Estimation of Annual Greenhouse Gas Emissions from Forest and Peat Lands in Central Kalimantan. Bogor, Indonesia: Research and Development Center for Conservation and Rehabilitation, Forestry Research and Development Agency.

3.2.2 Forest and Environmental Laws and Treaties

(Fourth Year Term II, 2 hours/week, 2 credits)

Suggested topics to be considered
The following topic can be included under the "Recent advances in regulations and international protocols"
The Need for an International Climate Change Agreement
Objectives and Principles under the UNFCCC, the Kyoto Protocol and the Paris Agreement
GHG Reporting requirements (e.g. national communications, BUR, FREL/FRL)
Climate change mitigation documents at the national level : NAMAs, CDMs, INDC, NDC, FREL/FRL
Climate change adaptation and vulnerability documents at the national level: NAPAs
Climate change finance (e.g. GCF, GEF etc.) and Developing and transferring technologies
Key Resources
1. IPCC. (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (Hewson)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. (Vol. 4): Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 2. IPCC. (2014). Summary for policymakers. In: 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 Field, C.B., 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 (Hewson)]: Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32. 3. IPCC. (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (Hewson)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 4. IPCC. (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (Hewson)]. . Retrieved from IPCC, Geneva, Switzerland:

5. Secretariat, U. (2015). Synthesis Report on the Aggregate Effect of the Intended Nationally Determined Contributions. Paper presented at the Bonn, Germany: United Nations Framework Convention on Climate Change.
6. Secretariat, U. (2016). Climate Action Now: Summary for Policymakers 2016.
7. Secretariat, C. C. (2002). A guide to the climate change convention process. Preliminary 2nd edition. Bonn.
8. Iversen P., L. D., and Rocha M., (2014). Understanding Land Use in the UNFCCC, Summary for Policymakers.
9. UNFCC. (2016). UN Climate Change Newsroom. Retrieved from http://newsroom.unfccc.int/
10. UNDP. (2012). Country papers: Preparation of National Communications from Non-Annex I Parties to the UNFCCC: A Compilation of Lessons Learned and Experiences from selected countries. Retrieved from http://www.unfccc.org.mk/content/Documents/INVENTORY/Country%20papers%20Final%20Version_1.pdf
11. UNFCCC. (2009). UNFCCC Resource Guide: Resource Guide for preparing the national communications of non-Annex I Parties. Module 1: The process of national communications from non-Annex I Parties.

3.2.3 Aerial Photogrammetry and Remote Sensing

(Second Year ,Term II, 3 hours/week, 3 credits)

Suggested topics to be considered
Bangladesh national land representation system developed by Bangladesh Forest Department, and how to use the system
Developing simplified land-use change matrix using IPCC land class
Key Resources
1. IPCC. (2003). Chapter 2: Basis for Consistent Representation of Land Areas. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan. 2. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter3: Consistent Representation of Lands. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan. 3. Akhter, M., Aziz, T., Costello, L., Di Gregorio, A., Hadi, M. A., Henry, M., Hossain, M. A., Iqbal, M. Z., Islam, M. S., Islam, M. R., Jalal, R., Mahboob, M. G., Rahman, M. S., Shahrin, F., Sumon, F. R., Tasnim, K. Z. & Udita, T. S., (2016). National Land Representation System of Bangladesh. Bangladesh Forest Department and Food and Agricultural Organization of the United Nations, Dhaka, Bangladesh.

3.2.4 Soil Conservation and Watershed Management

(Second Year, Term II, 3 hour/weeks, 3 credits)

Suggested topics to be considered
IPCC definition of managed and unmanaged wetlands.

How does wetland management can affect the GHG emissions and removals?
What are the greenhouse gases associated with wetlands?
Wetland classification based on the IPCC guidance
Basic approaches to estimate emissions and removals from Wetlands Remaining Wetlands and Land Converted to Wetlands
Key Resources
1. IPCC. (2003). Chapter 3.5: Wetlands. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan. 2. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter 7: Wetlands. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan. 5. IPCC. (2014). 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, [Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G. (Hewson).]. IPCC, Switzerland. 6. Krisnawati, H., Imanuddin, R., Adinugroho, W. C., & Hutabarat, S. (2015). Estimation of Annual Greenhouse Gas Emissions from Forest and Peat Lands in Central Kalimantan. Bogor, Indonesia: Research and Development Center for Conservation and Rehabilitation, Forestry Research and Development Agency. 7. Strack, M. (2008). Peatlands and climate change. Jyväskylä: International Peat Society.

Graduate level

3.2.5 Forest Soil and Site Productivity

(First Year, Term II, 3 hours/week, 3 credits)

Suggested topics to be considered
Forest soils and carbon sequestration - Carbon stock in forest ecosystems - Factors affecting the forest soils carbon stocks - Climate change and carbon dynamic in forest soils - Challenges in assessing carbon dynamics in forest soils
Soil types in Bangladesh based on FAO-UNESCO, USDA
Conversion of soil classes from one classification system to the IPCC soil classes
Basic approaches for assessing soil carbon stock changes using the IPCC methodology
Key Resources
1. Huq, S. I. S., Jalaluddin Md. (2013). The soils of Bangladesh: Springer Netherlands. 2. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter3: Consistent Representation of Lands, Annex 3A.5 Default climate and soil classifications. Chapter 2.3.3.1: Soil carbon estimation methods. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan. 3. IPCC. (2003). Chapter 3.3.2.2: Change in carbon stocks in soils. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D.,

Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan.
4. Poultouchidou, A., Chowdhury, S., Hoque, S., MN, H., Haque, A., Akther, M.,Henry, M. (2016). Mapping the soil carbon stocks of Bangladesh. Retrieved from Dhaka:
5. Corsi, S., Friedrich, T., Kassam, A., Pisante, M., & Sà, J. d. M. (2012). Soil organic carbon accumulation and greenhouse gas emission reductions from conservation agriculture: a literature review: Food and Agriculture Organization of the United Nations (FAO).
6. Jahn, R., Blume, H. P., Asio, V. B., Spaargaren, O., & Schad, P. (2006). Guidelines for soil description, 4th edition. Rome: FAO.
7. Group, I. W. (2014). World reference base for soil resources 2014 international soil classification system for naming soils and creating legends for soil maps. FAO, Rome.

3.3 University of Chittagong

Institute of forestry and Environmental Sciences

Undergraduate level

3.3.1 Aerial Photogrammetry, Remote Sensing and GIS

(Second Year, Fourth Semester, 3 hours/week, 4 credits)

Suggested topics to be considered
Bangladesh national land representation system developed by Bangladesh Forest Department, and how to use the system
Developing simplified land-use change matrix using IPCC land class
Key Resources
1. IPCC. (2003). Chapter 2: Basis for Consistent Representation of Land Areas. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan. 2. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter3: Consistent Representation of Lands. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan. 3. Akhter, M., Aziz, T., Costello, L., Di Gregorio, A., Hadi, M. A., Henry, M., Hossain, M. A., Iqbal, M. Z., Islam, M. S., Islam, M. R., Jalal, R., Mahboob, M. G., Rahman, M. S., Shahrin, F., Sumon, F. R., Tasnim, K. Z. & Udita, T. S., (2016). National Land Representation System of Bangladesh. Bangladesh Forest Department and Food and Agricultural Organization of the United Nations, Dhaka, Bangladesh.

3.3.2 Forest Mensuration and Inventory

(Fifth Semester, Forestry discipline, 4 credits)

Suggested topics to be considered
GHG inventory of forestry sector: Definition, importance and benefits in terms of REDD+ and UNFCCC.
National Forest Monitoring System: Definition, objectives and importance for GHG inventory of forestry sector
When does forest act as a net source or sink of CO_2
How to stratify forests into similar forest classes

Which are the forest carbon pools and how they affect the carbon cycle and carbon fluxes?
How to estimate carbon stocks in biomass using stand volume equations
Basic approaches for estimating carbon stock changes (Gain-loss and carbon stock change method)
Key Resources
1. Watson, R., Noble, I., Bolin, B., & Ravindranath, N. (2000). Land use, land-use change and forestry. Summary for policymakers: Intergovernmental Panel on Climate Change (IPCC). 2. IPCC. (2001). Chapter 3: The Carbon Cycle and Atmospheric Carbon Dioxide. In Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (Hewson)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 3. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter 1: Introduction, Chapter 2: Generic Methodologies applicable to multiple land-use categories, Chapter3: Consistent Representation of Lands, Chapter 4: Forest Land. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan. 4. IPCC. (2003). Chapter 2: Basis for Consistent Representation of Land Areas, Chapter 3: LUCF Sector Good Practice Guidance. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan. 5. UN-REDD. (2013). National Forest Monitoring Systems: Monitoring and Measurement, Reporting and Verification (M & MRV) in the context of REDD+ Activities. 6. Wageningen University, G.-G., World Bank FCPF. (2015). REDD+ training materials. Retrieved from http://www.gofcgold.wur.nl/redd/Training_modules.php 7. Larjavaara, M., Kanninen, M., Alam, S. A., Mäkinen, A., & Poeplau, C. (2017). CarboScen: a tool to estimate carbon implications of land-use scenarios. Ecography, n/a-n/a. doi:10.1111/ecog.02576 8. Krisnawati, H., Imanuddin, R., Adinugroho, W. C., & Hutabarat, S. (2015). Estimation of Annual Greenhouse Gas Emissions from Forest and Peat Lands in Central Kalimantan. Bogor, Indonesia: Research and Development Center for Conservation and Rehabilitation, Forestry Research and Development Agency.

