10, Institutional Area, Vasant Kunj, New Delhi

MINUTES OF THE FORTY SIXTH MEETING OF THE ACADEMIC COUNCIL HELD ON 26 JULY 2019 AT 10.30 A.M.

PRESENT

The following members of the Academic Council attended the meeting:

Members		**Special invitees**
Prof Manipadma Datta	Chairperson	
Prof Arun Kansal		
Prof Prateek Sharma		Dr Seema Sangita
Prof TC Kandpal		Dr Nandan Nawn
Prof Vivek Suneja		Dr Neeti
Assoc Prof Rakesh Mehrotra		Dr Anu Rani Sharma
Dr Ramakrishna Sitaraman		Dr Fawzia Tarannum
Dr Anandita Singh		Dr Sherly
Dr Shaleen Singhal		Dr Shantanu de Roy
Dr Atul Kumar		Dr Kavita Sardana
Dr Sapna A Narula		Dr Chandan Kumar
Dr Smriti Das		Dr Soumendu Sarkar
Dr Vishnu Konoorayar		Dr Shashi Bhushan Tripathi
Dr Vinay Shankar P Sinha		
Dr Sukanya Das		
Dr Akash Sondhi		
Dr Nithiyanandam Yogeswaran		
Capt. Pradeep Kumar Padhy (Retd.)	Secretary	

Dr Malathi Lakshmikumaran and Dr Anubha Kaushik could not attend the meeting. Dr Chaithanya Madhurantakam & Dr Sudipta Chatterjee were on leave of absence.

The Chair welcomed all the members of the Academic Council and requested the Registrar to start the proceedings of the meeting.

Item No.1: To confirm the minutes of the Forty Fifth Meeting of the Academic Council held on 08 April, 2019. The Registrar informed that the minutes of the Forty Fifth Meeting of the Academic Council, held on 08 April 2019, were circulated to the members and no comments have been received so far.

TS/AC/ 46.1.1: The Council resolved that the minutes of the meeting of the 45th Academic Council held on April 8, 2019 be confirmed.

Item No.2: **Matters for information**

(a) **AICTE Approval.** The Registrar informed that AICTE extension off approval (EOA) have been obtained vide AICTE Letter dated 10 April 2019 for five programmes namely MTech (REEM), MTech (UDM), MTech (WREM), MBA(BS) and MBA(Infra). He intimated that the AICTE had asked for compliance with respect to certain facilities and a letter requesting waiver of the same has been sent to AICTE.

(b) **Appeal to NAAC for re consideration of Grade:** The Registrar informed that NAAC has reviewed the appeal filed by TERI SAS for reconsideration of the grade conveyed in November 2018. He stated that NAAC has finally intimated that the appeal has been reviewed and have retained the original score of 2.84 at "B++" grade valid for a period of five years from May 1, 2019. Members enquired if NAAC has indicated where we are lacking to this the Dean (Academic) briefed about the areas where the scores have been low and intimated that a preliminary analysis was carried out prior to sending the appeal. Dr Kansal briefed the members about the process followed in preparation of the application for appeal. Members strongly recommended that an in-depth analysis of the NAAC report be carried out to find the gaps so that corrective measures for the same could be adopted.

Item No.3: **To discuss and approve name of co-opted member.** The Registrar intimated that as per UGC Regulations, the Academic Council is required to co-opt three persons who are not teachers. He mentioned that one of the member's seat fallen vacant needs to be filled and requested the Academic Council to approve a name. Members suggested that an internal committee of AC be formed to shortlist a name for the Council. The Chair requested Dr Shaleen Singhal, Dr Smriti Das and Dr Vishnu Konoorayar to constitute the internal committee and suggest a name to the Council.

TS/AC/ 46.3.1: The Council resolved to approve the constitution of the Internal committee consisting of the following to recommend a name as per UGC eligibility criteria.:-

(a) Dr Shaleen Singhal (Convenor)
(b) Dr Smriti Das
(c) Dr Vishnu Konoorayar

Item No.4: **To consider and approve the outline of following new and revised courses proposed by Department of Policy Studies**. The outlines of some of the new and revised coursed proposed by Department of Policy Studies and recommended by its Board of Studies held on May 10, 2019, were placed before the Council for approval. Course presentations were given by faculty members. The following suggestions were provided by the Council: -

Methods of Research in Economics

- Description text be changed to be compatible with the entry in the Programme Brochure
- Originality be added as one of the General Parameters of Assessment (module 9)
- Module 9 title may be changed to indicate that the contents are not exhaustive

Methods of Research in Economics; Natural Resource Economics; Environmental Economics

- Readings are to be separated as Core and Other
- Course offered in 'entry' to be made 'all semesters'

Trade, Development and Environment

- Discussion on International Finance and Capital Flows has not been covered.
- Replace the phrase "compulsory readings" with "core readings"
- Avoid specifying the semester

Economics of Health and Environment

- Readings are to be separated as Core and Other
- Course offered in 'entry' to be made 'all semesters'

Microeconomics II

- The details of the course coordinator to be removed (for all courses).
- "Semester offered in" information to be updated as "either semester"
- Reading material is now classified as "Core" and "Additional"

Labour Economics

- Incorporate global political economy and role of state in analysing informalisation of labour.
- Use 'core/other' readings rather than compulsory/optional readings in the course outline.

Applied Quantitative Data analysis in Development Practice

- Course outline to be revised and placed in the next AC

Advanced Econometrics; Time series and regression analysis

- For Time series and regression analysis course, topics to be rearranged to maintain flow and continuity.
- Additional learning outcome i.e., acquiring proficiency in statistical package to be added.
- Semester to be changed from third semester to all semester.
- Reading list title to be changed from compulsory and suggested to core and others respectively.

TS/AC/46.4.1 The Council resolved that the course outline of the following courses submitted by Department of Policy Studies placed at Annexure 1 be accepted and approved as amended: -

A. New Courses:

S. No.	**Course Title**	**Program**	**Type of Course**	**Credit**
(a)	Methods of Research in Economics	M.Sc. Economics	Core	4
(b)	Natural Resource Economics	M.Sc. Economics	Core	4

(c)	Environmental Economics	M.Sc. Economics	Core	4
(d)	Indian Agricultural Development: Contemporary Issues	M.Sc. Economics	Elective	4
(e)	Trade, Development and Environment	M.Sc. Economics	Elective	4

B. Revised Courses:

Ser.	**Course Title**	**Program**	**Type of Course**	**Credit**
(a)	Economics of Health and Environment	M.Sc. Economics	Elective	4
(b)	Microeconomics II	M.Sc. Economics	Elective	4
(c)	Labour Economics	M.Sc. Economics	Elective	4
(d)	Advanced Econometrics	M.Sc. Economics	Elective	4
(e)	Time series and regression analysis	M.Sc. Economics	Elective	4

Item No.5: **To discuss and approve the list of experts for Selection Committee to select faculty.** The Registrar presented a list of experts to the Council and stated that the proposed list has been reviewed by the Executive Committee of the University. He intimated that as required by UGC, VC would nominate members from the approved list of experts in various subjects for various selection committees. He requested the council to review and approve the list. Members mentioned that the list circulated needs to be reviewed once more and suggested that each recommended name must be looked into very carefully. Members also suggested that the names so chosen to be either at the rank of professors or equivalent.

TS/AC/ 46.5.1: The Council resolved that:-

(a) Revised names of experts in the rank of professors or equivalent in the following format be presented to the AC for further review:

Ser No	Name	Designation (Professor or Equivalent)	Specialisation	Affiliation	Full Address	Email id	Mobile No

(b) In the interim, the names in the rank of Prof and equivalent in the list presented in the agenda be used till a final list is approved by AC.

Item No.6: To consider and approve a policy on prevention of plagiarism in TERI SAS. The Registrar informed that as advised by the Academic Council vide its resolution TS/AC/45.10.1 dated April 8, 2019 in its 45th meeting, wider consultation on

suggested issues other than UGC stipulations were held by the Executive Committee of the University. He stated that based on the recommendation of the Committee it is now proposed that the UGC (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulations 2018, be adopted by TERI School of Advanced Studies w.e.f. AY 2019-20. Dr Ramakrishnan, Chairperson IAIP, apprised the members that a draft policy on the subject has been debated and the university intends to form certain guiding principles to implement the UGC policy. He informed that the UGC notification came in 2018 hence there is a need to initiate the University to its salient features. He informed that as regards to preparedness, the department level committees have been constituted and faculty members have been requested to get unique researcher id and orientation programme on plagiarism and software has been conducted for both faculty and students.

TS/AC/46.6.1: The AC resolved to approve that UGC regulations be adopted by the University while ensuring adequate spread of awareness and preparedness amongst all stake holders.

Item No.7: **To consider and approve the outline of Semester III courses of MSc (Geoinformatics) Programme.** The outlines of a few courses proposed by the Department of Natural Resources recommended by its BoS on February 12th, 2019 were placed before the Council for approval. Course presentations were given by faculty members. The following suggestions were provided by the Council:-

Advances in Remote Sensing [Thermal, Hyperspectral, Microwave, LIDAR and UAV]

- Title to be changed slightly.
- To remove error in course prerequisite.
- Modify course objective and outcomes.

Applications of Geoinformatics for water Resources

- Make lab list more clear for the students.
- Remove the Chlorophyll word from module no. 12.

TS/AC/46.7.1 The Council resolved that the course outline of the following courses submitted by Department of Natural Resources placed at Annexure 2 be accepted and approved as amended:-

	Course offered in Semester III	Core/Elective	Credit
(a)	Advances in Remote Sensing [Thermal, Hyperspectral, Microwave, LIDAR and UAV]	Core	4
(b)	Advances in GIS and current trend	Core	4
(c)	Applications of Geoinformatics for Land Resources	Core	3
(d)	Applications of Geoinformatics for water resources	Core	3
(e)	Applications of Geoinformatics for Atmosphere	Core	3
(f)	Geocomputation	Elective	3

Item No. 8 : **To consider and approve the Courses proposed by Department of Regional Water Studies.** The outlines of a few courses proposed by the Department of Regional Water Studies and recommended by its BoS on June 27th, 2019 were placed before the Council for approval. Course presentations were given by faculty members. The following suggestions were provided by the Council: -

Economic and financial evaluation of water infrastructure

- In module 3 there was a suggestion to include risk with uncertainty
- More number of hours be assigned to module 5.

Introduction to geoinformatics

- The topic 'Introduction to GPS' in Module 3 should have differential method of GPS mentioned in the syllabus.

TS/AC/46.8.1 The Council resolved that the course outline of the following courses submitted by Department of Regional Water Studies placed at Annexure 3 be accepted and approved as amended: -

	Course	Core/Elective	Credit
(a)	Economic and financial evaluation of water infrastructure	Core	4
(b)	Introduction to geoinformatics	Core	4
(c)	Qualitative research methods and technical writing	Core	3
(d)	Applied geoinformatics for water resources	Core	3

Item No.9: **To discuss and approve pre-requisite for course**. Dr Smriti Das informed that the Department of Policy Studies conducts a core course titled "Project design and management for sustainable development practice", which is offered in the third Semester of MA-SDP Programme. She stated that to make it more practice oriented and connect the course to ground level data and case studies, it was felt this course needs to be connected to a course offered in the second Semester titled "Group practicum : community needs assessment". She proposed that "Group practicum: community needs assessment", be approved as a pre-requisite course for taking the course "Project design and management for sustainable development practice".

TS/AC/46.9.1: The AC resolved to approve that ''Group practicum: community needs assessment be approved as prerequisite course for taking the course Project design and management for sustainability development.

Item No.10: Extension of maximum period of submission of Thesis. Dr Sapna A Narula informed the members that Mr Dangi registered for Ph.D. Programme at the University on July 15, 2013. She stated that while he had completed his thesis work on time and also submitted it. However since he had not yet fulfilled the requirement of one published paper in a peer reviewed journal his thesis could not be accepted. She mentioned that the student's papers are under consideration by a refereed journal. She mentioned that on the recommendation of the DRC, the AC

may consider granting an extension of one year to Mr Dangi to enable him to complete his Ph.D.

TS/AC/46.10.1: The Council resolved to approve an extension of one year with effect from 15 July 2018 for further submission of thesis for Mr Neeraj Dangi (Reg 1103 RPA).

Item No. 11: To discuss and approve a structure of a programme on Post Graduate Diploma in Renewable Energy. Dr Sapan Thapar shared the rationale for launching the proposed programme (1-year Post Graduate Diploma in Renewable Energy) with AC Members. Discussions were held on the market needs and requirement of the Programme. Programme structure placed at annexure 4 was presented giving an outline of the four modules -1 core and 3 electives. AC members suggested wider consultation with stakeholders to be held while designing the programme.

TS/AC/46.11.1 The Council resolved to provide in-principle approval for the proposed structure of '1- year Post Graduate Diploma Programme in Renewable Energy' placed at Annexure 4.

There being no other items for discussion, the meeting was adjourned with a vote of thanks to the Chair.

Sd/
Capt Pradeep Kumar Padhy (retd.)
Registrar

Enclosures:-
Annexure 1
Annexure 2
Annexure 3
Annexure 4

Distribution:-
Electronic Copy:
1. Vice Chancellor, TERI School of Advanced Studies
2. All members of Academic Council
3. Website

Printed Copy:
Registrar Office

Annexure 1

Course title: Methods of Research in Economics			
Course code: MPE xxx	**No. of credits:** 4	**L-T-P:** 42-4-20	**Learning hours:** 56
Pre-requisite course code and title (if any): Microeconomics and Macroeconomics at Post Graduate Level or equivalent; MPE 185 Environment and Economic Development			
Department: Department of Policy Studies			
Course coordinator(s): TBD	**Course instructor(s):** TBD		
Contact details: TBA			
Course type: Core	**Course offered in:** Any Semester		

Course description

This course provides a broad exposure on various steps in conducting meaningful and grounded research in economics with a focus on ecological, environmental and resource economics, the specialization of the MSc Economics programme. In the process, it walks the students through the entire spectrum of research design, that begin with theories, concepts, frameworks and models and end with a Research Proposal for the Masters' Thesis to be written in the fourth semester.

Course objectives

1. To provide the students an exposure to some stages of research in economics, from conceptualisation to proposal writing.
2. To make the students understand the significance of academic rigour, logical consistency and expositional clarity in research.

Course content

Module	**Topic**	**L**	**T**	**P**
1.	**Introduction** 1.1 Logical reasoning 1.2 Statement of facts 1.3 Facts – social and natural 1.4 Values -- social construction, assumptions and interpretations 1.5 Causation 1.6 Explanations--evolutionary, functional and causal 1.7 Method of scientific investigation: induction, inference, hypothetico-deductive model and falsification	12		
2.	**Theories, Concepts, Paradigms, Frameworks and Models** 2.1 Illustration 1: Institutional Analysis and Development Framework 2.2 Illustration 2: Socio-ecological systems	6		
3.	**Research Design: Research Problem, Research Questions and Research Method** 3.1 Goals, aims, objectives 3.2 Requirements for and of a Hypothesis	3		

	3.3 Case study method 3.4 Interdisciplinarity--potential and challenges			
4.	**Selected aspects of theoretical research** 4.1. Preliminaries: specification of agents, action space, state space, strategies, payoffs, assumptions 4.2. Notion of equilibrium/optimum used 4.3. Results: characterization, comparative statics, robustness 4.4. Interpretation and explanation	4		
5.	**Presentation of Research Concept Note**			8
6.	**Secondary Data** 6.1 Metadata [with illustrations from National Accounts Statistics Sources and Methods 2007 and SDG Index and Dashboards Report 2017 - Metadata] 6.2 Managing large database [with illustrations from IHDS and Cost of Cultivation Dataset] 6.3 Cleaning of data [with illustrations from IHDS and Cost of Cultivation Dataset]	3	4	
7.	**Primary data** 7.1. Type of Quantitative and qualitative data collection methods 7.2. Potential and challenges of use of qualitative data in economics 7.3. Sites of study 7.4. Framing of questions and Design of questionnaire 7.5. Conducting Field survey—issues and challenges	6		
8.	**Expressions for a proposal** 8.1.Framing of Abstract: proposals and papers 8.2.Framing of Introduction: motivations 8.3.Aligning the question with theoretical ideas and concepts 8.4.Reporting a Literature Survey or Review: meta analysis 8.5.Description of the Research Method: appropriateness, justification of choice, limitations 8.6.Listing of variables and their justification 8.7.Data to be used and collection method: sampling plan, sample size, unit of analysis, study site description, if any 8.8.Empirical Method for data analysis: prospects and limitations in answering the research question 8.9.Anticipated results: local, regional and national policy implications, if any 8.10. Matrix: linking hypothesis (if any), research design, variables, empirical method, data sources 8.11. Presentation of results: description, interpretation, implication, prescription 8.12. Professional Ethics in Research	6		
9.	**Overview of some of the General Parameters for Assessment, Evaluation and Review**	2		

	9.1. Content, Structure and Form 9.2. Academic Rigour 9.3. Expositional clarity 9.4. Logical consistency 9.5. Integration and coherence 9.6. Originality			
10.	**Presentations of Proposals**			12
		42	**4**	**20**

Evaluation criteria

1. **ASSESSMENT 1**: Research Concept Note – 20% (learning outcome 2)

Structure

A. Title: It should capture the essential theme(s) of the proposed research. It should show clearly what is being investigated. A concise and focused title is preferred (no more than 15 words).

B. Motivation: Provide an *account* of (a) why do you want to inquire into this specific area and (b) its relevance (ecological, economic, social, political, philosophical, policy related, legal, etc.)

C. Research Problem: Provide a clear and simple *description* of your research problem (maximum 200 words). What do you want to find out? What will be known after this research is conducted?

D. Objectives: *Identify* overall study goals and specific research objectives (maximum 100 words)

E. Background (a complete Literature Review is not necessary at this stage): A concise review of the main research work and current issues in the specific subject area. What is already known about this specific subject? What is/are the gap/s? Identify at least three papers whose methodology/ model you are most likely to apply. (300 words)

F. Hypotheses/research questions to be tested or answered (maximum 25 words each).

G. Analytical Methods: *Describe* economic theory/ies and concept/s that your work will rely on for testing hypotheses/ answering research questions (200 words)

H. Proposed Empirical Methods, if any (100 words): *Describe* type of models, tools of analysis, etc. and justify their employment.

I. Description of the Study Site (if any, but can be indicative), variables and data sources (100 words): definition of variables, indicators, etc.

Criteria and sub-criteria for assessment

A. Title: Extent of focus and relevance.

B. Research Problem: Expositional clarity and logical consistency.

C. Research objectives: Whether clear and achievable.

D. Background: Sufficiency of description of the state of knowledge and identification of gaps.

E. Research questions/hypothesis: How interesting the question/s is/are? How important are they? Does addressing it/them fill/s any gap in literature? Feasibility of answering them: does it require significant monetary expense, a duration of more

than 9 months, access to and use of leased in equipment and materials, new technical knowledge and yet-to-be acquired skill, and access to a really large number of human subjects.

F. Methods and data: Level of clarity on proposed methods (analytical and empirical) and approaches of data collection.

G. Integration and Coherence across different components.

Suggested weights in total marks:

25% each on (a) research question and (b) method and data

10% each on (c) title, (d) research problem, (e) research objectives, (f) background, and (g) integration & coherence.

2. **ASSESSMENT 2**: Presentation of Research Proposal – 30% (learning outcome 1)

Criteria and sub-criteria for assessment

A. Introduction, Problem Statement and Research Question: Relevance, Clarity, Innovativeness.

B. Literature review: Coverage, Ability to review the relevant literature, Inferences of gaps in the literature.

C. Method: Choice of method, Appropriateness of method, Comprehensive background, description and limitations of the method; Discussion of conjectures/variables/data sources/sampling strategy and questionnaire (if relevant)

D. Expected findings/Discussion of results: Clarity on expected outcome of the project; Interpretation and implications of results (in case of final presentation

E. Integration and Coherence: Linkages between the introduction, problem statement, research question, method, results, conclusion, etc.

F. Clarity of Presentation: Audible and comprehensible; Information is presented in logical sequence; Good language skills and pronunciation; Appropriate pace of presentation

G. Quality of visual presentation: Clarity; Organization and layout.

H. Responses during Q&A session: Response to questions and comments.

Suggested Weights in total marks:

20% each on (a) method of analysis, (b) integration & coherence and (c) clarity of presentation

10% each on (d) literature review, (e) expected findings/discussion of results, (f) quality of visual presentation and (g) responses during Q & A session.

3. **ASSESSMENT** 3: Research Proposal – 50% (learning outcome 2)

Structure

A. Abstract or a Summary of research proposal: a self-contained summary of the proposal with clear objective, research question/s, research method, data, and anticipated results. [400 words]

B. Research Problem: a clear and simple description of your research problem, the socio-economic and environmental context and why it is important to investigate further (your contribution in the backdrop of existing literature), and potential policy implications of your work.

C. Study Goals: identify your overall goal of the study, specific objectives /research question. You should clearly state single but critical and interesting research question/s to address the issue that raised in the 'Research Problem'.
D. Literature Review: an e*xhaustive* account of relevant knowledge domains. Review may be restricted to the works most pertinent to the study. You should clearly identify the research gaps and your likely contribution using latest literature.
E. Research Methods
    1. Theoretical ideas and relevant concepts: include logical/ theoretical/ behavioral model and link it with hypothesis, research question and empirical method/data.
    2. Hypothesis to be tested, if any.
    3. Clear indication of what variables to be used and why.
    4. Data to be used and collection methods (sampling plan, sample size, unit of analysis, etc.).
    5. A description of the study site, if any.
    6. Empirical methods for data analyses. It should be clearly linked with your research question, and how your proposed analysis answers the question.
F. Expected Results.
G. Policy implications: local, regional, or national.
H. Bibliography following an accepted citation style such as Chicago Manual of Style or APA or EPW.
I. Annexure: Draft questionnaire in case primary data are to be collected.

Criteria and sub-criteria for assessment

A. Abstract: Comprehensiveness.
B. Problem Statement and Research Question: Relevance; Clarity; Innovativeness.
C. Literature review: Coverage; Ability to review the relevant literature and Inferences of gaps in the literature.
D. Method: Choice of proposed method; Appropriateness of method; Comprehensive background, description and limitations of the method; Identification of variables and data sources (if relevant); Sampling strategy and questionnaire (if relevant); Formal Conjectures (if relevant).
E. Expected Findings: Clarity in the expected direction of thesis; Understanding on relevance of expected findings.
F. Integration and Coherence: Linkages between the problem statement, research question, method and expected findings.
G. List of references as per the Citation Style: Adequate use of references through-out the text; Link between list of references to text; Citation style, both in-text and in reference.

Suggested weights in total marks:

20% each on (a) problem statement and research question and (b) method of analysis
10% each on (c) abstract, (d) introduction, (e) literature review, (f) expected findings, (g) list of references and (h) integration & coherence.

Learning Outcomes

a. Skills for making effective presentations.

b. Ability to prepare a comprehensive research proposal.

Reading Materials

All readings are available here:

CORE:

Module 1

Mark Kanazawa. 2018. 'A brief history of knowledge and argumentation' in *Research Methods for Environmental Studies*, 15-39. London and New York: Earthscan,

John Pheby. 1988. 'lnductivism and Deductivism in Economics', 'Falsification and Economics' and 'Kuhn and Economics' in *Methodology and Economics: A critical introduction*,1-53. London: Macmillan.

Homa Katouzian. 1980. 'Value judgements and ideology: morality and prejudice in economic science' in *Ideology and Method in Economics*, 135-156. London: Macmillan.

Module 2

Edella Schlager. 2007. 'A Comparison of Frameworks, Theories, and Models of Policy Processes', in *Theories of the Policy Process* edited by Paul A. Sabatier, Colorado: Westview Press.

John R Wood, S Enarth and Amita Shah. 2016. 'Comparative CNRM: from concepts to field research' in *Community Natural Resource Management and Poverty in India* edited by S Enarth et al, New Delhi: Sage

K Chopra and G Kadekodi. 1999. 'Chapter 1: Economic-Ecological Modelling—Conceptual Framework' in *Operationalising Sustainable Development: economic-ecological modelling for developing countries*, 17-41, New Delhi: Sage Publications.

E Ostrom. 2011. 'Background on the Institutional Analysis and Development Framework' *The Policy Studies Journal* 39 (1): 7-27

Module 3

Mark Blaug. 1992. 'The falsificationists, a wholly twentieth-century story' in *The methodology of economics: or how economists explain*, 83-111. Second Edition. Cambridge: Cambridge University Press

John W Creswell and David J Creswell. 2018. 'Selection of a Research Approach' in *Research Design: Qualitative, quantitative and Mixed methods approaches*, 3-23 New Delhi: Sage [also, https://edge.sagepub.com/creswellrd5e, the companion website:]

Fritz Machlup. 1978. 'Fact and Theory in Economics' and 'The problem of verification in Economics' in *Methodology of Economics and Other Social Sciences*,101-130 and 137-157. New York: Academic Press.

Mark Kanazawa. 2018. 'General research design principles' and 'The case study method' in *Research Methods for Environmental Studies*, 40-59, 182-203. London and New York: Earthscan

Module 4

William Thomson. 2011. "Chapter 2: Writing Papers" in *A Guide for the young economist*, 45-117. Second edition. Cambridge: MIT Press.

Module 6

MOSPI. 2017. National Accounts Statistics Sources and Methods 2007. New Delhi: Government of India, available online at http://www.mospi.gov.in/publication/national-accounts-statistics-sources-and-methods-2007-0

Sachs, J., Schmidt-Traub, G., Kroll, C., Durand-Delacre, D. and Teksoz, K. (2017): SDG Index and Dashboards Report 2017 - Metadata. Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN), Gütersloh and New York, available online at http://sdgindex.org/assets/files/2017/2017-SDG-Index-and-Dashboards-Report--Metadata.pdf

Module 7

Martha A. Starr. 2012. 'Qualitative and mixed methods research in economics: surprising growth, promising future" *Journal of Economic Surveys* 28 (2): 238-264

Mark Kanazawa. 2018. 'Data Collection 1: Principles of Surveying' and 'Data Collection II: Interviewing' in *Research Methods for Environmental Studies*, 285-312 and 313-332. London and New York: Earthscan

John W Creswell and David J Creswell. 2018. 'Quantitative Methods' in *Research Design: Qualitative, quantitative and Mixed methods approaches*, 155-182, New Delhi: Sage

John W Creswell and David J Creswell. 2018. 'Qualitative methods' in *Research Design: Qualitative, quantitative and Mixed methods approaches*, 183-213, New Delhi: Sage

Module 8

John W Creswell and David J Creswell. 2018. 'Writing strategies and Ethical Considerations', 'The Introduction', 'The Purpose Statement', 'Research Questions and Hypotheses', 'Glossary' in *Research Design: Qualitative, quantitative and Mixed methods approaches*, 77-103, 107-121, 123-138, 139-153, 241-250. New Delhi: Sage

Mark Kanazawa. 2018. 'Ethical issues in environmental research' and 'Writing a Research Proposal' in *Research Methods for Environmental Studies*, 333-350 and 351-373. London and New York: Earthscan

Module 9

Elsevier. n.d. A guide for writing scholarly articles or reviews for the Educational Research Review. Available online at https://www.elsevier.com/__data/promis_misc/edurevReviewPaperWriting.pdf

OTHER

Module 1

Mark Blaug. 1992. 'From the received view to the views of Popper', 'From Popper to the new heterodoxy, 'The distinction between positive and normative economics' in *The methodology of economics: or how economists explain*, 1-52 and 129-156. Second Edition. Cambridge: Cambridge University Press**.**

Fritz Machlup. 1978. Section titled 'Methodology, logic, epistemology, philosophy' and 'Why bother with Methodology' in *Methodology of Economics and Other Social Sciences*,53-62 and 63-70. New York: Academic Press.

M Boumans and J B Davis. 2015. *Economic Methodology. Understanding Economics as a Science* 2nd edition. Palgrave-Macmillan

Fritz Machlup. 1978. 'Homo Oeconomicus and his class mates' in *Methodology of Economics and Other Social Sciences*, 267-281. New York: Academic Press

Module 2

John M Anderies and Marco A. Jansen. 2016. *Sustaining the Commons* Tempe: Center for Behavior, Institutions and the Environment, Arizona State University

V Dayal. 2014. ‘Chapter 2: Models and Frameworks’ in *The Environment in Economics and Development: pluralist extensions of core economic models*, 19-30. New Delhi: Springer.

Hinkel, J., P. W. G. Bots, and M. Schlüter. 2014. 'Enhancing the Ostrom social-ecological system framework through formalization'. *Ecology and Society* 19 (3): 51

Rana, Pushpendra and Daniel C. Miller. 2019. Explaining long term outcome trajectories in social–ecological systems. PLoS ONE 14(4): e0215230. https://doi.org/10.1371/journal.pone.0215230

Module 3

Milton Friedman. 1953. "The Methodology of Positive Economics" in *Essays in Positive Economics*, 3-46. Chicago and London: The University of Chicago Press

Fritz Machlup. 1963. "Introductory Remarks," *The American Economic Review*, 53 (2): 204

G. C. Archibald, Herbert A. Simon and Paul A. Samuelson. 1963. "Discussion," *The American Economic Review*, 53 (2): 227-236

Andreas G. Papandreou. 1963. "Theory Construction and Empirical Meaning in Economics" *The American Economic Review*, 53 (2): 205-210

Ernest Nagel. 1963. "Assumptions in Economic Theory," *The American Economic Review*, 53 (2): 211-219

Sherman Krupp. 1963. "Analytic Economics and the Logic of External Effects" *The American Economic Review*, 53 (2): 220-226

Daniel M. Hausman. Ed. 2008. *The Philosophy of Economics: An Anthology*. Third Edition. Cambridge: Cambridge University Press.

A L George and A Bennett. 2005. 'Phase One: Designing Case Study Research' In *Case studies and Theory Development in Social Sciences*, 73-88 Cambridge and London: MIT Press

Kevin Hoover. 2004. *The Methodology of Empirical Macroeconomics* Cambridge: Cambridge University Press

S Lele. 2009. "Reflections on Interdisciplinarity in Environmental Economics in India" in *Handbook of Environmental Economics in India* edited by K Chopra and V Dayal, 305-325, New Delhi: OUP

Jeffrey M Wooldridge. 2003. 'Carrying out an Empirical Project' in *Introductory Econometrics: A Modern Approach*,616-642, South-Western College Pub

Hal R Varian. 2016. "How to Build an Economic Model in Your Spare Time" *The American Economist* 61(1): 81-90

Module 4

Hal R Varian. 1989. "What use is Economic Theory" available online at http://people.ischool.berkeley.edu/~hal/Papers/theory.pdf

Module 6

M R Saluja. 2017. ‘Chapter 1: Indian and International Statistical Systems’, ‘Chapter 3: Agricultural Statistics’, ‘Chapter 12: National Accounts’ and ‘Chapter 14: Environmental Statistics”, in *Measuring India: The Nation's Statistical System*, 1-45, 96-135, 394-454 and 488-508, Delhi: Oxford

Module 7

Angus Deaton. 1997. *The Analysis of Household Surveys: Microeconomic Analysis for Development Policy*. Baltimore: Johns Hopkins University Press for the World Bank.

Priscilla Salant and Don A. Dillman. 1994. *How to Conduct your own Survey* Wiley

Module 8

William Thomson. 2011. "Chapter 3: Giving Talks" in *A Guide for the young economist*, 119-150. Second edition. Cambridge: MIT Press.

George DeMartino. 2013. "Professional Economic Ethics: Why Heterodox Economists Should Care," *Economic Thought* 2(1): 43-53

George DeMartino. 2013. "Epistemic Aspects of Economic Practice and the Need for Professional Economic Ethics," *Review of Social Economy* 71 (2): 166-186

Eric Rasmusen. 2001. "Aphorisms on Writing, Speaking, and Listening" in Readings in Games and Information edited by Eric Rasmusen, Blackwell Publishers

Paul Dudenhefe. 2009. *A Guide to Writing in Economics* available online at http://writing.ku.edu/sites/writing.drupal.ku.edu/files/docs/Guide_Writing_Economics.pdf

Module 9

William Thomson. 2011. "Chapter 4: Writing Referee Reports" in *A Guide for the young economist*, 151-165. Second edition. Cambridge: MIT Press.

Deirdre N. McCloskey. 2019. *Economic Writing*. University of Chicago Press

Pedagogical Approach

Additional information (if any)

Useful material:

1. On presentation: Leslie Roldan available online at https://ocw.mit.edu/courses/brain-and-cognitive-sciences/9-85-infant-and-early-childhood-cognition-fall-2012/assignments/MIT9_85F12_Proposal.pdf

2. On Academic Integrity: MIT handbook for students available online at http://integrity.mit.edu/handbook/writing-original-work

Student responsibilities

Prepared by: Nandan Nawn, with support from Soumendu Sarkar.

Reviewers:

1. Anirban Dasgupta, South Asian University, Akbar Bhawan, Chanakyapuri, New Delhi 110021; dasgupta@econ.sau.ac.in
2. Arindam Banerjee, Ambedkar University Delhi, Kashmere Gate Campus, Lothian Road, Delhi 110006; arindam@aud.ac.in
3. Vikram Dayal, Institute of Economic Growth, University Enclave, North Campus, Delhi 110007; vikday@iegindia.org
4. Bharat Ramaswami, Ashoka University, Rajiv Gandhi Education City, Sonipat, Haryana 131029; bharat.ramaswami@ashoka.edu.in
5. Priya Shyamsundar, Lead Economist**,** Nature Conservancy, Arlington, 4245 North Fairfax Drive, Suite 100, Arlington, VA 22203-1606, USA; priya.shyamsundar@tnc.org

Course title: Natural Resource Economics			
Course code: MPE XYZ	**No. of credits:** 4	**L-T-P:** 56-0-0	**Learning hours:** 56
Pre-requisite course code and title (if any): Microeconomics, and Environment and Economic Development at Post Graduate level or equivalent			
Department: Department of Policy Studies			
Course coordinator(s): TBD		**Course instructor(s):** TBD	
Contact details: TBA			
Course type: Core		**Course offered in:** Any Semester	

Course description

The course lies in the intersection of disciplines of economics and environment within which economic system operates. This interlinkage can be expressed through the (a) inputs from environment to the economic system and (b) by-products of economic system to the environment. The former, or 'source' function is covered in this course. Latter, or, the 'sink' function of the environment, is covered in the Environmental Economics course that complements it.

Over the years, with the rise in the scale of economic system, its dependence on the environment for a sustained supply of inputs to sustain its own functioning have increased. There have been many conceptualisations and associated theoretical frameworks on managing and/or governing an array of natural resources, such as forests, fossil fuel aquifers, fisheries etc. to attain stated goals like efficiency in use, equity in allocation, etc. A variety of instruments have been proposed in the literature and practiced. This course covers these aspects and attempts to connect them.

Course objectives

1. To appreciate the conceptual foundations and theoretical formulations in natural resource economics
2. To gain knowledge on the principles of governing and managing natural resources, with a focus on Indian context

Course content

Module	**Topic**	**L**	**T**	**P**
1.	**Conceptual foundations in Natural Resource Economics** 1.1 Biological growth functions 1.2 Biological yield and production functions 1.3 Optimal investment in a biotic resource 1.4 Rate of depletion of a abiotic resource 1.5 Social rate of discount and policy challenges 1.6 Non-convexities, irreversibilities and uncertainties in ecological processes and its impact on policy making	8		
2.	**Economics of Forests and Wetlands** 2.1 Growth functions and rotations 2.2 Optimal stock and maximum sustainable yield 2.3 Principles for Governing and Managing Forests 2.4 Bioeconomic models involving forests, wetlands and wildlife 2.5 Value and payment of ecosystem services	10		

	2.6 Economics of conversion of land use from forests to non-forests			
3.	**Economics of Fisheries** 3.1 Yield-effort function 3.2 Models of Open and regulated Access 3.3 Regulatory frameworks in governing and managing fisheries	6		
4.	**Economics of Exhaustible Resources** 4.1 Optimal extraction 4.2 Depletion, capital accumulation and backstop 4.3 Economics of managing and governing mineral extraction	8		
5.	**Some issues in policy making** 5.1 Safe Minimum Standard 5.2 Decisions on preservation, conservation and use/extraction under irreversibility and uncertainty	6		
6.	**Institutions for Governing Natural Resources** 6.1.Understanding and categorising institutions 6.2.Institutional Economics: variations across schools of thought 6.3.Property rights and resource regimes 6.4.Institutions in Action: typology and functioning 6.5.Institutions in Action: evaluation 6.6.Institutions in Action: outcomes	12		
7	**Presentations**			12
		50	**0**	**6**

Evaluation

1. **Test 1:** Written test (on 1-3 modules): 25%
2. **Test 2:** Presentation of a seminal paper in Natural Resource Economics: 15%

Choice: from the list supplied by the course coordinator

Structure: No presentation can exceed 20 minutes. No more than 8 slides (excluding title and references) will be used. No more than 10 minutes per presentation on Q&A. No more than two pages of handout distribution.

Criteria: Introduction; Identification of Research Question/Problem/Issue; Relevance-- either theoretically or in empirical terms or both; Clarity - Audible and comprehensible; Sequence and pace; Pronunciation and oratory skills; Organization and layout of visual presentation; Responses during Q&A session -- Clarity and sufficiency [each with equal weight]

3. **Test 3:** Written test (on 4-6 modules): 25%
4. **Test 4:** Submission of an original essay of 5,000 words: 35%
   Structure: (a) which one you think is the best answer to the question pursued by you addressed in the literature survey and why, (b) what are the strongest objections to your choice; (c) briefly outline what further work would be needed to provide a better answer.

Criteria: Indicators: (a) Logical consistency, (b) Academic Rigour, (c) Originality [each with equal weight]

Learning Outcomes

a. To appreciate the 'sink' function of environment, its impact on the economic system and its valuation in monetary terms (test 1)

b. To understand and assess applicability of a range of valuation methods, tools and techniques in the context of several environmental issues at local and national levels (test 1).
c. To be exposed to and learn in the process skills for making effective presentations (test 2).
d. To gain an understanding on a variety of economic instruments for addressing environmental problems (test 3)
e. To be exposed to and learn in the process skills for preparing original works (test 4)

Pedagogical Approach

– Lectures will provide an overview besides emphasizing on a few matters in each area. Students are expected to read the materials listed above but not marked compulsory to gain a better understanding. Presentations will provide opportunities for co-learning. They will complement the lectures.

Course Reading Materials

All readings are available here.

CORE

Module 1: Conceptual foundations in Natural Resource Economics

Partha Dasgupta. 2019. "Ramsey and Intergenerational Welfare Economics" in *The Stanford Encyclopedia of Philosophy* (Summer 2019 Edition), edited by Edward N. Zalta, Accessed at https://plato.stanford.edu/archives/sum2019/entries/ramsey-economics/.

J M Conrad. 2010. "Chapter 1: Basic Concepts" in *Resource Economics* Second Edition, 1-34, New Delhi: Cambridge University Press.

Partha Dasgupta and Karl-Göran Mäler. 2009. "Environmental and Resource Economics: some recent developments' in *Handbook of Environmental Economics in India* Edited by Kanchan Chopra and Vikram Dayal. 17-66. Delhi: OUP.

Martin S. Feldstein. 1964. "The Social Time Preference Discount Rate in Cost Benefit Analysis," *Economic Journal*, 74: 360–79

Module 2: Economics of Forests and Wetlands

J M Conrad. 2010. "Chapter 4: The Economics of Forestry" in *Resource Economics* Second Edition, 132-152, New Delhi: Cambridge University Press

K Chopra and S K Adhikari. 2004. "Environment Development Linkages: modeling a wetland system for ecological and economic value," *Environment and Development Economics* 9: 19-45

Sharachchandra Lele and Veena Srinivasan. 2013. "Disaggregated economic impact analysis incorporating ecological and social trade-offs and techno-institutional context: A case from the Western Ghats of India" *Ecological Economics* 91: 98–112

S Lele, Oliver Springate-Baginski, Roan Lakerveld, Debal Deb, Prasad Dash. 2013. "Ecosystem Services: Origins, Contributions, Pitfalls, and Alternatives," *Conservation & Society*11 (4): 343-358

Erik Gómez-Baggethun, Rudolf de Groot, Pedro L. Lomas and Carlos Montes. 2010. "The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes," *Ecological Economics* 69: 1209–1218

Module 3: Economics of Fisheries

J M Conrad. 2010. “Chapter 3: The Economics of Fisheries” in *Resource Economics* Second Edition, 75-131, New Delhi: Cambridge University Press

Mohammad Mojibul Hoque Mozumder, Md. Abdul Wahab, Simo Sarkki, Petra Schneider and Mohammad Mahmudul Islam. 2018. "Enhancing Social Resilience of the Coastal Fishing Communities: A Case Study of Hilsa (Tenualosa Ilisha H.) Fishery in Bangladesh". *Sustainability* 10, 3501, Accessed online at https://www.mdpi.com/2071-1050/10/10/3501/pdf

van Brakel, M. L., M. Nahiduzzaman, A. Mahfuzul Haque, M. Golam Mustafa, M. Jalilur Rahman, and M. Abdul Wahab. 2018. "Reimagining large-scale open-water fisheries governance through adaptive comanagement in hilsa shad sanctuaries." *Ecology and Society* 23 (1): 26. Accessed online at https://digitalarchive.worldfishcenter.org/bitstream/handle/20.500.12348/693/4235.pdf?sequence=1&isAllowed=y

Module 4: Economics of Exhaustible Resources

James L. Sweeney. 1993. “Economic Theory of Depletable Resources: an Introduction” in *Handbook of Natural Resource and Energy Economics*, vol**.** III, edited by A. K Kneese and J.L. Sweeney, 759-854Cheltenham: Elsevier [selected sections]

J M Conrad. 2010. “Chapter 5: The Economics of Nonrenewable Resources” in *Resource Economics* Second Edition, 153-199, New Delhi: Cambridge University Press

Partha Dasgupta and Geoffrey Heal. 1974. "The Optimal Depletion of Exhaustible Resources," *The Review of Economic Studies* 41: 3-28

Module 5: Some issues in policy making

Alan Randall and M C Farmer. 1995. "Benefits, Costs and Safe Minimum Standard for Conversation" in *Handbook of Environmental* Economics edited by Daniel W Bromley, 27-44, Oxford and Cambridge: Blackwell

Anthony C. Fisher and John V. Krutilla, 1985, “Economics of Nature Preservation” in *Handbook of Natural Resource and Energy Economics*, vol. 1, edited by A. V. Kneese and J.L. Sweeney 165-189, Cheltenham: Elsevier

Kenneth J. Arrow and Anthony C. Fisher (1974), “Environmental Preservation, Uncertainty and Irreversibility,” *Quarterly Journal of Economics,* 88: 312–19.