3.3.3 Watershed Management

(Fourth Year, Semester 8, , 3 hours/week, 4 credit)

Suggested topics to be considered
IPCC definition of managed and unmanaged wetlands.
How does wetland management can affect the GHG emissions and removals?
What are the greenhouse gases associated with wetlands?
Wetland classification based on the IPCC guidance
Basic approaches to estimate emissions and removals from Wetlands Remaining Wetlands and Land Converted to Wetlands
Key Resources

1. IPCC. (2003). Chapter 3.5: Wetlands. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan.
2. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter 7: Wetlands. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan.
3. IPCC. (2014). 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, [Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G. (Hewson).]. IPCC, Switzerland.
4. Krisnawati, H., Imanuddin, R., Adinugroho, W. C., & Hutabarat, S. (2015). Estimation of Annual Greenhouse Gas Emissions from Forest and Peat Lands in Central Kalimantan. Bogor, Indonesia: Research and Development Center for Conservation and Rehabilitation, Forestry Research and Development Agency.
5. Strack, M. (2008). Peatlands and climate change. Jyväskylä: International Peat Society.

3.3.4 Land Use Planning and Management

(Fourth Year, Semester 8, 3 hours/week, 4 credits)

Suggested topics to be considered
Six land use categories based on the IPCC Guidance
Three approaches for representing land areas based on the IPCC Guidance, and uncertainties associated with approaches
Brief overview of land-use databases development: Use of Data Prepared for other Purposes, and new data collection using remote sensing (RS) techniques and surveys.
Key Resources
1. IPCC. (2003). Chapter 2: Basis for Consistent Representation of Land Areas. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan. 2. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter3: Consistent Representation of Lands. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan.

Graduate Level

3.3.5 Forest Soils

(1hour/week, 4 credits)

Suggested topics to be considered
Soil types in Bangladesh based on FAO-UNESCO, USDA
Conversion of soil classes from one classification system to the IPCC soil classes

Basic approaches for assessing soil carbon stock changes using the IPCC methodology
Key Resources
1. Huq, S. I. S., Jalaluddin Md. (2013). The soils of Bangladesh: Springer Netherlands. 2. IPCC. (2006). Volume 4: Agriculture, Forestry and Other Land Use, Chapter3: Consistent Representation of Lands, Annex 3A.5 Default climate and soil classifications. Chapter 2.3.3.1: Soil carbon estimation methods. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan. 3. IPCC. (2003). Chapter 3.3.2.2: Change in carbon stocks in soils. In Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan. 4. Poultouchidou, A., Chowdhury, S., Hoque, S., MN, H., Haque, A., Akther, M.,Henry, M. (2016). Mapping the soil carbon stocks of Bangladesh. Retrieved from Dhaka: 5. Corsi, S., Friedrich, T., Kassam, A., Pisante, M., & Sà, J. d. M. (2012). Soil organic carbon accumulation and greenhouse gas emission reductions from conservation agriculture: a literature review: Food and Agriculture Organization of the United Nations (FAO). 6. Jahn, R., Blume, H. P., Asio, V. B., Spaargaren, O., & Schad, P. (2006). Guidelines for soil description, 4th edition. Rome: FAO. 7. Group, I. W. (2014). World reference base for soil resources 2014 international soil classification system for naming soils and creating legends for soil maps. FAO, Rome.

3.3.6 Climate Change

(1 hour/week 4 credits)

Suggested topics to be considered
The Need for an International Climate Change Agreement
Objectives and Principles under the UNFCCC, the Kyoto Protocol and the Paris Agreement
GHG Reporting requirements (e.g. national communications, BUR, FREL/FRL)
Climate change mitigation documents at the national level : NAMAs, CDMs, INDC, NDC, FREL/FRL
Climate change adaptation and vulnerability documents at the national level: NAPAs
Climate change finance (e.g. GCF, GEF etc.) and Developing and transferring technologies
Key Resources
1. IPCC. (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (Hewson)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. (Vol. 4): Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 2. IPCC. (2014). Summary for policymakers. In: 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 Field, C.B., 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 (Hewson)]: Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

3. IPCC. (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (Hewson)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
4. IPCC. (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (Hewson)]. . Retrieved from IPCC, Geneva, Switzerland:
5. Secretariat, U. (2015). Synthesis Report on the Aggregate Effect of the Intended Nationally Determined Contributions. Paper presented at the Bonn, Germany: United Nations Framework Convention on Climate Change.
6. Secretariat, U. (2016). Climate Action Now: Summary for Policymakers 2016.
7. Secretariat, C. C. (2002). A guide to the climate change convention process. Preliminary 2nd edition. Bonn.
8. Iversen P., L. D., and Rocha M., (2014). Understanding Land Use in the UNFCCC, Summary for Policymakers.
9. UNFCC. (2016). UN Climate Change Newsroom. Retrieved from http://newsroom.unfccc.int/
10. UNDP. (2012). Country papers: Preparation of National Communications from Non-Annex I Parties to the UNFCCC: A Compilation of Lessons Learned and Experiences from selected countries. Retrieved from http://www.unfccc.org.mk/content/Documents/INVENTORY/Country%20papers%20Final%20Version_1.pdf
11. UNFCCC. (2009). UNFCCC Resource Guide: Resource Guide for preparing the national communications of non-Annex I Parties. Module 1: The process of national communications from non-Annex I Parties.

3.3.7 Internship

Suggestions for implementation of internships programs
Support the Forest Department (BFD) and/or Department of Environment (DoE) in archiving and improved management and archiving of documents using a reference management software (e.g. EndNote)
Support the development of emission factor database for Bangladesh with country-specific values for the IPCC land categories
Support FD and/or DoE to update their websites
Support FD with activities related to BFI
Support FD and/or DoE with data collection, archiving and documentation.

3.4 Bangabandhu Sheikh Mujibur Rahman Agricultural University

Department of Agroforestry and Environment

Undergraduate course

3.4.1 Introduction to Agroforestry and Environmental Science

(Third Year, Summer Term, 3 credits)

Suggested topics to be considered
Biogeochemical Processes causing GHG emissions and removals
The carbon cycle
Causes of anthropogenic emissions and removals
Carbon sequestration in agroforestry systems
Climate change mitigation through agroforestry systems
Key Resources
1. IPCC. (2006). Chapter 1: Introduction. In 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Hewson).: IGES, Japan. 2. Iversen P., L. D., and Rocha M., (2014). Understanding Land Use in the UNFCCC, Summary for Policymakers. 3. Watson, R., Noble, I., Bolin, B., & Ravindranath, N. (2000). Land use, land-use change and forestry. Summary for policymakers: Intergovernmental Panel on Climate Change (IPCC). 4. Montagnini, F., & Nair, P. K. R. (2004). Carbon sequestration: An underexploited environmental benefit of agroforestry systems. Agroforestry Systems, 61(1). 5. Verchot, L. V., Van Noordwijk, M., Kandji, S., Tomich, T., Ong, C., Albrecht, A., Palm, C. (2007). Climate change: linking adaptation and mitigation through agroforestry. Mitigation and Adaptation Strategies for Global Change, 12(5). 6. Schoeneberger, M., Bentrup, G., de Gooijer, H., Soolanayakanahally, R., Sauer, T., Brandle, J., Current, D. (2012). Branching out: agroforestry as a climate change mitigation and adaptation tool for agriculture. Journal of Soil and Water Conservation, 67(5), 128A-136A. 7. IPCC. (2001). Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (Hewson)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

4 Development of a new optional course for graduate students

4.1 GHG inventory for Agriculture, Forestry and Other land use (AFOLU) sector

(4 hours/week, 4 credits)

Objective
The course is focused on how to estimate emissions and removals of greenhouse gases from Agriculture, Forestry and Other Land use (AFOLU) sector following the methodology provided by the IPCC 2006 Guidelines.
Content
The importance of the GHG-I This lesson will provide a background for understanding the GHG-I for the AFOLU sector: • The greenhouse effects and drivers of climate change • Importance of GHG-I in the context of UNFCCC (reporting requirements) • Identify the causes of GHG emissions and removals in the AFOLU sector • Describe the C cycle and how it is linked to CO_2 emissions in the AFOLU sector • Trends in AFOLU GHG emissions at a global and national level

- Carbon pools considered in the AFOLU sector

IPCC principles and methodology

The lesson will present the Guidelines of the Intergovernmental Panel on climate change

- Guidelines produced by the IPCC from 1996, 2000, 2003, 2006
- History and evolution of IPCC Guidance
- IPCC principles

Land representation

This lesson will focus on how to develop a dataset on activity data and emission factors

- IPCC Approaches to represent land area
- Examples of land area data and stratification
- Information and Guidance on collecting, harmonizing and compiling land area data
- IPCC Tiers for emission factors

Forestland:

This lesson will cover the methodology for estimating carbon stock changes using Tier 1 for different carbon pools of forest land remaining forestland and land converted to forest land.

FL remaining FL

- Forest land stratification (e.g. climate, ecological zone, soil type, forest type)
- Choice of Tier and carbon pools to estimate
- Estimating emissions/removals in living biomass for FL remaining FL
- Gain-Loss method (Tier 1), Stock change method (Tier 2 and Tier 3)
- Calculating Gain in carbon stocks
- Calculating Losses in carbon stocks
- Calculate emissions from organic soils

Land converted to FL

- - Choice of Tier and carbon pools to estimate
- Equation used to estimate emissions and removals for land converted to FL in biomass
- Equation used to estimate emissions and removals for land converted to FL in dead organic matter
- Equation used to estimate emissions and removals for land converted to FL in soils (organic and mineral)

Assignment: Calculation of GHG inventory of forest land.