Module 6: Institutions for Governing Natural Resources

Arild Vatn. 2005. "Institutions: the individual and the society", "Institutions: coordination and conflict", "Institutional Economics: different positions", "Resource Regimes" and "Evaluating Institutional change: the normative aspect of institutions" in *Institutions and the Environment*, 25-107, 252-298. Cheltenham: Edward Elgar

John R Wood. 2016. "CNRM in India: the problem and the context” in *Community Natural Resource Management And Poverty In India: Evidence From Gujarat And Madhya Pradesh* by Shashidharan Enarth, Jharna Pathak, Amita Shah, Madhu Verma, and John R Wood, 1-16, New Delhi: Sage

Partha Dasgupta. 2007. “Common Property Resources: Economic Analysis” in *Promise, Trust, and Evolution: Managing the Commons of South Asia* edited by R Ghate, N S Jodha, and P Mukhopadhyay, 19-50, Delhi: OUP

S Lele, 2014. “What is wrong with Joint Forest Management” in *Democratizing Forest Governance in India* edited by S Lele and A Menon, 25-62, New Delhi: OUP

OTHER

Module 1: Conceptual foundations in Natural Resource Economics

Robert M. Solow. 1974. “The Economics of Resources or the Resources of Economics,” *American Economic Review*, 64: 1–15

Kenneth Arrow, Partha Dasgupta, Lawrence Goulder, Gretchen Daily, Paul Ehrlich, Geoffrey Heal, Simon Levin, Karl-Göran Mäler, Stephen Schneider, David Starrett and Brian Walker. 2004. "Are We Consuming Too Much?," *Journal of Economic Perspectives*, 18 (3): 147–172

Kenneth J. Arrow, Maureen L. Cropper, Christian Gollier, Ben Groom, Geoffrey M. Heal, Richard G. Newell, William D. Nordhaus, Robert S. Pindyck, William A. Pizer, Paul R. Portney, Thomas Sterner, Richard S. J. Tol, and Martin L. Weitzman. 2014. "Should Governments Use a Declining Discount Rate in Project Analysis?," *Review of Environmental Economics and Policy* 8 (2): 145–163

Paul A. Samuelson. 1971. "Generalized Predator-Prey Oscillations in Ecological and Economic Equilibrium," *Proceedings of the National Academy of Sciences of the United States of America* 68 (5): 980-83

Arlindo Kamimura, Geraldo F. Burani and Humberto M. França. 2011. "The Economic System seen as A Living System: A Lotka-Volterra Framework," *Emergence: Complexity & Organization* 13 (3): 80-93

Karl-Göran Mäler, Anastasios Xepapadeas and Aart de Zeeuw. 2003. “The Economics of Shallow Lakes” *Environmental and Resource Economics* 26: 603–624

Supplementary reading:

Kenneth J. Arrow, Maureen L. Cropper, Christian Gollier, Ben Groom, Geoffrey M. Heal, Richard G. Newell, William D. Nordhaus, Robert S. Pindyck, William A. Pizer, Paul R. Portney, Thomas Sterner, Richard S.J. Tol, and Martin L. Weitzman. 2012. ‘How Should Benefits and Costs Be Discounted in an Intergenerational Context? The Views of an Expert Panel’. Discussion paper. No. RFF DP 12-53. Washington DC: Resources for the Future.

Module 2: Economics of Forests and Wetlands

V Dayal. 2007. "Social diversity and ecological complexity: how an invasive tree could affect diverse agents in the land of the tiger,"*Environment and Development Economics* 12 (4): 553-71

Michael D. Bowes and John V. Krutilla. 1985. “Multiple Use Management of Public Forestlands” in *Handbook of Natural Resource and Energy Economics*, vol. II, edited by A. V. Kneese and J. L. Sweeney, 531-569 Cheltenham: Elsevier

Nicolás Kosoy and Esteve Corbera. 2010. "Payments for ecosystem services as commodity fetishism" *Ecological Economics* 69: 1228–1236

K Chopra, and P Dasgupta. 2008. ‘Assessing the Economic and Ecosystem Services Contribution of Forests: Issues in Modelling, and an Illustration,’ *International Forestry Review* 10 (2): 376-386

Report of the Expert Committee on Net Present Value [Chair: K Chopra] submitted to Hon’ble SC of India

M Verma, D Negandhi D, A K Wahal, R Kumar, G A Kinhal, and A Kumar. 2014. "Revision of rates of NPV applicable for different class/category of forests". Bhopal: Indian Institute of Forest Management. [selected sections]

Paul A. Samuelson. 1976. "Economics of Forestry in an Evolving Society," *Economic Inquiry* 14: 466–92

Vernon L. Smith. 1968. "Economics of Production from Natural Resources," *American Economic Review* 58: 409–32

Module 3: Economics of Fisheries

H. Scott Gordon. 1954. "The Economic Theory of a Common Property Resource: The Fishery," *Journal of Political Economy*, 62: 124–42

K Fuller, D Kling, K Kroetz, N Ross and JN Sanchirico. 2013. "Economics and Ecology of Open-Access Fisheries" in Encyclopedia of Energy, Natural Resource, and Environmental economics edited by J F Shorgen [Shorgen hereafter]. Volume 2, 39-49, Cheltenham: Edward Elgar.

MN Reimer and JE Wilen. 2013. "Regulated Open Access and Regulated Restricted Access Fisheries" in edited by Shorgen. Volume 2, 215-223, Cheltenham: Edward Elgar

Module 4: Economics of Exhaustible Resources

Harold M. Hotelling. 1931. "The Economics of Exhaustible Resources," *Journal of Political Economy* 39: 137–75

Shantayanan Devarajan and Anthony C Fisher. 1981. "Hotellings "Economics of Exhaustible Resources: fifty years later," *Journal of Economic Literature* 19 (1): 65-73

Geoffrey M. Heal. 1993. The optimal use of Exhaustible Resources" in *Handbook of Natural Resource and Energy Economics*, vol. III, edited by A. K Kneese and J.L. Sweeney, 855-880, Cheltenham: Edward Elgar.

J Swierzbinski. 2013. "Economics of Exploration for and Production of Exhaustible Resources" in Shorgen. Volume 2. 1-9, Cheltenham: Edward Elgar

P Mukhopadhyay and G Kadekodi. 2011. "Missing the Woods for the Ore: Goa's Development Myopia," *Economic and Political Weekly* 66 (46): 61-67

Government of India. 2019. *National Mineral Policy*. Available online at https://mines.gov.in/writereaddata/UploadFile/NMP12032019.pdf

Lekha Chakraborty, Shatakshi Garg, Gurpreet Singh. 2016. "Cashing in on Mining: The Political Economy of Mining Regulations and Fiscal Policy Practices in India." Working paper No. 161. New Delhi: National Institute of Public Finance and Policy

Module 5: Some issues in policy making

John V. Krutilla. 1967. "Conservation Reconsidered" *The American Economic Review* 57 (4): 777-786

Module 6: Institutions for Governing Natural Resources

Frances Cleaver. 2012. "Getting Institutions Right: Interrogating Theory and Policy" in *Development through Bricolage: rethinking institutions for natural resource management*. London and New York: Routledge

Gopal Kadekodi. 2004. "Chapter 6: Existing Institutions to Manage CPRs in India" in *Common Property Resource Management: reflections on theory and the Indian experience*, OUP, Delhi

K Chopra, G K Kadekodi and M N Murty. 1989. "Peoples' Participation and Common Property Resources," *Economic and Political Weekly* 24 (51 & 52): A-175-A-189

K Chopra and G K Kadekodi. 1991. "Participatory institutions: The context of common and private property resources," *Environmental and Resource Economics* 1 (4): 353-372

B Agarwal. 2001. "Participatory Exclusions, Community Forestry and Gender: an Analysis for South Asia and a conceptual framework," *World Development* 29 (10): 1623-48

Kanchi Kohli and Manju Menon. 2014. "The Making of Forest (Re)Publics: Popular Engagement with Official Decision-making on Forest Conversions," in *Democratizing Forest Governance in India* edited by S Lele and A Menon, New Delhi: OUP

Shomona Khanna. 2014. "Boundaries of Forest Lands: The Godavarman Case and Beyond," in *Democratizing Forest Governance in India* edited by S Lele and A Menon, New Delhi: OUP

A Menon, V Lobo and S Lele. 2014. "The Commons and Rural Livelihoods: shifting dependencies and supra-local pressures" in *Democratizing Forest Governance in India* edited by S Lele and A Menon, 376-401, New Delhi: OUP

E Ostrom. 2009. "Beyond markets and states: polycentric governance of complex economic systems", Nobel Prize Lecture

HJ Albers and EJZ Robinson. "Reducing Emissions from Deforestation and Forest Degradation" in Shorgen, vol 2, 78-85, Cheltenham: Edward Elgar

Harold Demsetz. 1967. "Toward a Theory of Property Rights," *American Economic Review* 57: 347–59

Journals: *Environmental and Development Economics, Ecological Economics*

Advanced Reading Material: see above

Additional information (if any) : none

Student responsibilities

The students are expected to submit assignments in time and come prepared with readings when provided.

Prepared by: Nandan Nawn

Course reviewers:

1. Gopal Kadekodi, Honorary Professor, Centre for Multi-Disciplinary Development Research, Dr. B.R. Ambedkarnagar, Near Yalakki Shettar Colony, Dharwad-580004 Karnataka, India; gkkadekodi@hotmail.com

2. Pranab Mukhopadhyay, Professor, Department of Economics, Goa University, Taleigao Plateau, Panaji, Goa 403206, India; pmkolkata@gmail.com

Course title: Environmental Economics			
Course code: MPE xxx	**No. of credits:** 4	**L-T-P:** 48-8-0	**Learning hours:** 56
Pre-requisite course code and title (if any): MPE 131 Microeconomics			
Department: Department of Policy Studies			
Course coordinator(s): TBD		**Course instructor(s):** TBD	

Contact details: TBA

Course type: Core	**Course offered in:** Any Semester

Course description

The course lies in the intersection of disciplines of economics and environment within which economic system operates. This interlinkage can be expressed through the (a) inputs from environment to the economic system and (b) byproducts of economic system to the environment. Latter, or, the 'sink' function of the environment, is covered within this course. The former, or 'source' function is covered in the Natural Resource Economics course that complements it.

Over the years, impacts of economic system on the environment have increased; they have become qualitatively different too. The way in which environment impacts economic system have undergone both quantitative and qualitative changes. Discipline of economics have been one of first ones to recognize, appreciate and address environment related problems to human and environmental health. In the last one hundred years, the treatment has become more sophisticated, some which this course attempts to capture.

Course objectives

1. To familiarizes students with the theory and application of economics to environmental problems, in distinction with the other approaches.
2. To make the student aware of the different methods, grounded on economic theory, to assign monetary values to a variety of environmental goods and services.
3. To make the students appreciate the formulation of environmental policies involving economic instruments, associated institutions and supporting governance mechanisms.

Course content

Module	**Topic**	**L**	**T**	**P**
1.	**Property right, externalities and environmental problems** 1.1 The Human-Environment relationship 1.2 Environmental Problems and Economic Efficiency 1.3 Property Rights 1.4 Imperfect Market Structures 1.5 Externalities and Public Goods as sources of Market Failure 1.6 The Government Failure 1.7 The Pursuit of Efficiency	**3**		
2.	**Economic Principles and Overview of Valuation Methods** 2.1 Welfare Measures for Changes in Supply of Environmental Good 2.2 Environmental Values and their classification 2.3 Use Values, Non-use Values and Option Value	**3**		
3.	**Stated Preference Techniques** 3.1 Contingent Valuation Method and its applications 3.2 Choice Experiment Method and its applications	**8**		
4.	**Revealed Preference Techniques** 4.1 Household Production Function models 4.2 Travel Cost method 4.3 Hedonic Price models	**10**		
5.	**Meta- Analysis and Cost benefit Analysis**	**4**		

	5.1 Conducting Meta-analysis 5.2 Cost-Benefit analysis			
6.	**Economic Instruments** 6.1. Incentives through Market: prices through Charges and Subsidies 6.2. Incentives through Regulation: Liability Rules, Fees, Deposit-refunds 6.3. Incentives through Quantity Rationing—Tradeable Permits 6.4. Uncertainty and choice of Instruments 6.5. Market Structure, number of Players and choice of Instruments. 6.6. Evaluation of Instruments against selected criteria 6.7. Comparison of Instruments.	**12** 2 2 2 2 2 1 1		
7	**Environmental Governance: selected case studies** 7.1. Local Air Pollution: from stationary and non-point sources 7.2. Local and regional Water Pollution: from agriculture and industry	**8**	**8**	

Evaluation

1. **Test 1:** Written test (on 1-4 modules): 25%
2. **Test 2:** Presentation of a seminal paper in Environmental Economics: 15%

Choice: from the list supplied by the course coordinator

Structure: No presentation can exceed 20 minutes. No more than 8 slides (excluding title and references) will be used. No more than 10 minutes per presentation on Q&A. No more than two pages of handout distribution.

Criteria: Introduction; Identification of Research Question/Problem/Issue; Relevance-- either theoretically or in empirical terms or both; Clarity - Audible and comprehensible; Sequence and pace; Pronunciation and oratory skills; Organization and layout of visual presentation; Responses during Q&A session -- Clarity and sufficiency [each with equal weight]

3. **Test 3:** Written test (on 5-8 modules): 25%
4. **Test 4:** Submission of an original essay of 5,000 words: 35%
   Structure: (a) which one you think is the best answer to the question pursued by you addressed in the literature survey and why, (b) what are the strongest objection(s) to your choice; (c) briefly outline what further work would be needed to provide a better answer.

Criteria: Indicators: (a) Logical consistency, (b) Academic Rigour, (c) Originality [each with equal weight]

Learning Outcomes

a. To appreciate the 'sink' function of environment, its impact on the economic system and its valuation in monetary terms (test 1)
b. To understand and assess applicability of a range of valuation methods, tools and techniques in the context of several environmental issues at local and national levels (test 1).
c. To be exposed to and learn in the process skills for making effective presentations (test 2).
d. To gain an understanding on a variety of economic instruments for addressing environmental problems (test 3)
e. To be exposed to and learn in the process skills for preparing original works (test 4)

Reading Materials

CORE

Module 1

T Tientenberg Chapter 2: The Economic Approach: Property Rights, Externalities, and Environmental Problems, in *Environmental and Natural Resource Economics*

W J Baumol and W E Oates, 1988, *The Theory of Environmental Policy*, Cambridge University Press, 'Chapter 2: Relevance and the theory of externalities', 'Chapter 3: Externalities: definition, significant types, and optimal-pricing conditions', and 'Chapter 4: Externalities: formal analysis'.

Ayres, R. U., & Kneese, A. V. (1969). Production, consumption, and externalities. *The American Economic Review*, *59* (3): 282-297.

Module2

Freeman, III, A.M. (1993): *The Measurement of Environmental and Resource Values: Theory and Methods*, Washington D. C: Resources for the Future.

Karl-Göran Mäler, Jeffrey R. Vincent (Edited) (2005): Handbook of Environmental Economics: Valuing Environmental Changes, Volume 2, Elsevier/North-Holland, Amsterdam., 'Chapter 12 welfare theory of valuation' 'Chapter 13Environment, uncertainty and option values'

Module 3

Bateman, et al (2002) *Economic Valuation with Stated Preference Techniques: A Manual*, Edward Elgar Publishing, Cheltenham.

Whittington, D. (1998). 'Administering contingent valuation surveys in developing countries'. *World development*, *26*(1), 21-30.

Bennett, J and R. Blamey (2001) *The Choice Modelling Approach to Environmental Evaluation*, Edward Elgar.

Module 4

Freeman, III, A.M. (1993): *The Measurement of Environmental and Resource Values: Theory and Methods*, Washington D. C: Resources for the Future.

Case studies for module 3 and 4 [All SANDEE working papers; freely downloadable from http://www.sandeeonline.org/publicationdisp.php?pcid=1]

Revealed Preference

Irfan, M. (2013). Do Open Sewers Lead to a Reduction in Housing Prices? Evidence from Rawalpindi, Pakistan.

Das, S. (2007). Storm protection by mangroves in Orissa: an analysis of the 1999 super cyclone.

Guha, I., & Ghosh, S. (2009). A Glimpse of the Tiger: How Much are Indians Willing to Pay for It?.

Adhikari, N. Measuring Health Benefits from Air Pollution Reduction in Kathmandu Valley (No. 70)

Stated preference

Mishra, P. P. (2014). Potential Benefits and Earnings from Improving the Hussain Sagar Lake in Hyderabad: A combined revealed and stated preference approach (No. 90).

Rai, R. K., Nepal, M., Shyamsundar, P., & Bhatta, L. D. (2015). Demand for Watershed Services: Understanding Local Preferences through a Choice Experiment in the Koshi Basin of Nepal (No. id: 7292).

Rathnayake, R. W. (2015). Estimating demand for turtle conservation at the Rekawa sanctuary in Sri Lanka..

Module 5

Borenstein, M., Hedges, L. V., Higgins, J. P., & Rothstein, H. R. (2011). *Introduction to meta-analysis*. John Wiley & Sons.

N Hanley, 2017, 'Environmental Cost Benefit Analysis' in Shorgen et al, *Encyclopaedia of Energy, Natural Resource and Environmental Economics*, volume 3, pp. 17-24

Module 6

N Hanley, J F Shorgen and B White, 2007, *Environmental Economics in Theory and Practice* Palgrave Macmillan, Chapter 4: Incentive Design and Chapter 5: Pollution Taxes and tradable emission permits: Theory and Practice

W J Baumol and W E Oates, 1988, *The Theory of Environmental Policy*, Cambridge University Press, Chapter 5: Uncertainty and the choice of policy instruments: price or quantity controls? and Chapter 6: Market imperfections and the number of participants

Module 7

All from Jason F Shogren et al, eds., 2013 *Encyclopedia of Energy, Natural Resource and Environmental Economics*, Volume 3, London and San Diego: Elsevier

J B Braden and JS Shortle, 2013, 'Agricultural Sources of Water Pollution', pp. 81-85

AM Bento, 2013, 'Local/Regional Air Pollution from Stationary Sources', pp. 103-108

D Earnhart, 'Water Pollution from Industrial Sources', pp. 114-120

M Walls, 2013, 'Deposit-Refund Systems in Practice and Theory', pp. 133-137

JS Shortle and JB Braden, 'Economics of Nonpoint Pollution', pp. 143-149

I Parry, 'Green Tax Design in the Real (Second-Best) World', pp. 161-168

K Segerson, 'Price Instruments', pp. 185-192

T Requate, 'Prices versus Quantities', pp. 193-203

J Rubin and S Siriwardena 'Quantity Instruments', pp. 204-211

GE Helfand, 'Standards', pp. 217-221

OTHER

Module 1

K Singh and A Shishodia, '3. Basic Concepts and Theories: Individual Choices' and '4. Basic Concepts and Theories: Collective Choices' in K Singh and A Shishodia, *Environmental Economics: theory and application*, Sage

David Anderson, 'Chapter 2: Efficiency and Choice', 'Chapter 3: Market Failure', 'Chapter 4: Role of Government' in *Environmental Economics and Natural Resource Management*

Ronald H Coase, 1960, 'The problem of social cost', *Journal of Law and Economics* 3: 1-44

N Hanley, J F Shorgen and B White, 2007, *Environmental Economics in Theory and Practice* Palgrave Macmillan, 'Chapter 3: Market Failure'

R Perman et al, Chapter 5: Welfare Economics and the Environment in *Natural Resource and Environmental Economics*

Module2

Markandya, A. (2014). Economic principles and overview of valuation methods for environmental impacts.

Haab, Timothy C, and Kenneth E. McConnell (2002): *Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation*, Edward Elgar, Cheltenham, UK. Northampton MA, USA.

Per-Olov Johansson, 2000, 'Microeconomic of Valuation' in *Principles of Environmental and Resource Economics*, edited by H Folmer and H Landis Gabel, Cheltenham and Northampton: Edward Elgar

Per-Olov Johansson, 1987, *The economic theory and measurement of environmental benefits*, Cambridge: Cambridge University Press (also for module 3 and 4)

Mordechai Shechter, 2000, 'Valuing the Environment' in *Principles of Environmental and Resource Economics*, edited by H Folmer and H Landis Gabel, Cheltenham and Northampton: Edward Elgar

Module 3

Whittington, D. (2010). 'What have we learned from 20 years of stated preference research in less-developed countries?' *Annual Review of Resource Economics 2*(1), 209-236.

Hensher D.A., Rose J.M. & Greene W.H. (2005) *Applied Choice Analysis: A primer* Cambridge University Press.

Bennett J., Birol, E. (2010). *Choice experiments in developing countries. implementation, challenges and policy implications*.Edward Elgar Publications Ltd.

Module 4

Ward, F.A and D.J Beal (2000), *Valuing Nature with Travel Costs Models: A Manual*, Edward Elgar, Cheltenham

Viscusi (1993) 'The Value of Risk to Life and Health' *Journal of Economic Literature* 31.

Orgill-Meyer, Jennifer, Marc Jeuland, Jeff Albert, and Nathan Cutler. 2018. 'Comparing contingent valuation and averting expenditure estimates of the costs of irregular water supply' *Ecological Economics* 146: 250-264.

David Pearce, ed. (2009) *Environmental Valuation in Developed Countries: Case Studies*, Edward Elgar Publishing Ltd

M N Murty (2009): *Environment, Sustainable Development and Well-Being: Taxation, Incentivesand Valuation*, Oxford University Press, New Delhi.

A E Haque, M N Murty and P Shyamsundar. (2011). *Environmental Valuation in South Asia*. Cambridge University Press.

S Kumar and D N Rao (2001). 'Valuing the benefits of air pollution abatement using a health production function a case study of Panipat thermal power station, India'. *Environmental and Resource Economics*, 20(2), 91-102.

Module 5

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). 'Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement'. *PLoS medicine*, *6*(7), e1000097.

Lindhjem, H., & Navrud, S. (2008). 'How reliable are meta-analyses for international benefit transfers?' *Ecological Economics*, *66*(2-3), 425-435.

Asian Development Bank (2013) *Cost-benefit analysis for development: A practical guide*.

R Stavins, ed., 2005, *Economics of the Environment: selected* readings, W W Norton,

Section on The Goals of Environmental Policy: economic efficiency and benefit-cost analysis

Kenneth Arrow et al, 'Is there a role for Benefit-Cost Analysis in Environmental, Health and Safety Regulation?

Steven Kelman, 'Cost Benefit Analysis: An ethical critique'

Replies to Steven Kelman from J V DeLong, R M Solow, G Butterns, J Calfee and P Ippolito

N Hanley, 2000, 'Cost-Benefit Analysis' in *Principles of Environmental and Resource Economics*, edited by H Folmer and H Landis Gabel, Cheltenham and Northampton: Edward Elgar

Drèze, Jean, and Nicholas Stern. "The theory of cost-benefit analysis." In *Handbook of public economics*, vol. 2, pp. 909-989. Elsevier, 1987

Module 6

Tomasz Zylicz, 2000, 'Goals, principles and constraints in environmental policies' in *Principles of Environmental and Resource Economics*, edited by H Folmer and H Landis Gabel, Cheltenham and Northampton: Edward Elgar

Jean-Philippe Barde, 2000, 'Environmental policy and policy instruments' in *Principles of Environmental and Resource Economics*, edited by H Folmer and H Landis Gabel, Cheltenham and Northampton: Edward Elgar

Module 7

All from Jason F Shogren et al, eds., 2013 *Encyclopedia of Energy, Natural Resource and Environmental Economics*, Volume 3, London and San Diego: Elsevier

E Lichtenberg, 2013, 'Economics of Pesticide Use and Regulation', pp. 86-97

SL Stafford, 2013, 'Hazardous Substances', pp. 98-102

MA Cohen, 'Water Pollution from Oil Spills', pp. 121-126

C Bohringer and A Lange, 'European Union's Emissions Trading System', pp. 155-160

S Kallbekken, 'Public Acceptability of Incentive-Based Mechanisms', pp. 306-312

R Innes, 'Liability Rules and the Environment', pp. 169-184

Pedagogical Approach

Lectures will provide an overview besides emphasizing on a few matters in each area. Students are expected to read the materials listed above but not marked compulsory to gain a better understanding. Presentations will provide opportunities for co-learning. They will complement the lectures.

Additional information (if any): none

Student responsibilities

The students are expected to submit assignments in time and come prepared with readings when provided

Prepared by: Sukanya Das and Nandan Nawn

Reviewers:

1. M.N. Murty, Retired Professor, Institute of Economic Growth, Visiting Professor, TERI School of Advanced Studies
2. R.N. Bhattacharya, Honorary Adjunct Professor of Economics, School of Oceanographic Studies, Jadavpur University, Kolkata-700032.

Course title: Indian Agricultural Development: Contemporary Issues			
Course code: MPE XXX	**No. of credits:** 4	**L-T-P:** 56-0-0	**Learning hours:** 56
Pre-requisite course code and title (if any): Macroeconomics			
Department: Department of Policy Studies			
Course coordinator: TBD	**Course instructor** TBD		
Contact details:			
Course type: Elective	**Course offered in:** All Semesters		

Course description:

The course will discuss changes in the trajectory of agricultural development in India since Independence. Students will be exposed to impacts of policies on the growth processes in Indian agriculture. Further, it discusses changes in the relations among economic agents involved in the process of production and exchange that vary with the levels of capitalist development across agro-ecological zones in India. It also provides an exposure to the role of agricultural markets in facilitating the process of exchange.

Students will be acquainted with the impacts of some technological developments in Indian agriculture across social and economic groups, with a focus on the access, utilisation and sustainability of Green Revolution and BT cotton. Sustainability of farming practices will be discussed in this course, with specific illustrations from the literature on impacts of climate change and adaptation strategies of different sections of producers.

Liberalisation of economic regime that started in 1991 was followed by major structural changes resulting in modifications in the state provision of support to domestic agricultural sector—it had serious impacts on livelihood security of different sections of rural population, which the course covers as well.

Course objectives:

1. To critically examine the growth processes of Indian agriculture.
2. To make the students understand the nature of development of Indian agriculture, the role of agriculture in industrial development and land distribution in rural India.
3. To study inter-linkages across input and output markets in agriculture.
4. To provide the students an exposure to selected aspects of sustainability of agricultural development in India.
5. To gain knowledge on the impacts of climate change in Indian agriculture and adaptation strategies thereof.
6. To enable students, analyse the impacts of economic reforms on Indian agriculture.

Course content

S. No	Topic	L	T	P
1	**Module 1. Growth and Policies** 1.1 Growth Process 1.2 Selected Policy Level Interventions on the growth process In this module the performance of Indian agriculture and policy interventions at different phases since Independence will be discussed. This module will enable students to understand the development trajectory of Indian agriculture since Independence.	8		
2	**Module 2. Production Relations in Indian Agriculture** 2.1 Mode of Production in Indian Agriculture 2.2 Role of agriculture in industrial development 2.3 Tenancy Relations and the Issue of Land in Rural India	10		

	This module enables a student to understand the nature of and processes involved with capitalist development and identifying the beneficiaries (and non-beneficiaries) of such processes. It will showcase that farmers in India are not homogenous entities and they differ in terms of capital base, access to finance and terms and conditions under which they participate in the processes of production. Further, it enables the students to identify the different sections of farmers, economic relations between them in the process of production and to analyse the sections among the farmers that had benefited (and not benefited) from the growth process of Indian agriculture. Indian economy is primarily agrarian, and nature of agricultural development has a strong bearing on industrial development. In other words, constraints faced by the former in terms of growth rate and in terms of distributing the benefits of growth process to substantial sections of the rural population, will retard industrial development in such an economy. These matters are discussed in this module. Land is an important component in the production process of agriculture. Land distribution in India has always been uneven. An important outcome of uneven distribution of land has been the existence of tenancy relationships, across agro-ecological zones in India, that are extremely skewed in favour of the big landholders. However, there have been attempts, in certain regions in India, for equitable distribution of land. Land reform, a programme intended to create private property rights over land, has been discussed in this module. Also, the overall impact of land reform on the rural areas, the limitations of such a programme has been discussed.			
3	**Module 3. Exchange Relations in Indian Agriculture** 3.1 Contract Farming and Interlinkages Across Markets 3.2 Role(s) of Agricultural Markets Exchange relations encompass relations between different sections of the producers in the sphere of exchange. The module exposes the students to the issue of interlinkages across input and output markets in an agrarian economy. This module provides exposure to the linkages between credit, labour and output markets and the terms and conditions under which different sections of the producers participate in the process of exchange. It also analyses that how unequal access to resources also leads to variations in the terms of exchange for different sections of producers.	7		
4	**Module 4. Technology diffusion in Indian Agriculture: Issues of Ecological Sustainability** 4.1 Green Revolution and Sustainable Agricultural Development 4.2 Implementation of BT Cotton Technology and its Impacts 4.3 Sustainability of Farming Practices in India This module intends to bring into discussion issues of sustainability of agricultural development due to technological changes at various points in time. More specifically, it discusses ecological sustainability of Green Revolution technology and impacts of technological	12		

	development in Indian agriculture on natural resources like water and land. Sustainability of BT Cotton technology in India, a widely debated issue in Indian agriculture at the policy level, will be discussed in this module. It will also provide a critical take on one of the alternative farming practices, Zero Budget Natural Farming for promoting sustainability of Indian agricultural development.			
5	**Module 5. Climate Change and Indian Agriculture: Impacts and Adaptation Measures** This module intends to discuss impacts of climate change on Indian agriculture. It gives a detailed exposure to the students regarding the impact of climate change on yield and productivity of several major crops and on irrigation sources in India. It also aims to discuss the adaptation measures and determinants of adaptive capacity of the farming community in India to cope with the problems related to climate change.	9		
6	**Module 6. Economic Reforms and Indian Agriculture** Initiation of reforms in the nineteen nineties marked a new phase of development in the Indian economy. It had led by major changes in macroeconomic policies in India; trade liberalization in agriculture and accession into the WTO were integral parts of these changes. This module intends to discuss impacts of economic reforms in agriculture since the nineties. The issue of agrarian distress will also be discussed in this module.	10		
	Total	**56**		

Evaluation criteria:

1. **Test 1: Written test** [at the end of teaching of module 1] — 20% [learning outcome 1]
2. **Test 2: Submission of a term paper** [at the end of teaching of modules 2 and 3] – 25% [learning outcomes 1 and 2]

   Students will be asked to write an essay (in 2000 words) on a given topic. They will be assessed based on (a) answering the question, (b) maintaining word limit, (c) in-depth understanding of the topic, (d) strength of argument, (e) clarity of argument and (f) proper referencing.
3. **Test 3**: **Presentation** [after the completion of module 5] – 25% [learning outcomes 2, 3 and 4]

   There will be individual presentation of students based on the topics covered in the course. Topic(s) will be selected by the students; it will be related to the modules covered in the course.
4. **Test 4**: **Written test** [at the end of the semester, entire syllabus] – 30% [learning outcomes 1 to 5]

Learning outcomes:

By the end of the course, students will:

1. Develop critical understanding regarding growth processes in Indian Agriculture.
2. Ability to critically exam the nature and beneficiaries of development, agriculture-industry development linkages and land distribution in rural India.

3. Gain knowledge regarding sustainable farming practices in Indian agriculture.
4. Assess the impacts of climate change on Indian agriculture.
5. Evaluate the impacts of economic reforms on Indian agriculture.

Pedagogical approach

-Critically investigates policy level and climatic impacts on various socio-economic classes and social and religious groups in rural India.
-Class interactions and discussions.
-Class presentations.

CORE reading materials:

Module 1: Growth and Policies

1.1 Growth Process

Mohan Rao, J. and Storm, Servaas (1998), "Distribution and Growth in Indian Agriculture", in Byres, Terence J.(ed.), *The Indian Economy: Major Debates since Independence*, OUP.
De Roy, Shantanu (2018), "Economic Reforms and Agricultural Growth in India", in *Quarter Century of Liberalization in India: Looking Back and Looking* Ahead, Oxford University Press, New Delhi.
[Through these readings, students will be able to understand the growth performances of Indian agriculture during the pre- and post-reform periods.]

1.2 Policy Level Interventions

Bharadwaj, Krishna (1994), Agricultural Policies for Growth: The Emerging Contradictions, in Byres, T. J. (ed.), *The State, Development Planning and Liberalisation in India*, OUP. New Delhi.
Dev, Mahendra S and Rao, Chandrasekhara N (2010), "Agricultural Price Policy, Farm Profitability and Food Security", *Economic and Political Weekly*, June 26, 45(26/27)
[Discusses policy level impacts on the growth process during the pre- and the post-reform periods.]

Module 2: Production Relations in Indian Agriculture

2.1 Mode of Production Debate in Indian Agriculture

Patnaik, Utsa (1991), *Agrarian Relations and Accumulation: The Mode of Production Debate in India* (Chapters 5,6 and 7), OUP, 1990.
[Captures debates on the modes of production in India.]

2.2 Role of Agriculture in Industrial Development

Patnaik, Utsa (1986), "The Agrarian Question and Development of Capitalism in India", *Economic and Political Weekly*, May, 21(18).
Yadu, C. R. and Satheesha, B. (2016), "Agrarian Questions in India: Indications from NSSO's 70th Round", *Economic and Political Weekly*, 51(16).
[Analyses the role of agriculture in the industrialisation process in India.]

2.3 Tenancy Relations and the Issue of Land in Rural India

Rawal, Vikas (2008), "Ownership Holdings of Land in Rural India: Putting the Record Straight", *Economic and Political Weekly*, March, 43(10).
De Roy, Shantanu (2016), "Changes in the Distribution of Cultivated Land and Occupational Pattern in Rural West Bengal", *Indian Journal of Agricultural Economics,* October-December 71(4).
Rawal, Vikas (2013) and Siddiqur, Osmani, "Economic Policies, Tenancy Relations and Household Incomes: Insights from Three Selected Villages in India", ICSSR-ESRC Bilateral Collaboration Programme for Exchange of Scholars.
[Captures socio- political and economic issues related to land in the context of an agrarian economy like India.]

Module 3: Exchange Relations in Indian Agriculture

3.1 Contract Farming

Singh, Sukhpal (2002), "Contracting Out Solutions: Political Economy of Contract Farming in the Indian Punjab", *World Development*, September, 30(9).
Mahendra Dev, S. and Chandrasekhara Rao, N. (2005), "Food Processing and Contract Farming in Andhra Pradesh: A Small Farmer Perspective", *Economic and Political Weekly*, June-July, 40(26).
[Argues that unequal production relations are the basis of unequal relations of exchange.]

3.2 Agricultural Marketing in India

Ali, Muhamad Jan, and Barbara Harris White (2012), "Three Views About Agricultural Commodity Markets", *Economic and Political Weekly*, December 47(52).
[Analyses interlocked nature of markets in the rural economies and the process of surplus realization.]

Module 4: Technology Diffusion in Indian Agriculture: Issues of Ecological Sustainability

4.1 Green Revolution and Sustainability of Agricultural Development

Singh, R. B. (2000), "Environmental Consequences of Agricultural Development: A Case Study from the Green Revolution State of Haryana, India", *Agriculture, Ecosystems and Environment*, December, 82(1-3).
Chand, Ramesh (1999), "Emerging Crisis in Punjab Agriculture", *Economic and Political Weekly*, March-April,
34(13)
[These papers discuss impact of Green Revolution on natural resources like water, land and environment. These papers also bring into focus the issue of environmental sustainability of Green Revolution technology in India.]

4.2 Implementation of BT cotton Technology in India and its Impacts

Glover, Dominic (2010), "Is BT Cotton a Pro-Poor Technology? A Review and Critique of the Empirical Record", *Journal of Agrarian Change*, 10(4).
Ramakumar, R, Raut, Karan and Kamble, Tushar (2017), "Moving Out of Cotton: Notes from a Longitudinal Survey in Two Vidarbha Villages", *Review of Agrarian Studies*, January to June, 7(1).

Krishna, Vijesh V, and Qaim, Martin (2012), "BT Cotton and Sustainability of Pesticide Reductions in India", *Agricultural Systems*, Vol. 107.
[Discusses merits and demerits of BT cotton technology in India and its impacts on different sections of the producers.]

4.3 Sustainable Farming Practices in India

Khadse, Ashlesha et al (2017), "Taking Agroecology to Scale: The Zero Budget Natural Farming Peasant Movement in Karnataka, India", *The Journal of Peasant Studiesi*, February,45(1).
Patil, Sheetal et al (2014), "Comparing Conventional and Organic Agriculture in Karnataka , India: Where and When can Organic Farming be Sustainable?', *Land Use Policy*, Vol.37.
[These readings bring into discussion alternative farming practices, and conditions under which these practices can promote sustainable development.]

Module 5: **Climate Change and Indian Agriculture: Impacts and Adaptation Strategies**

Saravanakumar, V. (2015), "*Impacts of Climate Change on Yield of Major Food Crops in Tamil Nadu, India*", SANDEE Working Paper No. 91-15.
Balasubramanian, R. (2015), "*Climate Sensitivity of Groundwater Systems Critical for Agricultural Incomes in South India*", SANDEE Working Paper No. 96-15.
Banerjee, Rupsha R. (2015), "Farmer's Perception of Climate Change, Impact and Adaptation Strategies: A Case Study of Four Villages in the Semi-Arid Regions in India", *Natural Hazards*, 75(3).
[Discusses impacts of climate change on Indian agriculture and adaptation strategies by the farmers.]

Module 6: **Economic Reforms and Indian Agriculture**

Nayyar, Deepak and Sen, Abhijit (1994), "International Trade and the Agricultural Sector in India", *Economic and Political Weekly*, May, 29(20).
Gulati, Ashok (2002), "Indian Agriculture in a Globalising World", *American Journal of Agricultural Economics*, August, 84(3).
Patnaik, Utsa (2003), *Global Capitalism, Deflation and Agrarian Crisis in Developing Countries*, Working Paper no. 15, UNRISD.
Patnaik, Utsa (2004), "The Republic of Hunger", *Social Scientist*, September-October, 32(9/10).
[Discusses the rationale for economic reforms on Indian agriculture and impacts of India's accession in the WTO on the rural economy.]

OTHER reading materials

Ramachandran, V. K. and Swaminathan, M. (eds.) (2002), *Agrarian Studies: Essays on Agrarian Relations in Less-Developed Countries*, Tulika Publishers.
Mohanty, B. B. (ed.) (2016), *Critical Perspectives on Agrarian Transition: India in the Global Debate*, Rouledge.
Campling, Liam et. al. (eds.) (2013), *Journal of Agrarian Change: Special Issue*, July, 13(3).

Additional information (if any): None

Student responsibilities: Attendance, feedback, discipline: as per university rules.

Course reviewers:

Prof. R. Ramakumar, Tata Institute of Social Sciences, Mumbai.
Prof. Vikas Rawal, Jawaharlal Nehru University, New Delhi.

Prepared by: Dr. Shantanu De Roy

Course title: Trade, Development and Environment			
Course code: MPE XXX	**No. of credits:** 4	**L-T-P:** 56-0-0	**Learning hours:** 56
Pre-requisite course code and title (if any): MPE 131 **(**Microeconomics), MPE 172 (Econometrics) or equivalent			
Department: Department of Policy Studies			
Course coordinator: TBD		**Course instructor:** TBD	
Contact details:			
Course type: Elective		**Course offered in:** TBD	

Course description:

This course is centred around the following question: Why does trade take place and how does it affect the quality of life of people?

The initial part of the course presents the evolution of theoretical models which demonstrate that there are gains from international trade. The course also delves into empirical studies that have been carried out to validate these models. While trade may improve productivity and incomes of nations, the distribution of the gains from trade may not be uniform across the population. Further, trade may accelerate environmental degradation and climate change. In a globalized world, policies pertaining to trade, capital flows and environment in one part of the world could have adverse impact on other locations. And therefore, in a globalized world, the success of the goals of sustainable development depend heavily on long term multilateral policies and actions. Finally, the course explores the role of globalization on development in India.

Course objectives:

1. To train students to analyse globalization and its impact on environment and development.
2. Exposure to a wide range of theories of international trade. Some of these models establish gains from trade and others identify winners and losers from trade under a variety of contexts and assumptions.
3. To study empirical models of trade and trade policies.
4. To critically examine these theoretical and empirical models from the standpoint of developing nations.
5. To explore different aspects of the on-going debates on the impact of trade on environment, climate change, growth and development and to examine the empirical challenges that exist in this literature.

6. The specific impact of globalization and liberalization policies on India's economic development will be explored as a part of the broader discussion of trade and development.