Cropland

CL remaining CL

This lesson will cover the methodology for estimating carbon stock changes using Tier 1 for different carbon pools of crop land remaining cropland and land converted to crop land.

- - Choice of Tier and carbon pools to estimate
- Equation for estimating emissions and removals in biomass
- Stock change factors
- Equation for estimating SOC changes (mineral and organic soils) in cropland
- Method for calculating emissions and removals in dead organic matter

Land converted to CL

- Choice of Tier and carbon pools to estimate

Assignment: Calculation of GHG inventory of cropland.

Grassland

This lesson will cover the methodology for estimating carbon stock changes using Tier 1 for different carbon pools of grassland remaining grassland and land converted to grass land.

GL remaining FL

- Choice of Tier and carbon pools to estimate

- Equation for estimating emissions and removals in biomass (Tier 2)
- Equation for estimating emissions and removals in dead organic matter (Tier 2)
- Equation for estimating emissions and removals in soils

Land converted to GL

- Choice of Tier and carbon pools to estimate
- Equation for estimating emissions and removals in biomass
- Equation for estimating emissions and removals in dead organic matter
- Equation for estimating emissions and removals in soils (mineral and organic)

Assignment: Calculation of GHG inventory of grassland.

Wetland

This lesson will cover the methodology for estimating carbon stock changes using Tier 1 for different carbon pools of wet land remaining wetland and land converted to wetland.

- Types of wetlands in the 2006 IPCC Guidelines
- Types of wetland in the 2013 IPCC Wetlands Supplement

Peatland remaining Peatland

- Choice of Tier and carbon pools to estimate
- Overview of peat extraction and related emissions; What is the situation in Bangladesh
- Equation for estimating emissions from land undergoing peat extraction
- Equation for On-site soil CO_2–C emissions from managed peatlands
- Equation for Off--site soil CO_2–C emissions from managed peatlands
- Equation for on-site CO2 emissions from managed peatlands (Tier 2 and 3)
- Equation for non-CO2 emissions

- Land converted for Peatland

- Equation for CO2 emissions in peatland (Tier 2)

Land converted to flooded land

- Emissions related from flooded land
- Equation for estimating carbon stock change in biomass

Assignment: Calculation of GHG inventory of wetand.

Settlements

This lesson will cover the methodology for estimating carbon stock changes using Tier 1 for different carbon pools of settlements remaining settlements and land converted tosettlements

SL remaining SL

- Choice of Tier and carbon pools to estimate
- Annual biomass increment based on total crown cover area (Tier2)
- Annual biomass growth based on number of woody plants (Tier 2)

Land converted to SL

- Equation for carbon stock change in biomass
- Changes in carbon stocks in dead organic matter
- Changes in carbon stocks in soils

Assignment: Calculation of GHG inventory of settlement.

Other land

Land converted to other land

- Equation for estimating changes in carbon stocks in living biomass
- Equation for estimating changes in carbon stocks in soils

Assignment: Calculation of GHG inventory of otherland.

Key category analysis

This lesson will focus on how to perform a key category analysis for Agriculture and LULUCF

- Disaggregation level
- Level assessment
- Trend assessment
- Uncertainty assessment

Quality control

This lesson will focus on how to perform a quality control.

- General QC procedures
- Category specific QC procedures for emission factors and activity data

Institutional arrangements for GHG-I

This lesson will focus on the importance of institutional arrangements.

- Roles and responsibilities for robust institutional arrangements
- Examples from other countries

Key Resources

1. IPCC. (2003). Good Practice Guidance for Land Use, Land-Use Change and Forestry. [Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Hewson)]. Intergovernmental Panel on Climate Change (IPCC): IPCC/IGES, Hayama, Japan.
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6. Wageningen University, G.-G., World Bank FCPF. (2015). REDD+ training materials. . Retrieved from http://www.gofcgold.wur.nl/redd/Training_modules.php
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8. FAO. (2017). Greenhouse Gas Inventories. Retrieved from http://www.fao.org/in-action/micca/resources/learning/ghg-learning/en/
9. Tubiello, F., Cóndor-Golec, R., Salvatore, M., Piersante, A., Federici, S., Ferrara, A., Biancalani, R. (2015). Estimating greenhouse gas emissions in agriculture: a manual to address data requirements for developing countries. Estimating greenhouse gas emissions in agriculture: a manual to address data requirements for developing countries.
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11. Akhter, M., Aziz, T., Costello, L., Di Gregorio, A., Hadi, M. A., Henry, M., Hossain, M. A., Iqbal, M. Z., Islam, M. S., Islam, M. R., Jalal, R., Mahboob, M. G., Rahman, M. S., Shahrin, F., Sumon, F. R., Tasnim, K. Z. & Udita, T. S., (2016). National Land Representation System of Bangladesh. Bangladesh Forest Department and Food and Agricultural Organization of the United Nations, Dhaka, Bangladesh.

12. Poultouchidou, A., Chowdhury, S., Hoque, S., MN, H., Haque, A., Akther, M., Henry, M. (2016). Mapping the soil carbon stocks of Bangladesh. Retrieved from Dhaka
13. Costello, L. S., G., Aziz, T., Akhtar, M., Poultouchidou, A. (2016). Harmonization of forest inventory data in Bangladesh and calculation of emission factors for REDD+. Retrieved from Dhaka, Bangladesh.:

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6 Appendix: Current course coverage

6.1 Shahjalal University of Science and Technology

Department of Forestry and Environmental Science

Undergraduate Level

6.1.1 Forest Mensuration and Inventory

(Third Year, Semester 1, 3 Hours/Week, 3.0 Credits)

Current course coverage
Mensuration Definition, objectives, scope and importance of mensuration, definition of different terms related to forest mensuration and inventory.
Principles and methods of measuring diameter and height of trees
Principles and uses of different instrument: Use of diameter tape, biltmore stick, relaskope, haga altimeter, suntoo clinometer, abney level, trupulse rangefinder, Criterion RD 1000 Electronic BAF-scope/ dendrometer, DME in forest mensuration
Measuring single trees: Diameter, cross-sectional area, height, bark, crown, leaf area index and volume of log, slope correction for horizontal distance.
Form and shapes of trees, taper functions and equations.
Measurement of tree volume and biomass: Tree volumes, estimation of biomass, Construction and testing of volume table; construction and testing of biomass equation.
Tree growth: Simple expressions of growth rates, calculations of growth at constant rates, pattern of growth
Stem analysis, estimation of age and growth rate of trees in plantations.
Inventory Definition, types of forest inventory and objectives of forest inventory.
Sampling designs commonly applied in forest inventories - random, systematic, cluster, two phase, 3-P, multistage and stratified sampling designs, and relative efficiency of sampling designs, subjective and objective sampling designs, principles and application of point sampling.
Choice of plot size and shape, permanent sample plots and recurrent forest inventory.
Stand variables and measurements of basal area, canopy cover, and dominant height, stock measurement.
Estimation of growth and yield, construction of yield and stand tables, site classification based on MAI and CAI.
Carbon Inventory: Sampling, above and below ground carbon assessment, REDD+
Use of GIS in forest inventory; different types of error in inventory.
Inventory planning and reporting: Forest inventory planning and procedure; application of remote sensing and GIS technique in forest inventory planning and design; collection of data from field, processing and report writing.
Recommended references

1. Avery, T. E., 1967. Forest Measurements, McGraw-Hill Company, New York.
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3. Chaturvedi, A. N. and L. S. Khanna, 1982. Forest Mensuration. International Book Distributors, Dehradun-248001, India.
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5. Hutsch, B. Miller and Beers., 1972. Forrest Mensuration.
6. Lauly, J. P., 1973. Manual of Forest Inventory with Special Reference to Mixed Tropical Forests. FAO. Rome.
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8. Philip, M. S., 1984. Measuring Trees and Forests Division of Forestry. University of Dar es Saalaam.
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6.1.2 Watershed, Water Resources and Wetland Management

(Third Year, Semester 2, 2 Hours/Week, 2.0 Credits)

Current course coverage
Watershed Management Introduction: Definition, concept, principles and objectives of watershed management, importance of watershed management in Bangladesh.
Hydrological Cycle: Hydrological cycle of forests, precipitation, interception, surface flow, infiltration, percolation, ground water, stream flow.
Erosion: Geologic and accelerated erosion, agents, types and causes of erosion, forms of water erosion, estimating rate of erosion, universal soil loss equation and its development basis, erosivity and erodibility, classification of gullies, conditions, phases, causes and control measures of wind erosion, causes, effects and control measures of shifting cultivation.
Soil Conservation: Aim and principle of soil conservation, mechanical vegetative, agronomic and management based measures of soil conservation in watershed area, processes of desertification.
Planning for Watershed Management: Need for planning and procedure of watershed management, data requirements for integrated plan and economic analysis, preparation of watershed workplan.
Integrated Watershed Management: Watershed classification, organisation and institutional co-ordination for watershed management, background, approach, strategy, conceptual framework for integrated watershed management.
Review of existing watershed management programmes in Bangladesh.
Causes and processes of desertification.
Water Resources National water policy 1999 and Bangladesh Water Acts 2013.
Major river systems of Bangladesh.
Land classification according to water depth.
Relation between water resources, forestry and fisheries.
Water Supply: Introduction to water supply system, sources of water: ground water and surface water, collection and distribution of water, water pipes, pumps and pumping machinery.
Wetland Management Introduction: Definition, importance & scope of wetland management in forestry.
Major wetlands in Bangladesh: Sundarbans, Hakaluki Haor, Chalan Beel, Beel Dakatia.