Course contents

Module	Topic	L	T	P
1	International Trade: Theories and Empirics	24		
	1.1 Ricardian Model of Comparative Advantage 1.2 Heckscher Ohlin and Heckscher Ohlin Vanek Models 1.3 Trade in Intermediate Inputs 1.4 Monopolistic Competition and Gravity Equation 1.5 Global Value Chains			
2	Trade Policy	8		
	2.1 Regional and Multilateral Trade Agreements (including WTO) 2.2 Import Tariffs and Dumping 2.3 Import Quotas and Export Subsidies			
3	Trade and Environment	12		
	3.1 Globalization vs Environment Debate 3.2 Scale, Composition and Technology Effects 3.3 Trade and Environmental Regulations (PHH, Porter Hypothesis, etc) 3.4 Environment and Agreements (WTO & RTAs)			
4	Trade and Development	12		
	4.1 Globalization vs Development Debate 4.2 Trade and Poverty 4.3 Trade and Inequality 4.4 Economics of Fair Trade 4.5 Globalization and India's Economic Development			
	Total (in hours)	56		
	Total (in credits)	4		

Evaluation criteria:

Test 1: Empirical Exercise and presentation (30%) The students will empirically validate the testable hypothesis of a model of international trade. This task involves collating appropriate data, identifying suitable method and interpretation of the results.

a. Task: Replication of empirical analysis of any existing literature on any topic in groups
b. Structure of submission: A report that consists of the summary of the existing literature; outline of empirical method; data sources; interpretation of the results; class presentation and discussion.
c. Indicators of assessment: content (all items outlined in (b) above), structure and quality of the report (weightage: 75%); content and quality of presentation of the report in the class (weightage: 25%).

Test 2: Term Paper: The students will carry out a critical appraisal of literature on any topic of this course. (30%)

a. Task: Undertake a critical appraisal of literature on any topic listed in the syllabus.
b. Structure of submission: A paper that consists of introduction; summary of the literature; critique of the literature with supportive evidence; synthesis and conclusion
c. Indicators of assessment: selection of appropriate literature (weightage: 5%); clear and concise summaries (weightage: 30%); critique that is supported by evidence using author's calculations or by literature (weightage: 40%); effective introduction and

conclusion (weightage: 10%); well-structured essay with no grammatical errors (weightage: 10%); and appropriate format of citations and references (weightage: 5%).
Test 3: Written Exam: Covers all modules (30%)
Test 4: Assignments: Covers all modules (10%)

Learning outcomes:

1. Evolution of theoretical models of international trade and their empirical applications. (Evaluation: Written Exam, Term Paper)
2. Equipping the students with tools and techniques of empirical research in international trade. (Evaluation: Written Exam, Empirical Exercise)
3. Understanding the empirical challenges (data and techniques) of identifying causality between globalization and development/environment (Evaluation: Written Exam, Empirical Exercise, Term Paper)
4. Ability to evaluate the consequences of various instruments of trade policies on different stakeholders. (Evaluation: Written Exam, Term Paper)
5. Articulation of the debates between trade and developmental issues as well as trade and environmental issues (Evaluation: Written Exam, Empirical Exercise, Term Paper)

Reading list (* indicates core readings)

Module 1: International Trade: Theories, Empirics and Policy

*Feenstra, R (2016), *Advanced International Trade: Theory and Evidence, 2nd Edition*, Princeton University Press
Chapters 1, 2, 4, 5, 6
Schott, Peter K. (2003), "One Size Fits All? Heckscher-Ohlin Specialization in Global Production," *American Economic Review*, Vol. 93, 686-708.
Trefler, D. (1995), "The Case of the Missing Trade and Other Mysteries," *American Economic Review*, 85(5), 1029-46.
Grossman, G. M. & Rossi-Hansberg, E. (2008) "Trading Tasks: A Simple Theory of Offshoring," *American Economic Review*, vol. 98(5), pages 1978-97
Krugman (1979) "Increasing returns, monopolistic competition, and international trade," *Journal of International Economics*, vol. 9(4), pages 469-479.
*Baldwin & Taglioni (2006) "Gravity for Dummies and Dummies for Gravity Equations," *CEPR Discussion Papers 5850*
*Baldwin, R. and Lopez-Gonzalez, J. (2015) "Supply-chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses." *World Econ*, 38: 1682–1721. doi:10.1111/twec.12189
*R.C. Johnson (2014) "Five Facts about Value-Added Exports and Implications for Macroeconomics and Trade Research" *Journal of Economic Perspectives*, 28(2), 119-142.
Antràs, P and Davin Chor (2018). "On the Measurement 0f Upstreamness and Downstreamness in Global Value Chains" *NBER Working Paper 24185* http://www.nber.org/papers/w24185

Module 2: Trade Policy

*Feenstra, R (2016), *Advanced International Trade: Theory and Evidence, 2nd Edition*, Princeton University Press
Chapters 7, 8, 9
Romalis, John (2005) "NAFTA'a and CUSFTA's Impact on International Trade," *NBER Working Paper Number 11059*.
*Grossman, G.M. and E. Helpman, (1995) "The Politics of Free Trade Agreements," *American Economic Review*, 84(4), 667-90.

Broda, C, N Limao and D. Weinstein, (2008) "Optimal Tariffs and Market Power: The Evidence" *American Economic Review*, 98 (5): 2032-65.

Naito, Takumi, (2000) "A Rationale for Infant-Industry Protection and Gradual Trade Liberalization," *Review of Development Economics*, Wiley Blackwell, vol. 4(2), pages 164-174.

Messerlin, Patrick A. (2006) "Enlarging the Vision for Trade Policy Space: Special and Differentiated Treatment and Infant Industry Issues," *The World Economy*, vol. 29(10), pages 1395-1407.

Dasgupta, P. & Stiglitz, J. E., (1988) "Learning-by-Doing, Market Structure and Industrial and Trade Policies," Oxford Economic Papers, Oxford University Press, vol. 40(2), pages 246-268.

Module 3: Trade and Environment

*Grossman, G.M. and Krueger, A. B. (1993) "Environmental Impacts of a North American Free Trade Agreement." In *The U.S. - Mexico Free Trade Agreement*. P.M. Garber, ed. Cambridge, MA: MIT Press, 13-56.

*Antweiler,W., Copeland, B.R. and Taylor, M.S. (1998) "Is Free Trade Good for the Environment?" *NBER Working Paper No. 6*

*Copeland, B. R. and M. Scott Taylor (2004) "Trade, Growth, and the Environment" *Journal of Economic Literature*, Vol. 42, No. 1. pp. 7-71.

Copeland, B. R. and M. Scott Taylor (2005) *Trade and the Environment: Theory and Evidence*, Princeton University Press

Cherniwchan, J., Copeland, B. R., M. Scott Taylor (2017) "Trade and the Environment: New Methods, Measurements, and Results" *Annual Review of Economics* 9:1, 59-85.

Martin, LA. 2012. "Energy efficiency gains from trade: Greenhouse gas emissions and India's manufacturing sector." Unpublished manuscript https://arefiles.ucdavis.edu/uploads/filer_public/2014/03/27/martin-energy-efficiencynov.pdf

*Frankel, Jeffrey A. and Andrew K. Rose (2005) "Is Trade Good or Bad for the Environment? Sorting Out the Causality" *The Review of Economics and Statistics* 87:1, 85-91.

Frankel, J. A. (2003) "The Environment and Globalization" *NBER Working Paper No. 10090* http://www.nber.org/papers/w10090.pdf

George, C. (2014), "Environment and Regional Trade Agreements: Emerging Trends and Policy Drivers", *OECD Trade and Environment Working Papers, No. 2014/02*, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jz0v4q45g6h-en

Chander, Parkash & Khan, M. Ali, (2001) "International treaties on trade and global pollution," *International Review of Economic & Finance*, vol. 10(4), pages 303-324.

*Sawhney, A. and Rastogi, R. (2015) "Is India Specializing in Polluting Industries?" *The World Economy*, Volume 38(2): 360-378. ISSN 1467-9701

*Sawhney, A. (2004) "WTO-Related Matters in Trade and Environment: Relationship between WTO Rules and Multilateral Environmental Agreements", *ICRIER Working Paper 133, and WTO Research Series No. 5*, Indian Council for Research on International Economic Research, New Delhi.

Module 4: Trade and Development

*Bardan, Pranab and Udry, Christopher (1999) *Development Microeconomics*, Oxford University Press., (Chapter 14, Trade and Development)

Bardhan (2006) "Globalization and Rural Poverty", *World Development*, Volume 34, Issue 8, Pages 1393-1404.

*Winters, L. A., N. McCulloch, and A. McKay (2004). "Trade Liberalization and Poverty: The Evidence So Far", *Journal of Economic Literature*, 42(1): 72-115
*Rodrik, D. (1997). Has Globalization Gone Too Far? Washington D. C.: Institute of International Economics.
Chang, H.-J. (2002). Kicking away the ladder: Development strategy in historical perspective. London: Anthem.
Rodrik, D. and F. Rodríguez (2000). "Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence", in B. Bernanke and K. S. Rogoff (eds.), *Macroeconomics Annual*, MIT Press, Cambridge, MA, 261-325.
*Topalova (2007) "Trade Liberalization, Poverty, and Inequality Evidence from Indian Districts" http://www.nber.org/chapters/c0110.pdf
*Goldberg, P., Khandelwal, A., Pavcnik, N and Topalova (2010) "Multiproduct Firms and Product Turnover in the Developing World: Evidence from India." *The Review of Economics and Statistics* Vol. 92, No. 4 (NOVEMBER 2010), pp. 1042-1049 http://www.jstor.org/stable/40985812
Dollar, David and Aart Kraay (2004) "Trade Growth and Poverty" *Economic Journal*, vol. 114, issue 493, F22-F49
Darity, W. and Davis, L. (2005) "Growth, Trade, and Uneven Development," *Cambridge Journal of Economics*, 29(1), pp. 141-170.
Slaughter, M.J. (1999) "Globalization and Wages: A Tale of Two Perspectives." *World Economy* 22, 609-630.
Wood, A., (1995) "How Trade Hurt Unskilled Workers," *Journal of Economic Perspectives*, 9 (3).
*Dragusanu, Raluca, Daniele Giovannucci, and Nathan Nunn, (2014) "The Economics of Fair Trade", *Journal of Economic Perspectives*, 28/3, pp. 217 – 236.
Hoekman, Bernard and Michael Kostecki. (2001) *The Political Economy of the World Trading System: WTO and Beyond*. Oxford University Press

Additional information (if any): Suggested journals: Journal of International Economics, International Economic Review, World Economy.

Student responsibilities: Attendance, feedback, discipline: as per university rules.

Prepared by: Dr Seema Sangita

Course reviewers:

1. Prof. Aparna Sawhney – Centre for International Trade and Development, School of International Studies, Jawaharlal Nehru University, New Delhi, Delhi 110067
2. Dr. Dibyendu Maiti – Delhi School of Economics, University Enclave, Delhi, 110007

Course title: Economics of Health and Environment			
Course code: MPE XXX	**No. of credits:** 4	**L-T-P:** 41-13-4	**Learning hours:** 56
Pre-requisite course code and title (if any): Microeconomics (MPE 131)			
Department: Department of Policy Studies			
Course coordinator: TBD	**Course instructor** TBD		
Contact details:			
Course type: Elective	**Course offered in:** Any		

Course description:

This course introduces students to environment – health linkages and underscores the health outcomes related to exposure to air and water pollution other toxic substances, variations in the climate and food and energy sources, and environmental policy. It helps to build up the key concepts and applying tools and techniques of economic evaluation of life and health and associated health care markets.

Upon completion of the course, students would have gained knowledge about the methods, data sources, and models and specifications used in analysis of environment and health from an economist's perspective.

Course objectives

1. To provide students with a thorough knowledge of concepts on environmental health impacts.
2. To decide whether a particular evaluation is necessary for quantifying environmental pollution and choose the appropriate technique and undertake analysis.
3. Apply economic tools appropriately to analyze issues in health care and public health
4. Develop a critically constructive style of analysis of issues in health care organization, delivery, and financing, as well as health policy.
5. Integrate current literature on economic concepts, methods, and applications to issues in health care and public health.

Course content

Module	Topic	L	T	P
1	**Introduction to environmental health** 1.1 Environment-human interaction 1.2 Environmental impact on human health 1.3 Exposure, dose, response 1.4 Risk assessment and management	4	1	0
2	**Economic evaluation of health** 2.1 The relevance of health economics 2.2 Approaches to the economic evaluation of health 2.3 Microeconomic tools for health economics 2.4 Statistical tools for health economics	5	3	0
3	**Cost effectiveness analysis** 3.1 Average cost-effectiveness ratio 3.2 Incremental cost-effective ratio 3.3Distributional cost-effectiveness analysis in addressing health equity and health inequalities 3.4 Case studies	2	1	0
4	**Cost- Utility Analysis** **4.**1 Disability Adjusted life years 4.2 Quality Adjusted life years	6	2	4

	Practical session with the WHO data sets for calculation of DALY and QALY			
5	**Human capital Approach** 5.1 Grossman model 5.2 Cost of Illness	6	2	
6	**Health impacts from Air and water pollution** 6.1 Types of data and specifications used- 6.2 Quantification of health impact of outdoor and indoor air pollution applying several methodologies. 6.3 Quantification of health impacts of water pollution applying the methodologies	6	2	
7	**Climate change and health impacts** 7.1 Climate change and health – vector borne and water borne diseases and impact of heat have 7.2 Methodologies used for addressing climate change and health impacts	8	2	
8	**Impact evaluation of policies in the area of environmental health** Case studies from low and middle-income countries	4		
	Total	41	13	4

Evaluation criteria:

- **Test 1**: Written test [end of module 1 and 2] - 10%
- **Test 2**: Assignments [end of module 3 and 4] -30%
  - I. Assignments will be given as an individual or group to judge the clarity of the methods they have learnt and its area of application
  - II. The structure of submission: Research question, Outline of the methodology, data source, and interpretation of results.
  - III. Indicators of assessment: content and structure and quality of the report (weightage: 80%); presentation of the report in the class (weightage: 20%).
- **Test 3**:Term paper and presentation [end of all modules] - 30%
  - I. Students will be asked to write a term paper (in 5000 words) on a given topic.
  - II. The structure of submission: (i) Title and abstract (ii) Introduction (iii) Literature review (iv) Description of the issue that you will discuss and how it relates to the country you are studying(v) Discussion of the policies the government has enacted or plans to enact to address the problem and an analysis of those policies. (vi) Conclusion summarizing major points.
  - III. Indicators of assessment: (i) research question, (ii) maintaining word limit, (iii) content and clarity (iv) (v) adequate referencing.
- **Test 4**: Final exam [end of all the modules] :Written test - 30%

Learning outcomes: By the end of the course, students will:

- command on the foundations of the key concepts relating environment and health [test 1]
- develop competences with the tools and how to implement them [test 2]
- build confidence in writing term paper [test 3]

– understand linkages between environment and health, concepts, theoretical and methodological understanding with case studies and a brief overview of the health care incentives and financing. [test 4]

Pedagogical approach: Class interaction, teaching and discussion, group assignment, case studies presentation

Course Reading Materials

CORE

Module 1 - Introduction to environmental health

Zweifel, Peter, Friedrich Breyer, and Mathias Kifmann. *Health economics*. Springer Science & Business Media, 2009

Lopez, A. D., & Murray, C. C. (1998). The global burden of disease, 1990–2020. *Nature medicine*, *4*(11), 1241.

Prüss-Üstün, A., Mathers, C., Corvalán, C., & Woodward, A. (2003). Introduction and methods: assessing the environmental burden of disease at national and local levels.

Confalonieri, U., B. Menne, R. Akhtar, K.L. Ebi, M. Hauengue, R.S. Kovats, B. Revich and A. Woodward, 2007: Human health. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press.

Module 2

Module 2 Economic evaluation of health

Zweifel, Peter, Friedrich Breyer, and Mathias Kifmann. *Health economics*. Springer Science & Business Media, 2009.

Module 3 Cost effectiveness analysis

Folland, S., Goodman, A. C., & Stano, M. (2007). *The economics of health and health care* (Vol. 6). Upper Saddle River, NJ: Pearson Prentice Hall.

Zweifel, Peter, Friedrich Breyer, and Mathias Kifmann. *Health economics*. Springer Science & Business Media, 2009.

Raikou, M and McGuire, A. Measuring costs for cost-effectiveness analysis in Jones, A., editor The Elgar Companion to Health Economics, Cheltenham, Edward Elgar

Rudmik, L., & Drummond, M. (2013). Health economic evaluation: important principles and methodology. *The Laryngoscope*, *123*(6), 1341-1347.

Cookson, Richard, Andrew J. Mirelman, Susan Griffin, Miqdad Asaria, Bryony Dawkins, Ole Frithjof Norheim, Stéphane Verguet, and Anthony J. Culyer. "Using cost-effectiveness analysis to address health equity concerns." *Value in Health*20, no. 2 (2017): 206-212.

Module 4 Cost- Utility Analysis

Folland, S., Goodman, A. C., & Stano, M. (2007). *The economics of health and health care* (Vol. 6). Upper Saddle River, NJ: Pearson Prentice Hall.

Zweifel, Peter, Friedrich Breyer, and Mathias Kifmann. *Health economics*. Springer Science & Business Media, 2009.

Sassi, F. (2006). Calculating QALYs, comparing QALY and DALY calculations. *Health policy and planning*, *21*(5), 402-408.

Anand, S., & Hanson, K. (1997). Disability-adjusted life years: a critical review. *Journal of health economics*, *16*(6), 685-702

Module 5- Human capital Approach

Grossman, M. (1972). On the concept of health capital and the demand for health. *Journal of Political economy*, *80*(2), 223-255.

Zweifel, Peter, Friedrich Breyer, and Mathias Kifmann. *Health economics*. Springer Science & Business Media, 2009

Module 6 - Health impacts from Air and water pollution

Air pollution

Arcenas, A., Bojö, J., Larsen, B. and R. Ñunez, Fernanda (2010):The Economic Costs of Indoor Air Pollution: New Results for Indonesia, the Philippines, and Timor-Leste, Journal of Natural Resources Policy Research, 2: 1, 75 — 93

Chay, K. and Greenstone, M. 2003. The Impact of Air Pollution on Infant Mortality: Evidence from Geographic Variation in Pollution Shocks Induced by a Recession, Quarterly Journal of Economics

Cropper, M. L., Simon, N. B., Alberini, A. and Sharma, P.K. 1997. The Health Effects of Air Pollution in Delhi, India (December). World Bank Policy Research Working Paper

Ostro, B. D., 1983. The effects of air pollution on work loss and morbidity, Journal of Environmental Economics and Management, Vol. 10(4)

Ransom, M. and C. A. Pope. 1995. External Health Costs of a Steel Mill. Contemporary Economic Policy, 13.

Hubbell, B. J. 2006. Implementing QALYs in the Analysis of Air Pollution Regulations, Environmental and Resource Economics, 34(3), 34:365–384

Water Pollution

Clasen, T. F. and L. Haller. 2008. Water Quality Interventions to Prevent Diarrhoea: Cost and Cost-Effectiveness, Public Health and the Environment, World Health Organization,

Harrington, W., & Portney, P. R. (1987). Valuing the benefits of health and safety regulation. *Journal of urban Economics*, *22*(1), 101-112.

Module 7 Climate change and health impacts

Markandya, A and A. Chiabai. 2009. Valuing Climate Change Impacts on Human Health: Empirical Evidence from the Literature, International Journal of Environmental Research and Public Health, 6, 759-786

Deschenes, O., M. Greenstone and J. Guryan. 2009. Climate Change and Birth Weight, American Economic Review Papers and Proceedings, 99(2)

Kumar, R., P. Jawale and S. Tandon. 2008. Economic impact of climate change on Mumbai, India Regional Health Forum, Volume 12, Number 1.

Sachs, J. & P. Malaney. 2002. The Economic and Social burden of Malaria, Nature 415, 680-685 (7 February 2002)

Vogel, L., Hey, J. V., Faria, S. H., Spadaro, J. V. (2015). *Health impacts of atmospheric pollution in a changing climate*(No. 2015-03).

Trærup, S. L., Ortiz, R. A., Markandya, A. (2010). The health impacts of climate change: a study of Cholera in Tanzania.

Module 8 – Impact evaluation of policies in the area of environmental health

Liu, Hai-Ying, Alena Bartonova, Mathilde Pascal, Roel Smolders, Erik Skjetne, and Maria Dusinska. "Approaches to integrated monitoring for environmental health impact assessment." *Environmental health* 11, no. 1 (2012): 88.
Pattanayak, Subhrendu K. *Rough guide to impact evaluation of environmental and development programs*. SANDEE, 2009.
R E Glasgow, T M Vogt, and S M BolesAMC Cancer Research Center, Denver, CO 80214, USA. glasgowr@amc.org "Evaluating the public health impact of health promotion interventions: the RE-AIM framework.", *American Journal of Public Health* 89, no. 9 (September 1, 1999): pp. 1322-1327.