Wetland Biodiversity & Wetland Productivity.
Problems of wetland management in Bangladesh.
Recommended references
1. ASEAN- US Watershed project, 1988. Abstracts of Watershed Management Research and Related Studies in the ASEAN Region. Vol. I. A Publications of ASEAN-US watershed project, College, Laguna, Philippines 4031. 70pp. 2. Beattie, B. B., 1979. Watershed Conditions and Watershed Research needs, Chittagong Hill Tracts. Project Report No.2. Development of the East Pakistan Forest Research Institute, Chittagong. UNDP/ FAO/72/005, Forest Research Institute, Chittagong, 22pp. 3. Geyilk, M. P., 1983. Notes on Soil Erosion and Specification of Basic Structural and Vegetative Control Measures. Field Document No. 6. Dept. soil management and Conservation's education's project Nepal. His Majesty's Government of Nepal. UNDP/FAO, 37pp. 4. Hundson, N., 1971. Soil Conservation. B. T. Batsford Limited, 320pp. 5. Kohake, H. and A. R. Bertrand, 1959. Soil Conservation. McGraw Hill Book Co. New York, 298pp 6. Negi, S. S., 1983. Soil Conservation. Fundamentals of Forestry. Vol. 401. Bishen Singh Mahendra Pal singh. 23-4. Connaught Place, Dehra Dun, 88pp. 7. Nelson, D. V., Laban, P., Shrestha, B. D. and G. P. Kandel, 1980. A Reconnaissance Inventory of the Majorecological Land Units and their Watershed Conditions in Nepal. Integrated Watershed Management Project, Dept. of Soil Conservation's and watershed Management, 292pp. 8. Panday, K. and L. Wenhua, 1987. Watershed Management Experience in the Hindu -Kush-Himalaya, Region. International Center for Integrated Mountain Development Katmandu, Nepal and Commissions for Integrated survey of Natural Resource Chinese Academy of Science, Beijing, China. 9. Raeder-Roitzsch, J. E. 1968. Lectures on Watershed Management and Forest Hydrology. Pakistan Forest College, Peshwar, 244 p. 10. Shrestha, B. D., Vanginnekan, P. and K. M. Sthapit, 1983. Watershed Conditions of the Districts of Nepal. Field Document No. 9. Dept. Soil Conservations and Watershed Management, watershed Management and Conservations Education Project, Nepal. FAO/UNDP, 12pp. 11. Sopher, C. D. and J. W. Baird, 1982. Soils and Soil Management. 2nd edition, Reston Publishing Co. Inc., Virginia 312pp. 12. Wouters, H. J. and K. Shrestha, 1985. Runoff and Soil Loss Studies in the Kulekhani watershed OF/NEP/80/029. 13. Working paper No. 3. Dept. Soil Conservation and Watershed Management. Watershed Management and Conservation Education Project Nepal, His Majesty's Government of Nepal. UNDP/ FAO.

6.1.3 Environmental Pollution and Climate Change

(Fourth Year, Semester 1, 3 Hours/Week, 3.0 Credits)

Current course coverage
Introduction to environmental pollution and climate change: Scientific background of climate change, human and natural drivers of climate change, current and future scenario of climate change (Global and Bangladesh perspective), climate models and sensitivity, impacts of climate change on livelihood, ecosystem and economy, legal and policy frameworks of climate change (i.e., IPCC, UNFCCC, UNCCD, CBD, COP).
Environmental pollution: Global, regional and local environmental pollutions. Definition, causes, effects and control measures of (a) Air pollution (b) Water pollution (c) Soil pollution (d) Marine pollution (e) Noise pollution (f) Thermal pollution (g) Nuclear hazards; role of individual in

prevention of pollution; Arsenic contamination in water and soil, effects on human and other organisms; Acid rain and its effects on terrestrial and aquatic ecosystem, Social issues of environmental pollution.
Case studies on environmental pollution with particular reference to Bangladesh- industrial pollution, agrochemical pollution, domestic and urban pollution, and action plan to control these pollution in Bangladesh.
Treaties of combat pollution and climate change, and to maintain sustainable development.
Climate Change Adaptation and Mitigation: Definition and basic concepts of adaptation and mitigation, principles and importance of adaptation and mitigation, types of adaptation, community and ecosystem based adaptation, strategies of climate change mitigation (i.e., CDM, A/R, REDD+), Resettlement and Rehabilitation of climate refugee (its problem and concern). Conceptual understanding of resilience theory (social and ecological systems), community resilience to natural calamities, community resilience and NRM, ecosystem resilience (case studies of forestry, fishery, agriculture).
Recommended references
1. Andrews, S. and Natkin, M., 1983. World Environment Handbook: A Dictionary of Government Natural Resource Management Agencies in 144 countries. World Environment Centre, New York, 130pp. 2. Anon, 1984. Air Pollutants Effects on Forest Ecosystem. The Acid Rain Foundation, USA, 439pp. 3. Anon, 1979. Fundamentals of Air Pollution Control Technologies. Special Project Research on Detection & Control of environmental Pollution, Japan, 249pp. 4. Abul Bashar, S. H. M. and Reazuddin, M., 1990. Towards Sustainable Development: Issues of environmental Pollution in Bangladesh. Ministry of Environment & Forest and National Conservation Strategy Secretariat, BARC, Dhaka, 53pp. 5. Anon. 1990. UNEP Environmental Data Report, 2nd edition, UNEP, Kenya. 6. Atiq Rahman, A. Haider, R. .Huq. S., and Jansen, E.G. 1994. Environment and Development in Bangladesh. University Press Ltd., Dhaka, 524pp. 7. Chhatwal, G. R., Mehra, M. C., Satake, M., Katyal, T., Katyal, M. and Nagahiro, T., 1993. Environmental Noise Pollution and its Control. Anmol Publications, New Delhi, 301pp. 8. Rahman A. Atiq et al., 2007. Risks, Vulnerability and Adaptation in Bangladesh. UNDP Human Development Report. 9. Kaushik, A., and Kaushik C. P., 2004. Perspective in Environmental Studies. 3rd edition, New Age International Publisher, 309pp. 10. MoEF, 2008. Bangladesh Climate Change Strategy and Action Plan 2008. Ministry of Environment and Forests, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh, 68PP.

6.1.4 Land Use Planning and Management

(Fourth Year, Semester II, 2 Hours/Week, 2.0 Credits)

Current course coverage
Introduction: Definitions; Land characteristics; Significance of land use planning; Steps in land use planning.
Land Use: Concepts of land use; Land cover, Land use and Land cover change; Land function; Land tenure - Ownership; Determination of land and tree tenure; Driving forces of land use change; Models of land and land cover change and their applications.

Land Evaluation: Definition and concept of land evaluation; FAO (1976) framework for land evaluation; Major activities in land evaluation; Methods of land system; GIS application in land evaluation; Parametric land evaluation systems.

Land Evaluation for Forestry: Definitions; Significance of site quality in forest management; Factors of site quality; Keys for identify the site quality; Index of site quality Site qualities of Bangladesh forests Modification of site quality; Traditional system of land classification in Bangladesh; Land capability classification of Bangladesh; Forest land classes of Bangladesh ; Forest land information system; Methods of forest land/site capability evaluation; Appraisal of forest land use potential.

Ecological Regions of Bangladesh: Background information; Agroecological regions of Bangladesh; Dendroecological regions of Bangladesh.

Land Use Planning, Administration, and Policies in Bangladesh: Land use conflicts in Bangladesh; Participatory land use planning; Allocation of *Khas* land in Bangladesh; Basic principles and tools of urban planning; Urban land use planning in Bangladesh; Current land administration of Bangladesh and their functions; Land related policies and acts in Bangladesh.

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2. Beek, K. J., Bie, K. D. and Driessen, P., 2016. Land Information and Land Evaluation for Land Use Planning and Sustainable Land Management. International Institute for Aerospace Survey and Earth Sciences (ITC), PO Box 6, 7.500 AA Enschede, the Netherlands, 1-14.
3. Chaudhury, A. H., 2015. A Short History of Urban Planning in Bangladesh.
4. DAF, 2016. Land Capability Assessment. Department of Agriculture and Food, Western Australia. https://www.agric.wa.gov.au/land-use-planning/land-capability-assessment.
5. Drescher, A.W. 2016. Technical Tools for Urban Land Use Planning. University of Freiburg, Germany.
6. FAO, 1993. Guidelines for Land-use Planning. FAO Development Series 1 ISSN 1020-0819, Food and Agriculture Organization of the United Nations, Rome, Italy, 95pp.
7. FAO, 1995. Planning for Sustainable Use of Land Resources: Towards a New Approach. FAO Land and Water Bulletin 2, 60pp.
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6.1.5 Remote Sensing and Geographic Information System

(Third Year, Semester I, 3 Hours/Week, 3.0 Credit)

Current course coverage
Remote Sensing (RS) Introduction: Fundamental concepts of remote sensing, history, application.
Electromagnetic energy: nature, propagation of electromagnetic radiation, interaction of EMR with atmosphere (scattering, reflection, absorption, atmospheric windows, irradiance, exitance) and matter; spectral properties and reflectance characteristics of earth surface features: vegetation, soil and water; spectral signature; Red edge, vegetation indices.
Major remote sensing systems and sensor technology: spaceborne systems (Landsat, IRS, SPOT, ENVISAT, Terra and Aqua etc) and their sensor characteristics, airborne and spaceborne sensors, types, platforms.
Aerial photography and phtogrammetry: definition of terms- (e.g. drift, tilt, crab, displacement, overlap, photocenters, types of photography, quality, scale, aerial cameras, photo films and filters, mosaic, planning photography, ground control, ground truthing, parallax, stereoscopy, depth perception, application of aerial photography in the fields of forestry.
Satellite: orbit, orbital altitude, types of satellite, communication with satellite.
Global positioning system (GPS)

Satellite imageries: understanding digital imageries, image display and enhancement, FCC, image preprocessing (cosmetic operation, radiometric calibration, atmospheric correction and geometric correction/ geo-referencing); image resolution (spatial, spectral, temporal, radiometric); image classification.
Image interpretation and estimation of earth surface properties: principles, elements of image interpretation, estimation of earth surface properties especially vegetation properties from imageries.
Microwave remote sensing.
Geographic Information System (GIS) Introduction: Definitions of Geographic Information System, components, functional elements.
Theories and Basic of GIS.
Data structure and operations in GIS: raster and vector data, data layers, basic geometric vector operations, buffer zones and overlays, post overlay clean up operations (clip , update, dissolve, merge, eliminate), interpolation, data queries, spatial analysis; map projections, visualization and accuracy assessment.
Recommended references
1. Akthar, S. and Karki, A. S., 1999. Application of GIS to Mountain Land-use Planning. International Centre for Integrated Mountain Development. Kathmandu, Nepal. 2. Campbell, J. B., 2006. Introduction to Remote Sensing. 4th edition, Taylor and Francis, London and New York. 3. Avery, T.F. and Berlin, G.L., 1985. Interpretation of Aerial Photographs. 4th Edition, Burgess publishing co. Minneapolis, Minnesota. 4. Buhmann, S., 1996. Geographic Information System. In Bruenig, E.F. and Bossel, H. (Hewson), Natural Resource Systems Analysis. 5. Chrisman, N., 1997. Exploring Geographic Information Systems. John Wiley & Sons, 298pp. 6. Colwell, R.N.; Esters, I.C. and Thorley, G.A. (Hewson), 1983. Manual of Remote Sensing Vol. 2, Interpretation and Application. Amer. Soc. of Photogrametry, Virginia. 7. De Mers, M. N., 1999. Fundamentals of Geographic Information Systems. 2nd edition, New York, 498pp. 8. Lillesand, T. M. and Kiefer, R.W. 1987. Remote sensing and Image Interpretation. 2nd edition, John Wiley and Sons. New York, USA. 9. Moffit. F.H. and Mihlail, G.W. 1980. Photogrammetry. 3rd edition. Harper and Row Publishers New York. 10. Paine, D.P., 1981. Aerial Photogrammetry and Image Interpretation for Resource Management. John Wiley & Sons, New York, USA. 11. Sharma, M.K., 1986. Remote Sensing and Forest Surveys. International Book Distributors, Dehra Dun, India. 12. Simonett, D. S. and Ulaby, F.T. (Hewson), 1983. Manual of Remote Sensing. Volume-1, 2nd edition, American Society of Photogrammetry. USA. 13. Walford, N., 1995. Geographical Data Analysis. John Wiley & Sons, 446pp.

6.1.6 Internship

(Fourth Year, Semester II, 2 Hours/Week, 1.0 Credit)

Current Internship description
Each student will have to join any forest or environmental related organization (Government/Non-Government/ Private Organization) for at least one month. They will be supervised by the chairman of the examination committee.

Chairman/supervisor will evaluate (30%) the internship performance. This evaluation will be based on the performance report of the student provided by the respective organization. Student will submit a report based on their work experience and it will be evaluated by the two external examiners (20%+20%=40%). Rest of the marks (30%) will; be given for presentation and viva-voce of the student in front of the Chairman of the examination committee and two external examiners.

Graduate Level

6.1.7 Forest Soil Management

(First Year, Semester I, 4 Hours/Week, 4 Credits)

Current course coverage
Introduction: Concept and characteristics of forest soil.
Soils associated with major ecosystems: Ecosystems such as Boreal, sub-alpine lowland coniferous forests, temperate zone mixed forests, temperate zone deciduous forests, temperate zone broad-leaved evergreen forests, shrub and woodland formations, temperate rain forests, tropical forests; soil orders and major ecosystems of the world.
Forest floor: Introduction, function, layers, types of humus and properties of forest floor; characteristics and types of floors in different forests of Bangladesh.
Forest soil biology: Biota including higher plants, their kinds and functions in forest soils, conditions influencing biological activity in forest soils; mycorrhizae, their forms and functions in tree growth; biotic, abiotic and soil factors ion site productivity; interpreting soil factors in site evaluations.
Soil Water: Role of water in forest management; soil water energy and moisture constants; physical classification of soil moisture; methods for expressing water tension; ground water table; soil-plant-water continuum; forest management in relation to water yield, soil and site management.
Nutrient cycling in forest ecosystem: Geochemical nutrient cycling as nutrient input, output and short-term nutrient balances and biological nutrient cycling as nutrient uptake, retention, distribution, return, internal transfer etc.
Soil survey: Purpose, technique, base map used and types of soil survey; soil survey done by SRDI in Bangladesh.
Management of problem soils: Sites such as denuded hill slopes, sandy soils, waterlogged soil, saline, alkali and acidic soils.
Tropical forest soils: Climate, nutrient cycling and traditional system of management of forests in tropical region; Classification of forest soils in Bangladesh.
Forest soils and carbon sequestration: Carbon stock in forest ecosystems, Factors affecting the forest soils carbon concentration and stock, Forest harvesting and soil carbon stock, Climate change and carbon dynamics in forest soils, Challenges in assessing carbon dynamics in forest soils, Evaluation of the magnitude of potential of carbon sequestration by forest soils.
Forest soils education and research: The role of forest soils in contemporary forest management, Forest soils education and the modern forestry curriculum: trend and needs, Research trends and needs in forest soils
Recommended references
1. Armson, K. M., 1979. Forest Soils: Properties and processes. University Toronto Press, Toronto. *2.* Fisher, R. F., 2005, Forest Soils Education and Research: Trends, needs, and wild ideas. *Forest Ecology and Management,* Vol. 220:1–16.

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6.2 Khulna University

Forestry and Wood Technology Discipline

6.2.1 Forest Mensuration and Inventory

(Third Year, Term I, 3 credit hours)

Undergraduate Level

Rationale:
Students are expected to learn the techniques of measuring individual trees and quantifying the available resources in a forest.

Course Objectives:
This course is designed

- To provide acquaintance with forest measurement tools and instruments
- To provide knowledge on tree and stand measurements
- To provide knowledge on Sampling techniques of forest inventory
- To make the student capable in statistical analysis of inventory data

Intended Learning Outcomes (ILOs)
At the end of the course the students will be able to-

- Work in diverse field conditions in forests
- Find a suitable sampling design for forest inventory
- Develop allometric models for individual trees
- Apply allometric models for standing volume estimation before harvesting
- Apply the gained knowledge in forest management
- Present data in a form useful to forest managers

Course Content

Section – A

1. Measurements: The role of Mathematics and Statistics in Forest Mensuration and Inventory; definition of terms, accuracy in calculation, errors of measurement and the measurement of variation, the choice of where and how to measure forest produce.
2. Instruments and principles used in measuring trees: Principles and methods for measurement.
3. Measuring single trees: Diameter, cross-sectional area, height, bark, crown, leaf area index and log; Form and shape of trees, taper functions and equations.
4. Measurement and tree bole volume: Construction and testing of volume table and biomass equation.

5. Tree growth: Simple expressions of growth rates, calculations of growth at constant rates, pattern of growth and stem analysis.
6. Measuring tree crops: Parameters describing even-aged crops of one species; tree density, diameter, basal area, height, crown size & canopy closure, standing volume, biomass, descriptions of even-aged crops of more than one species; parameters describing uneven-aged crops of several species; the diameter and basal area frequency distribution.

Section – B

7. Forest inventory: Definition, types and objectives of forest inventory; recurrent forest inventory.
8. Forest inventory planning: Forest inventory planning and procedure; application of remote sensing and GIS technique in forest inventory planning and design.
9. Growth and yield: Estimation of growth and yield, site classification based on MAI and CAI, site index.
10. Statistical procedures in forest inventory: sampling designs commonly applied in forest inventories- random, systematic, cluster, two phase, multistage and stratified sampling designs; principles and application of point sampling; Point Centered Quarter Method (PCQM); Variable Area Transect (Tubiello et al.).
11. Sample plot design: Choice of plot size and shape; permanent sample plots (PSP)
12. Data processing: Collection of data from field, processing and report writing.

6.2.2 Forest and Environmental Laws and Treaties

(Fourth Year Term II, 2 credit Hours)

Rational: To become a professional forester a student must have the knowledge regarding forest and environment related laws, treaties and protocols, hence this course is an integral part of the forestry undergraduate program.

Course Objectives:

This course is designed

- To make the student understand the legislation process of forest sector
- To make the student familiar with forest and environment related laws, regulation and treaties.
- To provide knowledge about the international treaties and protocols
- To make the student familiar with the forest and environment administration of Bangladesh

Intended Learning Outcomes (ILOs)

At the end of the course the students will be able to-

- Understand how laws are promulgated
- Know about different section subsection of forest and environmental laws of Bangladesh
- Know about the process and bindings of different international treaties and protocols
- Have an idea about the forest and environment administration

Course Content

Section – A

1. Legislation process in Bangladesh: Legislation proposal, white paper, green paper, vetting, approval, and History of forest law in Indo-Bangladesh
2. Definition of common legal terms: Abetment, cognizable and non-cognizable offences, collusion, confession. Compounding offence, Seizure, confiscation, mischief, mistake of

fact, pre-emption, recognizance, royalty, salvage, search warrant, seizure, servitude, summary trials, warrant cases, wasteland, government property, rights and ownership.