OTHERS

Module 1- Module 1 - Introduction to environmental health

Forouzanfar, M. H., Afshin, A., Alexander, L. T., Anderson, H. R., Bhutta, Z. A., Biryukov, S., ... & Cohen, A. J. (2016)Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet*, *388*(10053), 1659-1724.

Module 2 Economic evaluation of health

Folland, S., Goodman, A. C., & Stano, M. (2007). *The economics of health and health care* (Vol. 6). Upper Saddle River, NJ: Pearson Prentice Hall

Module 3 Cost effectiveness analysis

Asaria, Miqdad, Susan Griffin, and Richard Cookson. "Distributional cost-effectiveness analysis: a tutorial." *Medical Decision Making* 36, no. 1 (2016): 8-19.

Ramachandran, A., Snehalatha, C., Yamuna, A., Mary, S., & Ping, Z. (2007). Cost-effectiveness of the interventions in the primary prevention of diabetes among Asian Indians: within-trial results of the Indian Diabetes Prevention Programme (IDPP). *Diabetes Care*, *30*(10), 2548-2552.

Goldie, S. J., Sweet, S., Carvalho, N., Natchu, U. C. M., & Hu, D. (2010). Alternative strategies to reduce maternal mortality in India: a cost-effectiveness analysis. *PLoS medicine*, *7*(4), e1000264.

Rose, J., Hawthorn, R. L., Watts, B., & Singer, M. E. (2009). Public health impact and cost effectiveness of mass vaccination with live attenuated human rotavirus vaccine (RIX4414) in India: model based analysis. *Bmj*, *339*, b3653.

Module 4 Cost- Utility Analysis

Simoens, S. (2010). Health economic assessment: cost-effectiveness thresholds and other decision criteria. *International journal of environmental research and public health*, *7*(4), 1835-1840.

Murray, C. J., Vos, T., Lozano, R., Naghavi, M., Flaxman, A. D., Michaud, C., ... & Aboyans, V. (2012). Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The lancet*, *380*(9859), 2197-2223.

Module 6 - Health impacts from Air and water pollution

Air pollution

Smith, K. R. (2000). National burden of disease in India from indoor air pollution. *Proceedings of the National Academy of Sciences*, *97*(24), 13286-13293.

Smith, K. R., & Mehta, S. (2003). The burden of disease from indoor air pollution in developing countries: comparison of estimates. *International journal of hygiene and environmental health*, *206*(4-5), 279-289.

Calthrop, E., & Maddison, D. (1996). The dose—response function approach to modelling the health effects of air pollution. *Energy Policy*, *24*(7), 599-607

Water Pollution

Dasgupta, P. 2004. Valuing health damages from water pollution in urban Delhi, India: A production function approach, Environment and Development Economics 9 (1)

Pattanayak, S. K., Yang, J. C., Whittington, D., & Bal Kumar, K. C. (2005). Coping with unreliable public water supplies: Averting expenditures by households in Kathmandu, Nepal. *Water Resources Research*, *41*(2).

Hutton, G., L. Haller, J. Bartram. 2007. Economic and health effects of increasing coverage of low-cost household drinking-water supply and sanitation interventions to countries off-track to meet MDG target.

Module 7 Climate change and health impacts

Bosello, F., Roson, R., Tol, R. S. (2006). Economy-wide estimates of the implications of climate change: Human health. *Ecological Economics*, *58*(3), 579-591.

Das, S., & Smith, S. C. (2012). Awareness as an adaptation strategy for reducing mortality from heat waves: evidence from a disaster risk management program in India. *Climate Change Economics*, *3*(02), 1250010.

Ingole, Vijendra, Joacim Rocklöv, Sanjay Juvekar, and Barbara Schumann. "Impact of heat and cold on total and cause-specific mortality in Vadu HDSS—a rural setting in Western India." *International journal of environmental research and public health* 12, no. 12 (2015): 15298-15308.

Das, Saudamini. "Effects of Climate Change and Heat Waves on Low Income Urban Workers: Evidence from India1

Patz, J. A., Campbell-Lendrum, D., Holloway, T., Foley, J. A. (2005). Impact of regional climate change on human health. *Nature*, *438*(7066), 310.

McMichael, A. J., Woodruff, R. E., Hales, S. (2006). Climate change and human health: present and future risks. *The Lancet*, *367*(9513), 859-869.

Module 8 – Impact evaluation of policies in the area of environmental health

Ferraro, Paul J. "Counterfactual thinking and impact evaluation in environmental policy." *New Directions for Evaluation* 2009, no. 122 (2009): 75-84.

Lagarde, Mylene, Andy Haines, and Natasha Palmer. "Conditional cash transfers for improving uptake of health interventions in low-and middle-income countries: a systematic review." *Jama* 298, no. 16 (2007): 1900-1910. Bryce, Jennifer, Cesar G. Victora, Jean-Pierre Habicht, J. Patrick Vaughan, and Robert E. Black. "The multi-country evaluation of the integrated management of childhood illness strategy: lessons for the evaluation of public health interventions." *American journal of public health* 94, no. 3 (2004): 406-415 Rocha, Romero, and Rodrigo R. Soares. "Evaluating the impact of community-based health interventions: evidence from Brazil's Family Health Program." *Health economics* 19, no. S1 (2010): 126-158. Chapter 5- Health policy making and planning in Collins, Charles, and Andrew Green. *Valuing health systems: A framework for low and middle income countries*. SAGE Publications India, 2014.
Advanced Reading Material
Additional information (if any): Journals Lancet, Journal of health economics, PLOS ONE.
Student responsibilities: Attendance, feedback, discipline: as per University rules.

Prepared by: Sukanya Das

Course reviewers:

1. Prof Indrani Gupta, Professor and Head, Health Policy Research Unit (HPRU),, Institute of Economic Growth, New Delhi
2. Prof Indrani Roy Chowdhury, Associate Professor (Economics),Centre for the Study of Regional Development (CSRD),JNU, New Delhi.

Course title: Microeconomics-II			
Course code: MPE 137	**No. of credits: 4**	**L-T-P: 56-0-0**	**Learning hours: 56**
Pre-requisite course code and title : MPE 131 Microeconomics; MPE 113 Mathematical Methods for Economics			
Department: Department of Policy Studies			
Course coordinator:	**Course instructor:**		
Contact details:			
Course type: Elective	**Course offered in:** either semester		
Course description: Standard Microeconomic theory claims that price-taking behaviour results in efficient market outcomes under assumptions like rational preferences, certainty of outcomes and complete information. This course recognizes possibility of market failure, i.e., inefficient market outcomes, when one or more of these assumptions are relaxed. It explores the special			

requirements for designing institutions like insurance, contracts, law, voting, auctions and matching to meet the challenge of market failure.

Course objectives:

1. To understand the role of asymmetric information and non-standard preferences in the failure of markets and other institutions
2. To appreciate the role of alternative axioms in characterizing solutions to institutional failure problems
3. To apply axiomatic theory for characterizing different solutions to institutional failure problems

Course contents

S.No	Topic	L	T	P
1	**Module 1: Flashback and Overview** • Recap of standard Microeconomic theory: individual decision-making and general equilibrium • Overview of the course • Axioms and their role in Microeconomics	**2**		
2	**Module 2: An uncertain world** • Expected Utility Theorem, Measures of Risk Aversion; Application: Insurance • General Equilibrium under uncertainty; Asset Markets; Application: Emission trading markets	8		
3	**Module 3: Lemons and Shirking** • Market for lemons; the screening problem; Application: the problem of a discriminating monopolist vs. the optimal auction problem • Moral hazard; optimal incentive schemes; Application: underdeveloped agriculture • Signalling; Application: signalling in job markets • General application: auctions vs. negotiations for coal blocks	10		
4	**Module 4: Law and Economics** • Coase and Transaction Cost approach; Coase on Federal Communication Commission and auctions for natural resources • Brief overview of law and economics	6		
5	**Module 5: Taking people along: social choice** • Aggregation of individual preferences; Condorcet Paradox; Arrow's Impossibility Result; Single-peaked preferences and other restrictions; Median Voter Rules • Strategic Social Choice: Gibbard-Satterthwaite Theorem; Nash Implementation; strategic social choice when outcomes are lotteries	10		
6	**Module 6: Design your own market** • Mechanism design with money: Optimal auction, VCG , double auctions; Application: mechanism design for land assembly • Mechanism design without money: marriage market and the Gale-Shapley algorithm; house allocation problem and the Shapley-Scarf algorithm	10		

	• Applications: school choice, kidney exchange			
7	**Module 7: Cooperative Games and Networks** • Bargaining Solutions: Nash solution, Core and Shapley Value; Applications to resource sharing problems • Economics of social networks: stability vs efficiency, network formation games.	10		
	Total	**56**		

Evaluation criteria:
Test 1: Submission and oral presentation of a Term Paper (at the end of Module 7) 40%
Test 2: Written Examination (at the end of Module 4) 30 %
Test 3: Written Examination (at the end of Module 7) 30 %

Learning outcomes:
On completion of this course, the students would:

1. Understand the nature of different forms of market failure and theoretical responses to such market failure (Test 2)
2. Understand collective decisionmaking processes and their properties in an axiomatic framework (Test 3)
3. Be able to conceptualize and resolve simple problems of market/institutional failure (Test 1)

Pedagogical approach:
Standard classroom teaching followed by problem solving sessions; classroom experiments.

Materials:
Lecture Notes will be provided.
Suggested readings
Required:
1. Mas-Colell, Andreu, Michael Dennis Whinston, and Jerry R. Green.Microeconomic theory. Vol. 1. New
York: Oxford university press, 1995.
2. Bergin, James. Microeconomic theory: a concise course. Oxford University Press, 2005.

Additional:
1. LeRoy, Stephen F., and Jan Werner. Principles of financial economics. Cambridge UniversityPress, 2001.
2. Salanié, Bernard. The economics of contracts: a primer. MIT press, 2005.
3. Laffont, Jean-Jacques, and David Martimort. The theory of incentives: the principal-agent model.
Princeton University Press, 2009.4. Bolton, Patrick, and Mathias Dewatripont. Contract theory. MIT press, 2005.
4. Coase, Ronald Harry. The firm, the market, and the law. University of Chicago press, 2012.
5. Gaertner, Wulf. A Primer in Social Choice Theory: Revised Edition: Revised Edition. Oxford
University Press, 2009.
6. http://alsamixer.files.wordpress.com/2013/03/iisclectures2.pdf
7. Krishna, Vijay. Auction theory. Academic press, 2009.
8. Peleg, Bezalel, and Peter Sudhölter. Introduction to the theory of cooperative games. Vol. 34.Springer, 2007.

9. Goyal, Sanjeev. Connections: an introduction to the economics of networks. Princeton University Press, 2012.
10. Roth AE. Who Gets What—and Why: The New Economics of Matchmaking and Market Design. Houghton Mifflin Harcourt; 2015
11. Tietenberg TH. Emissions trading: principles and practice. Routledge; 2010
12. Sarkar S. *Auctions, Negotiations and Winner's Curse in Coal Mining in India*, International Journal of Management Practice. Inderscience (forthcoming)

Additional information (if any):

Student responsibilities: Attendance, feedback, discipline: as per university rules.

Course reviewers:
This course was reviewed by

1. Prof Debasis Mishra, Indian Statistical Institute, New Delhi
2. Prof Priyodarshi Banerjee, Indian Statistical Institute, Kolkata

Course prepared by: Dr Soumendu Sarkar

Course title: Labour Economics			
Course code: MPE 174	**No. of credits:** 4	**L-T-P:** 56-0-0	**Learning hours:** 56
Pre-requisite course code and title (if any): 10+2 level knowledge of Mathematics and Macroeconomics (MPE 121)			
Department: Department of Policy Studies			
Course coordinator: TBD	**Course instructor:** TBD		
Contact details:			
Course type: Elective	**Course offered in:** All Semesters		

Course description:

The course discusses contributions of labour in the process of economic development. It locates, historically, changes in the nature of work at different phases of development. Students in this course will get exposed to macroeconomic theories of wages and analysis of labour markets. Further, it incorporates the political economy analysis of labour in the process of production in rural and urban settings with an emphasis of informalisation. The course also brings into discussion the contribution of labour in promoting sustainable rural livelihoods in the non-farm sector through the implementation of the MGNREGS. Students will be acquainted with the relationship between gender and the institution of caste in the processes of production. Impacts of contemporary globalisation on labour and contemporary debates on flexibility of Indian labour laws, incorporating the role of state which is a direct fall out of globalisation, is covered in the course as well.

Course objectives:

1. To familiarize students with the history of work, functioning of labour markets and determination of wage.
2. To provide exposure to the students with diverse labour relations in urban and rural settings.
3. To familiarise students regarding the role of labour in creating resilience of rural households to different climate shocks.
4. To study the relationships between gender and labour and caste and labour.
5. To critically examine the relationship between current phase of globalisation and labour while incorporating the role of Indian state.

Course contents				
S. No	**Topic**	**L**	**T**	**P**
1	**Module 1. Meaning/concept of labour**	3		
2	**Module 2. Labour markets and theories of wage** 2.1 Classical, New Keynesian, Keynesian, and search friction frameworks	12		
3	**Module 3. Agrarian relations and labour in rural India** 3.1 Evolution of the class of agricultural labourers in India 3.2 Agrarian relations and labour contracts: A theoretical perspective 3.3 Non-farm sector and rural labour	13		
4	**Module 4. Urban informal labour** 4.1 Types and nature of informalisation 4.2 Migration and livelihood situation of urban informal labour in India	8		
5	**Module 5. Gender, caste and labour** 5.1 Gender and labour 5.2 Caste discrimination and labour	10		
6	**Module 6. State, globalisation and labour** 6.1 An overview of the relationship between the labour and state in contemporary globalisation 6.2 Globalisation and informalisation of labour 6.3 Labour market reforms in India	10		
	Total	**56**		

Evaluation criteria:

1. **Test 1**: **Written test** [after the completion of modules 1 and 2] – 20%
2. **Test 2: Submission of a term paper** [after the completion of module 3] **–** 30%
   Students will be asked to write an essay (in 2000 words) on a given topic. They will be assessed based on (a) answering the question, (b) maintaining word limit, (c) in-depth understanding of the topic, (d) strength of argument, (e) clarity of argument and (f) proper referencing.
3. **Test 3: Presentation [**after the completion of module 5] – 20%
   There will be individual presentation of students based on the topics covered in the course. Topic(s) will be related to the modules covered in the course.
4. **Test 4: Written test** [at the end of the semester, entire syllabus] – 30%

Learning outcomes:

1. Students will develop a critical understanding regarding history of work and theory of wages [test 1]
2. Ability to evaluate diverse rural and urban labour relations and the role of labour in mitigating shocks related to climate change. Students will also understand linkages between social constructs like gender and caste and labour [tests 2 and 3].
3. Students will be able to assess the impacts of globalisation on labour. They will develop understanding of labour as social relations of production that will enable them to locate it in that perspective rather than locating labour simply as a factor of production [test 4].

Pedagogical approach:

-- Key importance of class interactions and discussions.
-- Presentations by students

CORE reading materials

Module 1. **Meaning/concept of labour**

Bhattacharya, Sabyasachi (2014). "Introduction", in Bhattacharya, S. (ed.), *Towards a New History of Work,* Tulika Books, New Delhi, India.
Edgell, Stephen (2012). "The Transformation of Work: From Work as an Economic Activity to Work as Employment" (Chapter 1) in *The Sociology of Work: Continuity and Change in Paid and Unpaid Work*. Sage Publications Ltd.
[Through these readings students will be able to understand the transformation of work with development of capitalism and related changes in production relations]

Module 2. Labour markets and theories of wage
Smith, Stephen (2003). "Wage Determination and Inequality" (Chapter 3) in *Labour Economics 2nd edition,* Routledge, London and New York.
[Classical understanding of wage determination in the labour market]
Shapiro, Carl and Joseph, Stiglitz (1986). "Equilibrium Unemployment as a Worker Discipline Device" in Akerlof, G. A and J. L. Yellen (eds.), *Efficiency Wage Models of the Labour Market.* Cambridge University Press.
[New-Keynesian understanding of wage determination in the labour market]
Keynes, J. M. (1935). "Changes in Money Wages" (Chapter 19) in *The General Theory of Employment, Interest and Money.* Atlantic Publishers and Distributors (P) Ltd, New Delhi, India.
[Keynesian understanding of wage determination in the labour market]
Marx, K. (1849). *Wage, Labour and Capital & Value, Price and Profit* (Chapter 2-7).
[Marxian understanding of wage determination and relation of wage-labour to capital]
Bowles, Samuel and Herbert, Gintis (1990). "Contested Exchange: New Micro-foundations for the Political Economy of Capitalism", *Politics and Society,* 18(2).
[Analyses the political economy relationship between the employers and workers with a model of contested exchange]
Mortensen, Dale T. (2011). "Markets with Search Friction and the DMP Model", *American Economic Review*, 101(4).
[Analyses the roles that search, and frictions play in the functioning of labour markets.]

Module 3. Agrarian relations and labour in rural India

3.1 Evolution of the class of agricultural labourers in India

Patnaik, Utsa (1983). "On the Evolution of the Class of Agricultural Labourers in India", *Social Scientist,* 11(7).
[This paper analyses economic processes that had led to the creation of agricultural labourers in India]

3.2 Agrarian relations and labour contracts: A theoretical perspective

Dreze, Jean. P. and Mukherjee, Anindita (1990). "Labour Contracts in Rural India: Theories and Evidence", in Chakravarty, Sukhamoy (1990). *The Balance Between Industry and Agriculture in Economic Development: Volume 3, Manpower and Transfers*. Macmillan Press, London.
Mohan Rao, J (1999). "Agrarian Relations and Unfree Labour in Byres", T. J. et. al (eds.). *Rural Labour Relations in India,* Routledge, London and New York.
[These two readings provide theoretical analysis of labour relations in rural India]

3.3 Non-farm sector and rural labour

Himanshu et. al. (2011). *Non-Farm Diversification and Rural Poverty Decline: A Perspective From Indian Sample Survey and Village Study Data,* Working Paper no. 44. LSE Asia Research Centre. London, United Kingdom.

[This paper analyses occupational diversification in the rural areas of India and its importance in ensuring livelihood security to the workers]

Dreze, J. (2011). "Employment Guarantee and the Right to Work", in Khera (ed.) *The Battle for Employment Guarantee*, Oxford University Press, New Delhi.

[Analyses history and the debates related to the NREGA, an important component of rural non-farm jobs.]

Steinbach, Dave et al (2017). *Building Resilience to Climate Change: MGNREGS and Drought in Jharkhand*, Issue Paper, International Institute for Environment and Development, London, United Kingdom

[Analyses role of the MGNREGS in creating resilience of rural households to different climate shocks]

Tiwari, Rakesh et al (2011). "MGNREGA for Environmental Service Enhancement and Vulnerability Reduction: Rapid Appraisal in Chitradurga District, Karnataka", *Economic and Political Weekly*, 46(20).

[This paper examines and assesses the environmental implications of the activities implemented under the NREGA]

Module 4: Urban informal labour

4.1 Types and nature of informalisation

Standing, Guy (2011). "The Pracariat" (Chapter 1) in *The Precariat: The New Dangerous Class*, Bloomsbury Academic, London and New York.

[Students will be able to understand that the informal sector is being considered as being excluded, a catastrophe under capitalism rather than its normal functioning.]

Bhattacharya, Saumyajit (2018). "Comprehending the 'in-formal': Formal-Informal Conundrum in Labour under Capitalism" (Chapter 11) in Ghosh Dastidar, Ananya, Malhotra, Rajeev and Suneja, Vivek (eds.). *Economic Theory and Policy Amidst Global Discontent: Essays in Honour of Deepak Nayyar*. Routledge. London and New York.

[Through this reading the students will be able to understand that informality is not the 'other' but which is always present in strategies of capital which labour fights for contesting and negotiating subjugation.]

4.2 Migration and livelihood situation of urban informal labour in India

Breman, Jan (1996). "Inflow of Labour into South Gujarat (Chapter 3)", in *Footloose Labour: Working in India's Informal Economy* (1996), Cambridge University Press, London.

[Explains the widely prevalent phenomena of migration from villages to towns and conditions of employment of informal workers]

NCEUS (2007). "Towards Protection and Promotion of Livelihoods of Unorganised Workers (Chapter 12)", in the *NCEUS Report on Conditions of Work and Promotion of Livelihoods in the Unorganised Sector* (2007), Government of India, New Delhi.

[This government report analyses economic situation of informal workers and measures to enhance their livelihood security]

Module 5: Gender, caste and labour

5.1 Gender and labour

Beneria, Lourdes (1992). "*Accounting for Women's Work: The Progress of Two Decades",* World Development, 20(11), pp. 1547-1560.

Banerjee, Nirmala (1999). "Analysing Women's Work Under Patriarchy" in Sangari, Kumkum and Chakravarti, Uma (eds.) (1999), *From Myths to Markets: Essays on Gender*, Indian Institute of Advanced Study, Shimla and Manohar Publishers and Distributors, New Delhi, India.