3. Legal classification of forests in Bangladesh: Constitution of reserved forest, Constitution of protected forest. Jurisdiction of forest departments over forest resources in Bangladesh
4. Forest and environmental legislative measures: Definition, necessity and limitations of a special forest law, history of forest law in Indo-Bangladesh, application of forest law; history of environmental legislation
5. Forest act and rules: Section by section study of Forest Act. 1927 and Forest Ordinance 1989 (Amendment 2000): Environmental Pollution Control Ordinance (Ordinance No. XIII or 1977); "Bangladesh environment preservation ordinance" Proposed: regulation of toxic materials (Pesticides, insecticides, fungicides, etc.) to up to date. Punishment for different forest offences as per Forest Act 1927 (Amendment 2000), forest cases.

Section – B

6 Rules and regulations in forest sector since 1959 till up to date: Transit rules for Sundarbans Reserve Forest, hill forest, Social forestry rules 2004 (Amendment 2011) Sawmill rule 2012, Brick burning control Act 2013,Private forest ordinance 1959, etc

7 Environment Laws: Bangladesh environment preservation ordinance" Proposed: regulation of toxic materials (Pesticides, insecticides, fungicides, etc.)

8 Treaties: MIKE, CITES, CBD, UNFCC, COPS, RAMSAR, CITES, UNCCD, GTI

9 Legal organization and forest environment services: definition of forest officer; job of forest officer, appointment; powers and limitations of forest officers, special obligation; protection extended by law to forest officers; legal powers of forest officers: Organization responsible for environmental of management.

6.2.3 Aerial Photogrammetry and Remote Sensing

(Second Year Term II, 3 credit Hours)

Rationale This course is designed for the 2nd year students of Forestry and Wood Technology discipline. Students of the course are expected to learn and understand natural resource management with the fundamentals of spatial data acquisition from airborne and spaceborne sensors. It will provide an introduction into the theory of spectral reflectance properties of vegetation, the principles of photographic analysis and aerial photo-interpretation and new advances such as LIDAR, SAR etc.

Course Objectives:

- To be familiar with the methods of taking aerial photograph, analyzing and interpretation of this photograph
- To understand the remote sensing processes of collecting and analyzing satellite images
- To integrate Geographic Information System with remote sensing.

Intended Learning Outcomes (ILOs)

At the end of the course the students will be able to-

- Comprehend the issues related to geometry of aerial photograph
- Measure the height and area from aerial photograph
- Be familiar with the photo interpretation techniques
- Learn the fundamentals of remote sensing and GIS
- Understand Satellite image processing, corrections and analysis
- Integrate the remote sensing images with GIS

Course Content
Section – A
1. Introduction: Definition, history and development of aerial photography, remote sensing and GIS in forestry 2. Aerial Photographs: Geometry of aerial photographs; Vertical and oblique photograph, stereoscopic vision, parallax, photo scale, flight planning, Photo Mosaic. 3. Height and area measurement: Object height measurement on aerial photograph, object count, area measurement, Errors and uncertainties in aerial photogrammetry. 4. Coordinate Systems: Datum, Geographic and Projected Coordinate system, UTM, Global Positioning System 5. Image Integration with GIS: Different methods of integration; problems in integration. 6. Photo interpretation: Principles and elements of image recognition. 7. Application of Aerial photogrammetry and remote sensing in forestry.
Section – B
8. Fundamentals of Remote Sensing: Physical principles of remote sensing, Remote sensing signals, electromagnetic spectrum, Spectral signature, Spatial, temporal and spectral Resolution. 9. Interactions: Atmospheric absorption, scattering, reflection and transmission of solar radiation, Interaction of EMR with earth surface. 10. Satellites and sensors: Remote sensing satellites. Orbit characteristics, Sensor characteristics, scanning mechanics and data acquisition. 11. Satellite Images and its processing: Structure of satellite data, error & accuracy of satellite images, pre-processing and processing techniques, Image Enhancement techniques and corrections. 12. Satellite image analysis: Image classification, supervised and unsupervised image classification, Vegetation index in remote sensing. 13. Microwave Remote Sensing: Concept of RADAR systems, SAR and SLAR, Concept of LiDAR system, Concepts of thermal remote sensing.

6.2.4 Soil Conservation and Watershed Management

(Second Year, Term II, 3 credit hours)

Rationale: Soil conservation and watershed management is an important field of forestry education. Proper understanding of soil conservation and watershed management plays pivotal role in natural resource like forest management. This particular course will offer opportunities to learn major issues of soil degradation and the relevant conservation measures, estimation of loss, soil conservation for watershed area, planning and management of watershed.
Course Objectives: • To make students understand the soil erosion, its mechanism, effect and control measures. • To deliver basic knowledge of watershed area, watershed characteristics and anagement especially in a forested ecosystem.
Intended Learning Outcomes (ILOs) At the end of the course the students will be able to- • Learn and understand major causes of soil degradation and learn solution for soil conservation.

• To be familiar with watershed management concepts and its importance in forests.
Section – A
1. Introduction: Definition and importance of soil erosion, Global context of soil erosion, spatial and temporal variation of soil erosion, soil erosion in Bangladesh. 2. Soil Erosion: Agents and types of soil erosion, Processes and mechanics of erosion, factors influencing erosion, effects of erosion 3. Estimate of soil erosion: Field and laboratory measurement of soil erosion, universal soil loss equation to estimate water erosion; estimating wind erosion losses 4. Soil conservation techniques: Aims and principles of soil conservation and erosion control. Overview and Classification of conservation techniques, Biological conservation techniques; Agronomic conservation measures; Agroforestry as a conservation techniques; Mechanical methods; Conservation by soil management. 5. Restoration of eroded and degraded soil: Definition features and scope of restoration of degraded soil. Types of degraded soil, restoration measures for degraded soil.
Section – B
6. Introduction: Watershed-Definition concept, Importance of watershed, causes and results of watershed deterioration. Basic characteristics, Watershed delineation, watershed divide. 7. Watershed Hydrology: Concept; Basic hydrologic processes with special reference to forest hydrology, precipitation interception, infiltration, evaporation and transpiration, runoff, sub-surface water, ground water, stream order & stream flow water budget and its application. 8. Watershed Management: Introduction principles and objectives of watershed management Watershed planning-Organization and procedure; data requirements for watershed planning. 9. Integrated watershed management; problems in relation to watershed development; need for integrated watershed management study in Bangladesh.

Graduate Level

6.2.5 Forest Soil and Site Productivity

(Major areas: Forest management, 2nd Term, 3Hours/Week)

Section – A
Forest soil: Definition, texture, structure, origin of soil structure, consistency, porosity, temperature and aeration of soil. Origin of soil structure. Forest soil development: factors of soil development, process of soil development, additions, losses, translocation and transformation. Soil organic matter: type and amount of organic matter, form and composition of litter. Energy transformations and decomposition of litter, humus and organic matter, the forest floors. Soil biology: organisms and processes, soil fauna, soil micro flora, bacteria, actinomycetes, fungi, algae and the rhizosphere;. Soil chemistry: Soil reaction -pH, soil elements (carbon, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, aluminum, manganese, trace elements) and oxidation-reduction. Soil water: energy relationships of water, movement of water in soil, soil moisture regimes.
Section – B

Soil fertility and productivity: Elements in plants and in the soil; plant growth, plant-soil relationship. Roots and soil: form and abundance of roots, rooting volume of soil, root growth and soil properties, ecological and silvicultural aspects of root and shoot growth, ecological significance. Organic matter status in Bangladesh soils, Organic matter and energy cycle in forest soils. Classification of Bangladesh soil, agroecological and dendroecological zones of Bangladesh. Identification of sites in Bangladesh forests, relationship of forest sites with the growth factors. Relationship of sites with forest productivity, Identification of land components in the field. Identification of growth factors in the field : Organic matter, colour, soil depth, drainage, texture etc. Soil erosion and forest productivity, forest soil management.

6.3 University of Chittagong

Institute of forestry and Environmental Sciences

Undergraduate Level

6.3.1 Aerial Photogrammetry, Remote Sensing and GIS

(Fourth Semester, Forestry and Environmental Science discipline 4 credit)

Theory
1. Introduction: Scope, importance, historical development of remote sensing 2. Electromagnetic energy: Nature, propagation of electromagnetic radiation, interaction of EMR with atmosphere (scattering, reflection, absorption, atmospheric, windows, irradiance, exitance) and matter, spectral properties and reflectance characteristics of earth surface features: Vegetation, soil and water: Spectral signature: Red edge, vegetation indices 3. Aerial photography: Cameras, films and filters used in aerial photography; Planning, taking and handling of aerial photographs; Determination scale of aerial photographs, supervised and unsupervised data, ground truthing. 4. Photo mosaics: Controlled and uncontrolled mosaics, mapping from remote sensing data with emphasis on triangulation method. 5. Photo interpretation: Principles and elements of image recognition; Topographical study, drainage assessment and road planning from aerial photographs. 6. Satellite imagery: Types of imagery, satellite technology and imagery production; Digital and manual image analysis, multi-concept of remote sensing and MSS data. 7. Major remote sensing systems and sensor technology: Spaceborne systems (Landsat, IRS, SPOT, ENVISAT, Terra and Aqua etc.) and their sensor characteristics, airbone sensors, types, platforms. 8. Introduction to GIS: Concepts, scopes and components of GIS; Map data representation. 9. Geographic database: Concepts, data input, verification and storage. 10. Spatial data analysis: Acquisition of data from different resources, analytical tools and analysis; Digital terrain model and satellite data processing, spatial data set management using GIS; GPS technique.
Practical
1. Orientation of aerial photographs for stereo viewing and scale determination.

2. Visuals image interpretation –delineation of areas, measurement of height and canopy cover.
3. Practical works using GIS software's and GPS.
4. Field visits for mapping and computerized image analysis to Remote Sensing and Mapping Institutions SPARRSO, RIMS and Office of the Survey General of Bangladesh.

References

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2. Avery, T.F. and Berlin, G.L.. 1985. Interpretation of aerial photographs. 4th edn. Burgess publishing co. Minneapolis, Minnesota.
3. Buhmann, S. 1996. Geographic Information System. Bruenig, E.F. and Bossel, H. (Hewson). Natural Resource Systems Analysis.
4. Burrough, P. A. and McDonnel, R. A. 1998. Principles of Geographic Information Systems. Oxford University Press.
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7. Colwell, R.N.; Esters, I.C. and Thorley, G.A. (Hewson). 1983. Manual of Remote Sensing Vol. 2. Interpretation and Application. amer. Soc. of Photogrametry, Virginia.
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10. IDRISI. 1997. IDRISI for WINDOWS ver 2. IDRISI resource center, Clark University, Worchester, MA, USA.
11. Korte, P and George, B. The GIS Book. Onward press.
12. Lillesand, T.M. and Kiefer, R.W. 1987. Remote sensing and Image Interpretation. Second edition. John Wiley and Sons. New York, USA.
13. Lo, C. P. and Yeung A. K. W. 2002. Concepts and techniques of Geographic Information Systems. Prentice-Hall of India.
14. Moffit. F.H. and Mihlail, G.W. 1980. Photogrammetry. 3rd edn. Harper and Row Publishers N. York.
15. Paine, D.P. 1981. Aerial Photogrammetry and Image Interpretation for Resource Management. John Wiley & Sons. New York, USA.
16. Sharma, M.K. 1986. Remote Sensing & Forest Surveys. International Book Distributors. Dehra Dun, India.
17. Simonett, D.S. and Ulaby, F.T. (Hewson). 1983. Manual of Remote Sensing. Volume One. Second edition. American Society of Photogrammetry. USA.
18. Walford, N. 1995. Geographical data analysis. John Wiley & Sons.

6.3.2 Forest Mensuration and Inventory

(Fifth Semester, Forestry discipline, 4 credit)

Theory

Mensuration

1. Definition, objectives, scope and importance of Mensuration in Forestry.
2. Principles, methods and instruments for measurements of diameter and height of trees; Errors of measurements and variations.

3. Principles and uses of Relaskope in forest mensuration; Basal area factors and its uses.
4. Forms and shapes of trees; taper functions and taper equations.
5. Measurement of logs and tree volume; Stack volume estimation, different formulae for calculating volume of logs; Construction and testing of volume table, types of volume tables.
6. Stand variables and measurements of basal area, canopy cover and dominant height; stock measurement.
7. Stem analysis; estimation of age and growth rate of trees in plantations.

Inventory

1. Revision of statistical procedures in sampling and objectives of inventory.
2. Types of forest inventory. Inventory Planning.
3. Sampling designs commonly applied in forest inventories—random, systematic, cluster, two phase, multistage and stratified sampling designs; relative efficiency of sampling designs; subjective and objective sampling designs; Principles and application of point sampling.
4. Choice of plot size and shape, permanent sample plots. Application of remote sensing technique in forest inventory; Forest inventory planning and procedure; Collection of data from field processing and report writing.
5. Estimation of growth and yield, yield table, uses of yield table, MAI and CAI, dominant height, Rotation age fixation, site assessment in plantations for forecasting growth and yield.

Practical

1. Practice of commonly used instruments in forest mensuration and inventory: Diameter tape, Spiegel Relascope, Wedge prism, Sunto clinometer, Haga Altimeter etc .
2. Field exercises in tree and stand measurements, estimation of log volume, standing tree volume, form factor, crown diameter, crown area etc.
3. Use of different sampling techniques in forest inventory.
4. Construction and testing of volume tables, biasness in volume table.
5. Planning and executing an inventory in forests.

References

1. Avery, T.E. Forest Measurements. McGraw-Hill Comp., New York.
2. Bruce, D. and Schumacher, F.X., Forest mensuration, McGraw-Hill book Company, Inc., New York.
3. Chaturvedi, A.N. and L.S. Khanna, Forest Mensuration, International Book Distributors, Dehradun-248001, India.
4. Dilwarth, J.r. and Bell, J.F.. Variable probability sampling. Variable Plot and Three P. OSU Book stores Inc. USA.
5. Hutsch, B. Miller and Beers. Forrest Mensuration.
6. Lauly,J.P. Manual of Forest Inventory with special reference to Mixed Tropical Forests. FAO. Rome.
7. Loetsch, F. and Haller, K.E.. Forest Inventory. Vol. 1 & Vol. 2. HGV Verlagsgesselschaft muucheu, Beru Wien.
8. Philip, M. S. Measuring trees and Forests. Division of Forestry, Univ. of Dar es Saalaam.
9. Temu, A.R. Forest Mensuration. UNDP/ FAOBGD/ 85/011. Field document No. 3. IFESCU.

6.3.3 Watershed Management

(Eighth Semester, Forestry and Environmental Science discipline, 4 credit)

Theory

1. Introduction: Concepts of watershed, its management, objectives, importance and classification in Bangladesh; Important surface and under ground features of watershed;

Classification of soil mantle and nomenclature of various components of under ground water; Hydrological characteristics of rocks and sediments, ground water depth in Bangladesh.

2. Hydrology: Hydrology and forest hydrology; Hydrological cycle, factors influencing infiltration; Measuring infiltration rates; infiltration rates under varied micro-environmental situations, water balance equation and water balance in Bangladesh; Influences of forests on infiltration, rainfall, interception and water storage.
3. Water quality: Water quality and importance of water to quality life of humans, palatability of water, common impurities in water with their effects; Comparative advantages of ground water and surface water, water quality standards and parameters.
4. Erosion and sedimentation: Geologic and accelerated erosion; agents, types and causes of erosion; forms of water erosion; Estimating erosion rates, erosion rates under different land covers, universal soil loss equation, erosivity and erodibility; Conditions, phases, causes and control measures of wind erosion, sediments and sedimentation process, causes of flood in Bangladesh.
5. Shifting cultivation: Shifting cultivation worldwide and in CHTs, land administration system, extent, intensity and causes of shifting cultivation in CHTs.
6. Soil conservation: Aim and principles of soil conservation; mechanical, vegetative, agronomic and management based measures of soil conservation in upland watershed of Bangladesh; low cost and expensive soil conservation structures and which one to be applied under which situation; contour and contouring; effects of different forest management activities on watershed health; SALT in soil conservation; indigenous technology knowledge for watershed management in Bangladesh and mouza forest.
7. Planning for watershed development: Need for planning, procedure of watershed planning, data requirements for an integrated plan, economic analysis and watershed work plan for watershed development.

Practical

1. Field demonstration on concepts and important features of a watershed.
2. Laying out of contours on hill slope and measurement of hill slopes.
3. Surveying and identifying various forms of soil erosion including gullies.
4. Demonstration of techniques and procedures to reduce various soil erosions related problems.
5. Measurements of discharge and sediment loads in streams.
6. Determination of watershed characteristics, such as length of stream, stream density, and drainage density of watershed using maps of river systems in Bangladesh.
7. Determination of infiltration rates in the field under different land uses and topographical positions, and drawing graphs with collected data.
8. Preparation of report based on collected information from laboratory and field.

References

1. S. M. Sirajul Haque, C-sequestration and CO_2 release in upland watershed of Bangladesh, IFESCU and USDA, 2013, ----pp.
2. S. M. Sirajul Haque, Hill cutting in and around Chittagong city, IFESCU and USDA, 2011, 90 pp.
3. S. M. Sirajul Haque, Infiltration in upland watershed of Bangladesh, IFESCU and USDA, 2012, 75 pp.
4. Raeder-Roitzsch, J. E Lectures on Watershed Management and Forest Hydrology.. 1968, Pakistan Forest College, Peshawar.

5. Notes on soil Erosion and specification of basic structural and vegetative control measures. Geyilk, M. P. Field Document No. 6. Nepal. UNDP/FAO.37. 1983
6. Principles of Forest Hydrology, Hewlett, J. D. 1982
7. Soil and water in upland watershed of Bangladesh, S. M. Sirajul Haque, IFESCU and USDA, 2013, 350 pp.
8. Soil Conservation. Hundson, N. 1971, B. T. Batsford Limited.
9. Soil Conservation. Kohake, H. and A. R. Bertrand 1959, McGraw Hill Book Co.NewYork.
10. Soil erosion in upland watershed of Bangladesh, S. M. Sirajul Haque, IFESCU and USDA, 2012, 131 pp.
11. Vegetation in upland watershed of Bangladesh, S. M. Sirajul Haque and Mostafa Kamal Pasha, IFESCU and USDA, 2013, 302 pp.
12. Watershed Management Extension and Environmental Conservation in Bangladesh, S. M. Sirajul Haque and Maung Hla Myant, IFESCU and USDA, 2011, 188 pp.
13. Watershed Management from Bangladesh Perspective, S. M. Sirajul Haque, IFESCU and USDA, 2013, ---- pp.