[These papers will enable the students to understand the problems in measuring women's work. It will also enable them to understand women's work under patriarchy.]

Hirway, Indira and Jose, Sunny (2011). "Understanding Women's Work Using Time-Use Statistics: The Case of India", *Feminist Economics,* 17(4).

[The paper shows that the time use surveys has built-in advantages that lead to improved estimates and understanding of the workforce.]

5.2 Caste discrimination and labour

Thorat, Sukhadeo (2008). "Labour Market Discrimination: Concept, Forms and Remedies in the Indian Situation", *The Indian Journal of Labour Economics*, 51(1).

[This paper discusses forms of discrimination that exist against vulnerable social groups in the Indian labour market]

Ito, Takahira (2009). "Caste Discrimination and Transaction Costs in the Labour Market: Evidence from Rural North India", *Journal of Development Economics,* 88(2).

[The paper discusses existence of transaction costs against backward castes regarding access to regular employment].

Module 6: State, globalisation and labour

6.1 An overview of the relationship between the labour and state in contemporary globalisation

Banerjee, Debdas and Goldfield, Michael (2007). Neoliberal globalization, labour and the state in Banerjee, Debdas and Goldfield, Michael (eds.) (2007), *Labour, Globalisation and the State: Workers, Women and Migrants Confront Neoliberalism*. Routledge, London and New York.

[Analyses the contemporary nature of development and the role of state vis-à-vis labour]

6.2 Globalisation and informalisation of labour

Sanyal, Kalyan and Bhattacharya, Rajesh (2009). "Beyond the Factory: Globalisation, Informalisation of Production and the New Locations of Labour", *Economic and Political Weekly*, 44(22).

[Analyses changes in the conditions of employment with the current phase of globalization]

Roy, Satyaki (2014). Informality' and Neo-liberalism: Changing Norms and Capital's Control in Kannan et al (eds.) *Labour and Development: Essays in Honour of Professor T. S. Papola,* Academic Foundation, New Delhi-215-234.

[This paper questions the notion of 'informality' as a transitory feature of the development process.]

6.3 Labour market reforms in India

NCEUS (2009). "Labour Law Reforms: Beyond a Narrow Agenda (Chapter 7)", in *The Challenge of Employment in India: An Informal Economy Perspective,* Government of India, New Delhi.

Roychowdhury, Anamitra (2018). "A Critical Examination of the Labour Market Flexibility Debate in India" (Chapter 2), *Labour Law Reforms in India: All in the Name of Jobs*, Routledge, London and New York.

Bhattacharjea, Aditya (2006). "Labour Market Regulation and Industrial Performance in India: A Critical Review of the Empirical Evidence", *The Indian Journal of Labour Economics*, 49(2).

[These three readings critically examine the nature of reforms in labour laws, whether these reforms are beneficial for the workers employed informally, thereby leading to overall increase in employment and industrial development.]

Additional information (if any): None

Student responsibilities: Attendance, feedback, discipline: as per university rules.

Course Reviewers:

Professor Sumangala Damodaran, School of Development Studies, Ambedkar University Delhi.
Dr. Satyaki Roy, Associate Professor, Institute for Studies in Industrial Development, Vasant Kunj, New Delhi.

Prepared by: Dr. Shantanu De Roy

<table>
<tr><td colspan="4">Course title: Advanced Econometrics</td></tr>
<tr><td>Course code: MPE 179</td><td>No. of credits: 4</td><td>L-T-P: 38-7-22</td><td>Learning hours: 56</td></tr>
<tr><td colspan="4">Pre-requisite course code and title (if any): MPE 172 or equivalent</td></tr>
<tr><td colspan="4">Department: Department of Policy Studies</td></tr>
<tr><td colspan="2">Course coordinator: Dr. Kavita Sardana</td><td colspan="2">Course instructor</td></tr>
<tr><td colspan="4">Contact details: kavita.sardana@terisas.ac.in</td></tr>
<tr><td colspan="2">Course type: Elective</td><td colspan="2">Course offered in: All semesters</td></tr>
<tr><td colspan="4">Course description:
This is an advanced level course in the area of Applied Econometrics dealing with Panel Data and Nonlinear Models. The range of topics covered in the course will span a large part of econometrics generally, though we are particularly interested in those techniques as they are adapted to the analysis of panel or longitudinal data sets. The asymptotic distribution theory necessary for analysis of generalized linear and nonlinear models will
be reviewed or developed as we proceed. The second half of the course will focus on nonlinear models. Topics covered will focus on micro-econometric methods, including binary and discrete choice modelling, limited dependent variables, and sample selection. Special emphasis is given to estimation methods including maximum likelihood and generalized methods of moments.
Lab Practicals
This course places heavy emphasis on solving computer exercises. Practicals will involve applications from the fields of labor economics, environmental economics, and agricultural economics.</td></tr>
<tr><td colspan="4">Course objectives:
1. To understand basic differences in linear endogenous variables and non-linear endogenous variables</td></tr>
</table>

2. Learn about violations of classical linear model assumptions (relating to first and second moments) under panel and non-linear regression.
3. Learning solutions through theoretical and empirical analysis

Course contents

Module	Topic	L	T	P
1	**Linear Models: Panel Data Models Basic Linear Unobserved Effects Panel Data Models** 1.1 Estimating Unobserved Effects by Pooled OLS 1.2 Random Effects Methods 1.3 Fixed Effects Methods 1.4 First Differencing Methods 1.5 Comparisons of Estimators **Unobserved Effects Models without the Strict Exogeneity Assumption** 1.6 Models with Individual-Specific Slopes **1.7** GMM approaches to Linear Unobserved Effects Models	**14**	**3**	**7**
2	**Nonlinear Models** **Geometry of Non-linear Modelling** 2.1 Intrinsic Nonlinearity 2.2 Parameter Effects Nonlinearity 2.3 Linear Approximations 2.4 Nonlinear Least Squares 2.5 Gauss Newton algorithm **Discrete Response Models** 2.6 Index Models for Binary Response: Probit and Logit 2.7 Multinomial Response Models 2.8 Ordered Response Models **Cornered Solution Outcomes and Censored Regression Models** 2.9 Estimation and Inference with Censored Tobit 2.10 Sample Selection, Attrition, and Stratified Sampling. 2.11 Selection on the basis of the Response Variable: Truncated Regression 2.12 A Probit Selection Equation 2.13 A Tobit Selection Equation 2.14 Stratified Sampling **Count Data and related Models** 2.15 Poisson Regression Models 2.16 Negative Binomial Regression Models and log-normal Poisson Models	**24**	**4**	**15**
	Total	**38**	**7**	**22**

Materials:

Textbooks

Module 1 and Module 2

1. (**Core**) J.M. Wooldridge, Econometrics Analysis of Cross Section and Panel Data. The MIT Press,
Cambridge, Massachusetts. 2002.

Module 2

2. (**Core**) Bates, Douglas M., and Donald G. Watts. "Nonlinear regression: iterative estimation and linear approximations." Nonlinear regression analysis and its applications (1988): 32-66.

Other readings

Module 1

1. Baltagi, B.H., Econometric Analysis of Panel Data. New York: John Wiley. 1995.2.
2. Module 2: Hsiao, C., Analysis of Panel Data. Cambridge: Cambridge University Press. 1986.
3. Chamberlain, G., "Multivariate Regression Models for Panel Data," Journal of Econometrics 18 (1982), pp. 5-46.
4. Cornwell, C., and D Trumball, "Estimating the Economic Model of Crime with Panel Data," Review of Economics and Statistics 76 (1994), pp. 360-366.

Module 2

1. William H. Greene, Econometric Analysis. New York: MacMillan. 1997.
2. Cameron, A.C., and P.K. Trivedi, Microeconometrics: Methods and Applications. Cambridge University Press, New York. 2005.
3. Maddala, G.S., Limited Dependent and Qualitative Variables in Econometrics. Cambridge: Cambridge

University Press. 1983.

4. Joshua D. Angrist and Alan B. Krueger, "Does Compulsory School Attendance Affect Schooling and

Earnings?" The Quarterly Journal of Economics 106 (1991), pp. 979-1014.

5. Bartik, T. J., "The Estimation of Demand Parameters in Hedonic Price Models," Journal of Political

Economy 95 (1987), pp. 81-88.

6. Qian, H., and P. Schmidt, "Improved Instrumental Variables and Generalized Method of Moments

Estimators," Journal of Econometrics 91 (1999), pp. 145-169.

7. Vella, F. "Estimating models with Sample Selection Bias in Censored and Discrete Choice models," Journal of Applied Econometrics 7 (1992), pp. 413-421

Evaluation criteria:

1.	Written Examination (Test 1)	15% [Module 1]
2.	Written Examination (Test 2)	15% [Module 2]
3.	Lab Practical (Test 3)	30% [Modules 1-2]
4.	Major Exam (Test 4)	40% [Modules 1-2]

Learning outcomes:

After completing this course the students will be able to

1. Distinguish modelling issues relating to panel and non-linear regression modelling [Tests 1-2 and Test 4]
2. Analyse problems that seek solutions through panel and non-linear regression. [Test 3]
3. Proficiency in statistical software. [Test 3]

Student responsibilities: Attendance, feedback, discipline: as per university rules.

Prepared by: Dr Kavita Sardana

Course reviewers:

1. Prof. Octavio Ramirez, Head and Professor, University of Georgia, USA.
2. Prof. Subrata Sarkar, Professor, IGIDR.
3. Prof. Abhiroop Mukhopadhyay, Associate Professor, ISI, Delhi.

Course title: Time series and regression analysis			
Course code: MPE 177	**No. of credits:** 4	**L-T-P:** 42-0-28	**Learning hours:** 56
Pre-requisite course code and title (if any): MPE 172 or equivalent			
Department: Department of Policy Studies			
Course coordinator: Dr. Kavita Sardana	**Course instructor**		
Contact details: kavita.sardana@terisas.ac.in			
Course type: Elective	**Course offered in:** All semesters		

Course description:

The aim of this course is to provide students with the essential expertise to handle modern time series techniques. Idea is to introduce students to comprehensive set of tools and techniques for analysing various forms of univariate and multivariate time series and for understanding the current literature in applied time series. After the course students will also be able to appreciate and apply key concepts of estimation and forecasting in a time series context. Endeavor will be to provide simple examples that illustrate how the theoretical results are used and applied in
Practice.

Lab Practicals

This course places heavy emphasis on solving computer exercises. Practicals will involve applications from the fields of macroeconomics with a focus on issues relating to environment and resource.

Course objectives:

1. To understand violation of classical linear model assumptions when continuous random variables change over time.
2. To learn about theoretical and empirical solutions when assumptions are violated.

Course contents

Module	Topic	L	T	P
1	**Theory of Univariate Time Series** **1. Model Specification** 1.1 Normal (Gaussian) White Noise 1.2 AR (1) Process 1.3 Random Walk 1.4 Unit Root Process 1.5 AR (2) Process	14		6

	1.6 AR(p) Process 1.7 MA (1) process 1.8 ARMA(p) process 1.9 Weakly Dependent processes or integrated of order zero 1.10 Integration of order one **2. Efficiency and Inference** 2.1 Testing for First Order Autocorrelation 2.2 Testing for Serial Correlation in the Presence of Lagged Dependent Variable 2.3 Testing for Serial Correlation with Strictly Exogeneous Regressors 2.4 Testing for Higher Order Serial Correlation 2.5 Correcting for Serial Correlation with First Order Autocorrelation, Lagged dependent Variable, and Strictly Exogeneous Regressor 2.6 Serial Correlation Robust Inference after OLS 2.7 Testing for Heteroskedasticity 2.8 Autoregressive Conditional Heteroskedasticity (ARCH and GARCH models) 2.9 Heteroskedasticity and Autocorrelation (HA) in Regression Models 2.10 Heteroskedasticity and Autocorrelation Corrected Inference (HAC)			
2	**Theory of Multivariate Time Series** 1. Cointegration Analysis 1.1 The Engel-Granger (EG) Approach 1.2 The Johansen Approach 1.3 Identification of the beta coefficient and Restriction Tests: With one or more cointegrating vector(s) 1.4 Vector Error Correction Models (VECM)	7		4
3	**The Econometric Forecasting: Theory and Application** 3.1 Modelling Trends, Seasonality and Cycles 3.2 Graphic Method of Forecasting 3.3 One-step-ahead forecast 3.4 Point forecast 3.5 Forecast Interval 3.6 Vector Autoregressive Model 3.7 Granger Causality 3.8 Scenarios Analysis and Impulse Response Functions	21		18
	Total	**42**		**28**

Evaluation criteria:

Written Examination (Test 1) 12.5% [Module 1]
Written Examination (Test 2) 12.5% [Module 2]
Lab Practical (Test 3) 25% [Modules 1-3]

Major Exam (Test 4) 50% [Modules 1-3]
Learning outcomes: After completing this course, the students will be able to 1. Distinguish problems in econometrics relating to cross-section and time series [Tests 1-2 and Test 4] 2. To theoretically and empirically formulate problems that can be resolved using time series analysis [Test 3] 3. Proficiency in use of statistical package [Test 3]
Materials: **Core Reading** 1. Wooldridge, J.M., 2015. Introductory econometrics: A modern approach. Nelson Education. Chapter 10-12 and 18 **Other Readings** **Module 1 and Module 2** 1. Stock, J.H. and Watson, M.W., 2007. *Econometrics*. Addison Wesley. Chapter 12-16 2. Greene, W.H., 2003. *Econometric analysis*. Pearson Education India. Chapter 11, 12, 19, 20
Student responsibilities: Attendance, feedback, discipline: as per university rules.

Prepared by: Dr Kavita Sardana

Course reviewers:

1. Prof. Bharat Ramaswami Indian Statistical Institute
2. Prof. Abhiroop Mukhopadhyay, Indian Statistical Institute

Annexure 2

Course title: **Advances in remote sensing: Thermal, Hyperspectral, Microwave, LIDAR and UAV**			
Course code: NRG 177	**No. of credits:** 4	**L-T-P:** 26-13-34	**Learning hours:** 73
Pre-requisite course code and title (if any): NRG 172 & NRG 178			
Department: Natural Resources			
Course coordinator: Dr Nithiyanandam		**Course instructor:** Dr Nithiyanandam	
Contact details: nithiyanandam.y@terisas.ac.in			
Course type: Core		**Course offered in:** Third semester	
Course Description: This course will provide an opportunity to understand and work with advanced developments in Remote Sensing and covers a wide range of remote sensing data interpretation and processing techniques.			
Course objectives: To teach basics of Thermal, Hyperspectral, Microwave and UAV remote sensing, and to inculcate practical skill for processing advance remote sensing datasets for various applications including natural resources management.			

Course content

Module	Topic	L	T	P
1.	Thermal remote sensing ▪ Introduction: Laws and definitions –Thermal emission characteristics – Physics behind thermal mapping (including thermal inertia)– Errors and assumption in thermal remote sensing – Modelling Thermal data ▪ Processing and Analysis: Radiometric Calibration of Satellite and Airborne Thermal data – TIR Image processing – Emissivity databases – visual and quantitative image interpretation of TIR data – Data fusion ▪ Applications of thermal imagery – UHI and coal mine fire mapping.	6	3	
2.	Hyperspectral remote sensing ▪ Introduction: Imaging spectroscopy–History and development of Hyperspectral remote sensing – working principles of imaging spectrometers – hyperspectral sensors ▪ Processing and Analysis: Data preparation and Transformation–Atmospheric correction–End member detection and extraction–spectral unmixing–target and anomaly detection ▪ c. Applications of hyperspectral imagery – Mineral and vegetation mapping.	6	3	
3.	Microwave remote sensing ▪ Introduction: Active and passive microwave systems – basic principle of Radar/SAR (Geometric and statistical properties and imaging geometry) –Radar Relief displacement (Foreshortening, Layover, Shadow & Speckle) ▪ Processing and interpretation: Filters– Radar interferometry and polarimetry	8	4	

	▪ c. Applications of microwave remote sensing – ocean topography and flood mapping.			
4.	LIDAR ▪ Introduction: Principles and Geometry– sensor and platforms ▪ Processing and interpretation: Data processing – Quality control– information extraction. ▪ c. Applications of LIDAR – land surface topography and 3D mapping.	4	2	
5.	Unmanned Aerial Vehicle (UAV): Overview of the technology, data visualization, and interpretation.	2	1	
	Total	**26**	**13**	**0**
Exp. No.	**Labs**			
1.	Land surface emissivity estimation and compare outputs of two estimation techniques			4
2.	Estimate land surface temperature and analyse its spatial variation with respect to different land cover types			4
3.	Pre-processing hyperspectral datasets (Data preparation, Spectral analysis, atmospheric correction)			2
4.	Spectral analysis comparing hyperspectral and multi-spectral datasets			2
5.	Target detection using the hyperspectral data			2
6.	Dimension reduction analysis with hyperspectral data			2
7.	SAR imagery pre-processing			4
8.	Radar Bathymetry			4
9.	Lidar data visualisation, quality checking and basic processing in latosols			4
10.	Surface and terrain model creation using Lidar data (			4
11.	UAV data visualization			2
	Total	**26**	**13**	**34**

Evaluation criteria

Test I: 15 % **(Module 1& 2) (learning outcome 1 & 2)**

Test II: 15% **(Module 3&4) (learning outcome1 & 2)**

Practical: 30% **(Module 1:5) (learning outcome 3)**

Test III: 40% (Module 1:5) (learning outcome 1 & 2)

Learning outcomes:

Upon completion of this course, a fully engaged student shall be able to:

1. Comprehend the basics of thermal, hyperspectral, microwave, LIDAR and UAV remote sensing.
2. Process and interpret thermal, hyper spectral, microwave, LIDAR datasets.
3. Utilize skills obtained for different applications of thermal, hyper spectral, microwave, LIDAR remote sensing.

Pedagogical approach: Interdisciplinary learning, discovery learning, peer teaching, practical and case studies.

Materials: Books

Module 1:

▪ Kuenzer, C., & Dech, S. (2013). Thermal Infrared Remote Sensing, ISBN 978-94-007-6639-6.

- Quattrochi, D., & Luvall, J. (2004), Thermal Remote Sensing in Land Surface Processing, CRP Press, ISBN: 978-0-415-30224-1.

Module 2:

- Marcus Borengasser, William S. Hungate, Russell Watkins (2007) Hyperspectral Remote Sensing: Principles and Applications, CRC Press.
- Ruiliang Pu (2017), Hyperspectral Remote Sensing: Fundamentals and Practices, CRC press.

Module 3:

- H. Woodhouse (2005). An introduction to microwave remote sensing. Taylor and Francis, London.
- J.S. Lee, E.Pottier (2008), Polarimetric Radar Imaging: From Basics to Applications, CRC Press
- Oliver and Quegan (1998). Understanding synthetic aperture radar images. Artech House.
- Van Zyl, J., & Kim, Y (2011), Synthetic Aperture Radar Polarimetry, John Wiley & Sons, Inc,
- Van Zyl, J., & Kim, Y (2011), Synthetic Aperture Radar Polarimetry, John Wiley & Sons, Inc,

Module 4:

- Qihao Weng (2011), Advances in Environmental Remote Sensing: Sensors, Algorithms, and Applications, CRC Press.
- Qihao, Weng (2012), An Introduction to Contemporary Remote Sensing, McGraw-Hill Professional, ISBN: 978-0-071-74011-1.

Module 5:

- Gianluca C, Andras S, Gergely S (2017), Small Flying Drones, Applications for Geographic observation, Springer, ISBN:978-3-319-66576-4

Journals references

- ISPRS Journal of Photogrammetry and Remote Sensing
- Journal of Indian Society of Remote Sensing
- Remote Sensing of Environment

Magazines

- Coordinates
- Geospatial world
- GIM International

Others

Other online materials including case studies will be shared time to time.

Additional information (if any)

Student responsibilities:

The students are expected to read supplementary materials provided along with the course to get holistic knowledge about the subject. Further expected to complete practical exercises and assignments on time.

Course Reviewers:

1. Professor Qiao Weng, Director, Center for Urban and Environmental Change; Professor, Department of Earth & Environmental Systems, Indiana State University, Terre Haute, IN 47809, USA.
2. Professor Muralikrishna V Iyyanki, Dr Raja Ramanna Distinguished fellow at DRDO, Hyderabad, India.
3. Dr. Nusret Demir, Space Sciences and Technologies Division, Akdeniz University, Turkey.