6.3.4 Land Use Planning and Management

(Eighth Semester, Forestry discipline, 4 credit)

Theory

1. Land: Land and its characteristics; land tenure- ownership rights; land use conflicts

2. Land use: Combined and multiple land uses, irreversible and reversible land uses, Land use change, drivers/factors and effects and history of land use change, land use models and examples; Importance of land use study, agrarian transformation, land reforms and some experiences.

3. Land use planning: Nature, scope, usefulness, planning goals and focus of land use planning, levels of planning, and planning process and steps in land use planning.

4. Land and land use policy in Bangladesh: Land use policies, Principles and national policies and covering land and land use in Bangladesh

5. Land assessment: Description of land factors considered for land evaluation; simplified methods for site classification and site suitability assessment; framework for land evaluation; soil information systems, parametric methods, and the land system methods.

6. Capability classification: Understanding the terms land capability, crop suitability, traditional system of land classification in Bangladesh, main land capability classes and subclasses in Bangladesh and description of land capability classes selected for forests.

7. Site quality: Site and Site quality, significance of site quality in forest management; site and forest productivity and site factors that influence productivity; modification of site productivity; approaches for determination of site quality; site qualities recognized for the forests of Bangladesh,

8. Agroecological and dendroecological regions: Background information for creation of agroecological and dendroecological regions in Bangladesh, description of the main components of agroecological regions; Description of dendroecological classification in Bangladesh.

9. Landscape management: Characteristics, objectives and procedures of landscape management.

10. Urban planning: Factors consideration, principles for urban planning.

References

1. Brammer, H. 2002. Land Use and Land Use Planning in Bangladesh. The University Press Limited, Dhaka.
2. Davidson, D.A. 1982. Soil and Land Use Planning. Longman, London.
3. Davies, K.P. 1976. Land Use. McGraw-Hill Inc. USA.
4. FAO, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development, UNDP/FAO Project BGD/81/035, Technical Reports 1-7, FAO, Rome.
5. FAO. 1993. Guidelines for Land-use Planning. Food and Agriculture Organization of the United Nations, Rome (
6. FAO/UNDP. 1971. Bangladesh Soil Resources, Soil Survey Project, AGL: SF/PAK 6 Technical Report 3.
7. Hassan, M.M. 1999. Soils of Bangladesh: Their genesis, classification and use potential. March Printers Ltd., Dhaka.
8. Mandal, R.B. 1990. Land Utilization: Theory and Practice. Concept Publishing, New Delhi.
9. OECD, 1976. Land use policies and agriculture. Organization for Economic Co-operation and Development, Paris.
10. Richards, B.N. and Hassan, M.M. 1988. A Co-ordinate Forest Soil Research Program for Bangladesh.
11. Richards, B.N. and Hassan, M.M. 1989. Dendroecological regions of Bangladesh: A land capability assessment for tree species. FAO/UNDP Project BGD/81/010, Working Paper- 7, BFRI, Chittagong.
12. Sabrousse, R. 1984. Preliminary Report on the Ecological Classification of Plantations in the Chittagong and Chittagong Hill Tracts District. Working Paper No. 2, FAO/UNDP Project BGD/79/017.
13. Stevens, P.R. 1987. A simplified field manual for site classification and site suitability assessment in Bangladesh forests. FAO/UNDP Project BGD/81/011- Assistance to the second Agricultural research Project.

Graduate Level

6.3.5 Forest Soils

(Forestry discipline, 4 credit)

Theory

1. Introduction: Concept and characteristics of forest soils.
2. Soils associated with major ecosystems: Forest ecosystems such as boreal, sub-alpine lowland coniferous forests, temperate zone mixed forests, temperate zone deciduous forests, temperate zone broad-leaved evergreen forests, shrub and woodland formations, temperate rain forests, tropical forests; soil orders and major ecosystems of the world.
3. Forest floor: Introduction, function, layers, types of humus and properties of forest floor; characteristics and types of floors in different forests of Bangladesh.
4. Soil biology: Biota including higher plants, their kinds and functions in forest soils, conditions influencing biological activity in forest soils; mycorrhizae, their forms and functions in tree growth.
5. Effects of vegetation on Soil: Effects of tree growth on soil properties.
6. Soil water: Role of water in forest management; soil water constants; physical classification of soil moisture; methods for expressing water tension; soil-plant-water continuum; forest management in relation to water yield; soil and site management.

7. Nutrient cycling: Geochemical nutrient cycling as nutrient input, output and short-term nutrient balances and biological nutrient cycling as nutrient uptake, retention, distribution, return, internal transfer etc. in forest ecosystem.
8. Management of problem soils: Management of sites such as denuded hill slopes, land slips, sandy soils, waterlogged area, saline, alkali and acidic soils.
9. Tropical soils: Climate, geology, soils, nutrient cycling and traditional system of management of forests in tropical region; classification of forest soils in Bangladesh.
10. Soil survey: Purpose, technique, base map used and types of soil survey; soil survey done by SRDI in Bangladesh.

Term paper: Students will prepare term paper on topics given by course teacher.

References

1. Armson, K.M. 1979. Forest Soils: Properties and Processes. Univ. Toronto Pres. Toronto.
2. N. C. Brady. 1996. The Nature and Properties of Soils 10th edition, Prentice Hall of India Private Ltd.
3. Pritchett W.L. and Frisher. R.F. 1987. Properties and Management of Forest Soil. John Wiley & sons, New York.
4. S.M. S. Haque. 1997. Afforestation Effects on Formar agricultural Soil Ph D Thesis, Aberdeen University. UK.
5. USDA, 1951. Soil Survey Manual, Hand Book No- 18, Washington D. C. U.S.A.
6. Wilde S.A. 1958. Forest Soil, Ronald Press Company.

6.3.6 Climate Change

(Forestry discipline, 4 credit)

Course contents

1. Climate Change: Definition; Scope; Importance for planet with advanced protocols; Impacts on temperature rise, Sea-level rise, Precipitation change, Carbon sequestration; Droughts and floods.
2. Impacts on Human and Natural Systems: Food and water resources; Ecosystem and biodiversity; Human settlements; Human health.
3. Adaptation Process: Assessment of adaptation practices, options, constraints and capacity. Socioeconomic development paths; Economic growth; Technology; Population and Governance.
4. Mitigation: Issues related to mitigation in the long term context; Energy supply, Transport and its infrastructure, Residential and commercial buildings, Industry, Agriculture, Forestry, Waste management. Mitigation from a cross sectoral perspectives.
5. Emissions and Concentrations: Advanced knowledge on Greenhouse gases and Aerosols.
6. Climate Change Scenarios: Derivation procedure; Modelling approach; Extrapolation methods from international to regional, national and local climate change scenarios.
7. Future Impacts of Climate Change: Africa, Asia, Australia and New Zealand, Europe, Latin America, North America, Polar Regions (Arctic and Antarctic) and Small islands of the world.

Term paper

1. Term paper on issues on climate impact on Bangladesh.
2. Adaptation due to climate change in plants, human being.
3. Mitigation procedure generally followed for changing climate special ref to sea level rese

References

1. IPCC. 2001. Climate Change 2001. Synthesis Report. A contribution of working groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Watson, R. T. and The core writing team (Hewson)]. Cambridge University Press. Cambridge. United Kingdom and New York, NY, USA. 398pp.
2. Lillesand, T.M. and Kiefer, R.W. 1987. Remote sensing and Image Interpretation. Second edition. John Wiley and Sons. New York, USA.
3. Miller (Jr), G.T. 2002. Environmental Science, Working with the Earth. Thompson Learning Inc. 541 pp.
4. Moffit. F.H. and Mihlail, G.W. 1980. Photogrammetry. 3rd edn. Harper and Row Publishers NY.
5. Paine, D.P. 1981. Aerial Photogrammetry and Image Interpretation for Resource Management. John Wiley & Sons. New York, USA.
6. Sharma, M.K. 1986. Remote Sensing & Forest Surveys. International Book Distributors. Dehra Dun, India.
7. Simonett, D.S. and Ulaby, F.T. (Hewson). 1983. Manual of Remote Sensing. Volume One. Second edition. American Society of Photogrammetry. USA.
8. Walford, N. 1995. Geographical Data Analysis. John Wiley & Sons. 446p.

7 Bangabandhu Sheikh Mujibur Rahman Agricultural University

Department of Agroforestry and Environment

7.1 Introduction to Agroforestry and Environmental Science

(Course credit: 3 + 1.5)

Course contents
Agroforestry
Concepts and definition of Agroforestry, characteristics and components of Agroforestry.
Status of forest in major forest ecosystems of Bangladesh.
Overview of world forest.
Need and perspective areas of Agroforestry in Bangladesh.
Benefits of Agroforestry.
Social forestry and community forestry.
Hypothesis in Agroforestry.
Classification in Agroforestry.
Multipurpose tree species of Agroforestry.
Brief description of major Agroforestry systems in Bangladesh.
Environmental Science
Concepts and major components of Environment
Description of different layers of atmosphere
Brief description of hydrosphere, lithosphere and biosphere.
Environmental pollution: Air pollution, water pollution, noise pollution.
Arsenic contamination of ground in Bangladesh
Greenhouse gases and global warming