<table>
<tr><td colspan="6">Course title: Advances in GIS and current trends</td></tr>
<tr><td colspan="2">Course code:</td><td>No. of credits: 4</td><td>L-T-P: 22-10-36</td><td colspan="2">Learning hours: 66</td></tr>
<tr><td colspan="6">Pre-requisite course code and title (if any):</td></tr>
<tr><td colspan="6">Department: Department of Natural Resources</td></tr>
<tr><td colspan="3">Course coordinator(s): Dr Anu Rani Sharma</td><td colspan="3">Course instructor(s):</td></tr>
<tr><td colspan="6">Contact details:</td></tr>
<tr><td colspan="3">Course type: Core</td><td colspan="3">Course offered in: Semester 3</td></tr>
<tr><td colspan="6">Course description
This course is designed to introduce Web GIS, programming concepts for constructing high quality web mapping applications, participatory GIS, mobile GIS and fundamental concepts behind Internet of Things. The course will be delivered using both COTS and FOSS platform and related programming tools to customize web-mapping applications and to develop distributed GIS based web services.</td></tr>
<tr><td colspan="6">Course objectives
1. Introduces new ways of data collections, dissemination and applications of GIS technology
2. Provide state-of-art technical skills to build Web GIS applications and the knowledge needed to choose from various Web GIS development options
3. Introduces fundamental concepts of Internet of Things and its applications in GIS</td></tr>
<tr><td colspan="6">Course content</td></tr>
<tr><td>Module</td><td colspan="3">Topic</td><td>L</td><td>T</td><td>P</td></tr>
</table>

1.	Introduction to Web mapping, Web publishing technology: CSS and HTML	2		
2.	WebGIS: Concept of WebGIS, Server Architecture, Web server, Application server, Database server, GIS server	2	2	
3.	Web server: IIS server, apache tomcat / GIS server: ArcGIS server, Geoserver / Database server: Oracle, postgreSQL	2		
4.	Database Management in Oracle and PostgreSQL, sde architecture in Oracle and PostgreSQL	2		
5.	Introduction to GIS web services: WMS, WFS, WMTS, Mapservices, Feature Services. Publishing Spatial data as one of the above specified web services	2	2	
6.	Web Mapping: Introduction, Geospatial web services, Geospatial mashups	2		
7	Participatory GIS and Mobile GIS	2	2	
8	Distributed GIS System	2		
9	Internet GIS : Web mapping application using open source api to consume GIS web services in web application.	4	2	
10	Internet of Things: Introduction, Designing principles for connected devices, Internet Principles, Embedded devices and codes (sensors, actuators, platform: Arduino, Raspberri Pi), Applications in GIS	2	2	
	LAB			
1	Creating a webmap using Google map and ArcGIS online			4
2.	Write a page using HTML and CSS			4
3.	Creating web application using spatial data			4
4	Writing query in PostgreSQL and creating a customized map			8
5	Creating a geodatabase using ArcSDE			4
6	Creating web maps using different web services: leaflet, geoserver			8
7	Development of distributed GI services application			4
8	Development of mobile app.			6
9	Creating a web based map using open source API			6
	Total	22	10	36

Evaluation criteria:

- Test 1: 15% [Modules 1, 2 and 3] (Learning outcome1)
- Test 2: 15% [Module 4,5 and 6] (Learning outcome 1,2 and 3)
- Assignment/tutorial: 20% [every week] (All the learning outcomes over semester)
- Lab Exam: 20% [from all modules at the end of semester] (All the learning outcomes)
- Test 3: 30% [All the modules] (All the learning outcomes)

Learning outcomes

After completion of this course students should be able to

1. Assess benefits and challenges of development of web based application in GIS
2. Differentiate between webGIS, mashup, mobile GIS
3. Critically examine the internal workings of "communities" and "mapping."
4. Able to develop web based application in GIS

Pedagogical approach

The course will be delivered through class lectures, lab exercise and tutorials

Course Reading Materials

1. Peng, Z. R., & Tsou, M. H. (2003). *Internet GIS: distributed geographic information services for the internet and wireless networks*. John Wiley & Sons.(Module 1-6)
2. Sheehan, M. (2015). *Developing Mobile Web ArcGIS Applications*. Packt Publishing Ltd. (Module 7)
3. Weiner, D., & Harris, T. M. (2008). Participatory geographic information systems. *The handbook of geographic information science*, 466-480. (module 7)
4. McEwen, A., & Cassimally, H. (2013). *Designing the internet of things*. John Wiley & Sons (Module 10)

Advanced Reading Material

1. McCord, P., Tonini, F., & Liu, J. (2018). The Telecoupling GeoApp: A Web-GIS application to systematically analyze telecouplings and sustainable development. *Applied Geography*, *96*, 16-28.

2. Al–Sahly, A., Hassan, M. M., Al–Rubaian, M., & Al–Qurishi, M. (2018, April). Using GIS for Measuring Mobile Tower Radiation on Human. In *2018 1st International Conference on Computer Applications & Information Security (ICCAIS)* (pp. 1-6). IEEE.

3. Radil, S. M., & Anderson, M. B. (2018). Rethinking PGIS: Participatory or (post) political GIS?. *Progress in Human Geography*, 0309132517750774.

4. Cao, H., & Wachowicz, M. (2019). The design of an IoT-GIS platform for performing automated analytical tasks. *Computers, Environment and Urban Systems*, *74*, 23-40.

Recommended journals for reference

5. Journal of Digital Earth,

6. Computers, Environment and Urban System

7. Computer and Geosciences

Additional information (if any)

Student responsibilities

The students are expected to submit assignments in time and come prepared with readings when provided.

Course reviewers:

1. Prof. C. Jeganathan, BIT Mesra, Ranchi.
2. Mr. Greg Fiske, Senior Geospatial Analyst, WHRC, USA

Course title: Applications of Geoinformatics for Land Resources			
Course code:	**No. of credits: 3**	**L-T-P: 16-8-36**	**Learning hours: 42**
Pre-requisite course code and title (if any):			
Department: Department of Natural Resources			
Course coordinator(s): Dr. Neeti	**Course instructor(s):** Dr. Neeti/ Dr. C.K. Singh		
Contact details:			
Course type: Core	**Course offered in: Semester 3**		

Course description

This course is designed for students to learn applications of geospatial technology for land resources. The course is designed to quantify different landscape elements using remote sensing. It also introduces mapping of agriculture, forest, soil and minerals using remote sensing and GIS.

Course objectives:

1. To gain broad understanding of the geospatial approaches for detecting and characterizing landscape pattern and the causes of landscape pattern
2. To study utility of geospatial technology for agriculture, forest, soil and minerals detection

Course content (max 15)

Module	**Topic**	**L**	**T**	**P**
1.	Introduction: Landscape, landscape characterization, patterns and changes, Concepts of landscape Elements and quantification analysis	4		
2.	Quantification of landscape using landscape metrics and remote sensing, Scale issues in landscape observation,	2		
3.	Applications of Geoinformatics (Case studies): land use/land cover mapping, vegetation mapping: Forest type, density and biomass assessment, Change detection, crop type, crop stress due to disaster, habitat suitability mapping	2	2	
4.	Introduction to soils, soil formation models/processes, soil profile, soil classification, spectral reflectance of soil, models of radiation scattered by soil, factors affecting soil spectra, soil mapping	4	4	
5.	Spectroscopy; emission and reflectance spectra, Spectroscopic processes, electronic and vibrational processes, spectral library of	4	2	

	minerals; silicates, carbonates, sulphides, arsenates, etc and spectral library of rocks; igneous, sedimentary and metamorphic rocks, alteration minerals			
	LABS			
1.	Defining Landscape			2
2.	Quantifying patch mosaic: landscape metrics using FragStats			4
3.	Quantifying point and pattern in landscape			2
4.	**Group project:** This will be hands-on training for students. Students will do group project with group size of 2-3 on relevant topics taught in the course			28
	Total	16	8	36

Evaluation criteria:

- Assignments/Tutorials: 20% (All learning outcomes)
- Test1 [Module 1, 2, 3]: 20% (Learning outcome 1 and 2)
- Test2 [Module 4, 5]: 20% (Learning outcome 3 and 4)
- Concept Note for research project: 10%

  (a) Title: 5%
  (b) Introduction: 15%
  (c) Literature review: 20%
  (d) Aim and objectives, research questions: 25%
  (e) Data and method: 15%
  (f) Potential outcomes: 15%
  (g) References: 5%

- Final Presentation: 10%

  (a) Defining the problem (10%)
  (b) Objectives are framed to address the problem (10%)
  (c) Methodology addresses the issue (15%)
  (d) Results orient towards the problem (10%)
  (e) Appropriate findings (15%)
  (f) Presentation (formatting/style/clarity) (10%)
  (g) Viva (30%)

- Final Report: 20%

a) Abstract (clarity and comprehensiveness) (5%)
b) Introduction (scientific background and rationale of study is properly stated, statements are referenced properly) (15%)
c) Literature review (Structure and logic of argument, statements are properly referenced) (15%)
d) Objectives (Logic of argumentation, justification of hypothesis/research questions, Link to actual scientific knowledge) (15%)

e) Material and method (Choice of methodology and their appropriate application Structure, link to objectives, Referencing and use of methodology outlined in literature) (15%)
f) Results (Completeness and clarity, Structure, link to objectives, Tables and figures and their link to the text) (15%)
g) Discussion and Conclusion (Linkage with previous sections, clarity in findings from the study and based on literature, proper interpretation, understanding of limitation of study) (15%)
h) List of references (proper formatting) (5%)

Learning outcomes (Connect with the evaluation criteria mentioned above)

The student will be able to

1. Able to apply different landscape metrics to quantify landscape pattern
2. Use geospatial technology for vegetation mapping
3. Understand spectral properties of soil and mineral geological applications
4. Apply Advanced techniques for soil and mineral mapping
5. Ability to conceptualize and perform a research project

Pedagogical approach

Course Reading Materials (* = compulsory readings)

Module 1:

Gergel, Sarah E., and Monica G. Turner, eds. *Learning landscape ecology: a practical guide to concepts and techniques*. Springer, 2017.

Turner, M. G., Gardner, R. H., O'neill, R. V., Gardner, R. H., & O'Neill, R. V. (2001). *Landscape ecology in theory and practice* (Vol. 401). New York: Springer.

Module 2:

Gergel, Sarah E., and Monica G. Turner, eds. *Learning landscape ecology: a practical guide to concepts and techniques*. Springer, 2017.

Turner, M. G., Gardner, R. H., O'neill, R. V., Gardner, R. H., & O'Neill, R. V. (2001). *Landscape ecology in theory and practice* (Vol. 401). New York: Springer.

Module 3:

Gergel, Sarah E., and Monica G. Turner, eds. *Learning landscape ecology: a practical guide to concepts and techniques*. Springer, 2017.

Turner, M. G., Gardner, R. H., O'neill, R. V., Gardner, R. H., & O'Neill, R. V. (2001). *Landscape ecology in theory and practice* (Vol. 401). New York: Springer.

Module 4:

Wulder, M. A., & Franklin, S. E. (Eds.). (2012). *Remote sensing of forest environments: concepts and case studies*. Springer Science & Business Media.

Steven, M. D., & Clark, J. A. (Eds.). (2013). *Applications of remote sensing in agriculture*. Elsevier.

Module 5:

Diwedi, R.S. (2017). *Remote Sensing of Soils*. Springer

Module 6:

Prost, G. L. (2002). *Remote sensing for geologists. A guide to image interpretation*. CRC Press

Borengasser, M., Hungate, W.S. and Watkins, R., 2007. *Hyperspectral remote sensing: principles and applications*. CRC press.

Advanced Reading Material

Lu, D., Chen, Q., Wang, G., Liu, L., Li, G., & Moran, E. (2016). A survey of remote sensing-based aboveground biomass estimation methods in forest ecosystems. *International Journal of Digital Earth*, *9*(1), 63-105.

White, J. C., Coops, N. C., Wulder, M. A., Vastaranta, M., Hilker, T., & Tompalski, P. (2016). Remote sensing technologies for enhancing forest inventories: A review. *Canadian Journal of Remote Sensing*, *42*(5), 619-641.
Tang, L., & Shao, G. (2015). Drone remote sensing for forestry research and practices. *Journal of Forestry Research*, *26*(4), 791-797.
Healey, S. P., Cohen, W. B., Yang, Z., Brewer, C. K., Brooks, E. B., Gorelick, N., ... & Loveland, T. R. (2018). Mapping forest change using stacked generalization: An ensemble approach. *Remote Sensing of Environment*, *204*, 717-728.
Cohen, W. B., Yang, Z., Healey, S. P., Kennedy, R. E., & Gorelick, N. (2018). A LandTrendr multispectral ensemble for forest disturbance detection. *Remote Sensing of Environment*, *205*, 131-140.
Khanal, S., Fulton, J., & Shearer, S. (2017). An overview of current and potential applications of thermal remote sensing in precision agriculture. *Computers and Electronics in Agriculture*, *139*, 22-32.
Gago, J., Douthe, C., Coopman, R., Gallego, P., Ribas-Carbo, M., Flexas, J., ... & Medrano, H. (2015). UAVs challenge to assess water stress for sustainable agriculture. *Agricultural water management*, *153*, 9-19.
Mulder, V.L., De Bruin, S., Schaepman, M.E. and Mayr, T.R., 2011. The use of remote sensing in soil and terrain mapping—A review. *Geoderma*, *162*(1-2), pp.1-19.
Metternicht, G.I. and Zinck, J.A., 2003. Remote sensing of soil salinity: potentials and constraints. *Remote sensing of Environment*, *85*(1), pp.1-20.
Clark, R.N. and Roush, T.L., 1984. Reflectance spectroscopy: Quantitative analysis techniques for remote sensing applications. *Journal of Geophysical Research: Solid Earth*, *89*(B7), 6329-6340.
Van der Meer, F.D., Van der Werff, H.M., Van Ruitenbeek, F.J., Hecker, C.A., Bakker, W.H., Noomen, M.F., Van Der Meijde, M., Carranza, E.J.M., De Smeth, J.B. and Woldai, T., 2012. Multi-and hyperspectral geologic remote sensing: A review. *International Journal of Applied Earth Observation and Geoinformation*, *14*(1), pp.112-128.
Cracknell, M.J. and Reading, A.M., 2014. Geological mapping using remote sensing data: A comparison of five machine learning algorithms, their response to variations in the spatial distribution of training data and the use of explicit spatial information. *Computers & Geosciences*, *63*, pp.22-33.

Recommended journals for reference

Remote Sensing of Environment
Computer and Geosciences
Geoderma

Additional information (if any)

Student responsibilities

Course reviewers:

Dr. Benidhar Deshmukh, IGNOU, New Delhi

Dr. P. L. N Raju, NESAC

Course title: Applications of Geoinformatics for Water resources			
Course code: NRG 165	**No. of credits: 3**	**L-T-P: 28-00-28**	**Learning hours: 42**
Pre-requisite course code and title (if any):			
Department: Department of Natural Resources			
Course coordinator(s): Vinay S P Sinha	**Course instructor(s): Vinay S P Sinha**		
Contact details:			
Course type: Core	**Course offered in:** 3rd Semester		

Course description

Course start with basis overview of Remote Sensing and GIS application in Water Resources followed by basic concept of hydrological process and estimation of hydrological parameters. Geospatial technique to evaluate and management of watershed. Further soil, snow, glacier study link with water resources and enhanced the capability to estimate water budget of the watershed. A detail description on ground water with basic knowledge to evaluating the hydrogeomorphology and quality aspects of water. Finally, the water resources link with climate change and hydrological disaster

Course objectives: Enhance the capability and advanced knowledge of Geoinformatic tools and technique to understand, monitor, mapping and management of Water Resources in various aspects.

Course content

Module	Topic	L	T	P
1.	Overview of RS & GIS Application in Water Resources Management; Hydrological Modelling with Geospatial Inputs	2		
2.	Hydrological cycle, Estimation of precipitation, Hydrological Parameter Estimation using RS & GIS; Digital Elevation Model (DEM) hydro-processing,	2		
3.	Drainage network and drainage pattern, watershed definition and scope, morphometric parameter	2		
4.	Watershed Characterization; Watershed Prioritization and Conservation Planning			
5.	Aquatic System; Classification of Wetland and Wetland mapping using Remote Sensing	2		
6.	Water balance studies- interception, soil moisture, evaporation, run off and discharge	2		
7.	Snow/Glacier Mapping, Monitoring and Snow Melt Runoff Model;	2		
8.	Soil erosion and Sediment modelling, Reservoir Sedimentation Assessment using Remote Sensing	2		
9.	Darcy's Law, porosity, permeability, Transmissibility, specific yield, specific capacity, field capacity and depression storage; role of remote sensing in evaluation hydrological investigations	2		
10.	Type of aquifer, aquiclude, aquitard, aquifuge, ground water regimes, application of remote sensing for the hydro geomorphological interpretation and Ground Water Prospects Zonation	2		
11.	Source of Water Pollution, Water quality parameters, Water Quality modelling: Surface and Ground Water quality mapping and modelling	2		

12.	Application of remote sensing in Oceanography: Sea Surface Temperature, Total Suspended Solids, Fishing potential and Coastal wetland.	4		
13.	Monitoring of Hydro-meteorological Disasters and Damage Assessment; Flood Modelling and Early Warning Systems,	2		
Labs:				
1	Stream order, watershed delineation and editing			2
2	Exercise on Water balance modelling (one case study)			6
3	Exercise on Ground Water modelling (one case study)			6
14.	**Group project** The objective of this module is to give hands on experience on tools and techniques learnt throughout the course. Group project (Students will undertake a group project on relevant topics [module 3 to 13]. This module will consist of requisite data download, data processing, analysis and final presentation on any thematic areas [module 3 to 13] at the end of the semester)			14

Evaluation criteria:

- Test 1: 10% [Syllabus—module no.s 1, to 4
- Test 2: 10% [Syllabus—module no.s 5 to 8]
- Test 3: 40% [End of the module no.s 1 to 13]
- Test 4: 40% [Group project module no.s 3 to 13] - Synopsis 10%; Presentation 20%; Report 10%
  (Students will developed a project on application based on from module no.s 3 to 13

Learning outcomes

- Develop appropriate methods for studying and/or solving the problems related to hydrological cycle, estimation of hydrological parameter and water budget with the help of RS&GIS
- Able to provide geo-information science and earth observation technology to watershed management and prioritization
- Hands on training on geoinformatics tools and technique in the application of water resources

Pedagogical approach

Course Reading Materials (* = compulsory readings)

Jensen J. R, Remote Sensing of the Environment: An Earth Resource Perspective, Pearsons, 2009.

Lillesand T, Kiefer RW and Chipman J, Remote Sensing and Image Interpretation, Wiley &Sons. 2009.

Chang K., Introduction to Geographic Information Systems, McGraw-Hill, New York, 2006.

Lo, C.P. and Yeung, A.K.W., Concepts and Techniques of Geographic Information Systems, PHI Leaning Private Limited 2011.

JVS Murty, 2004, "Watershed management" New Age International Pvt Ltd, New Delhi

Ebgman, E.T., and R.J. Gurney. (1991) Remote sensing in hydrology. London, Chapman and Hall

Shamsi UM, GIS Applications for Water, Wastewater, and Stormwater Systems, Taylor and Francis, 2005

Lyon JG GIS for Water Resources and Watershed Management Chen Y, GIS and Remote Sensing in Hydrology, Water Resources and Environment, 2004

Bedient B. Philip and Huber C. Wayne (2002). Hydrlogy and floodplain analysis, Prentice Hall, Upper saddle river, New Jersey. USA. Bastiaanssen,

W.G.M. 1998. Remote sensing in water resources management: the state of the art. Colombo, Sri Lanka: IWMI

Karanth, K.A, 2008, Ground water assessment Development and management. Tata McGraw Hill

Recommended journals for reference

Journal of the American Water Resources Association
Climate change
Australian Journal of Water Resources
International Journal of Ecology and Environmental Sciences
International Journal of Disaster Risk Science
Aquatic Procedia
Hydrological Sciences journal
Journal of Hydrology
Geoscience Frontiers
Global Environmental Change
Modeling Earth Systems and Environment
Agricultural Water Management
International Journal of Water Resources and Environmental Engineering

Additional information

Student responsibilities

Course reviewers:

Dr M P Punia, Sr. Scientific Officer, Department of Remote Sensing, BIT (Mesra), Jaipur

Prof R B Singh, Head Department of Geography Delhi University

Course title: Application of Geoinformatics for Atmosphere

Course code:	**No. of credits: 3**	**L-T-P: 14-14-28**	**Learning hours: 42**

Pre-requisite course code and title (if any): Prior knowledge of remote sensing and image processing

Department: Dept of Natural Resources

Course coordinator(s): Dr Anu Rani Sharma	**Course instructor(s):** Dr Anu Rani Sharma

Contact details:

Course type: Core	**Course offered in:** Semester 3

Course description

The analysis of satellite measurements is critical in weather, climate studies, air quality etc. and transforming these observations into information is a current challenge in the developing world. This course deals with study of earth's atmosphere using data obtained from geostationary and polar orbiting satellites for meteorological and atmospheric science applications. This course will provide fundamental understanding about meteorological and atmospheric remote sensing as well as operational and future satellite missions. It will also deal with satellite image interpretation for identification of several weather phenomena, cloud types, aerosols etc. This course will further focus on various applications of satellite-derived parameters in meteorology, weather forecasting, air quality and climate monitoring.

Course objectives

1.To provide fundamental understanding about meteorological and atmospheric processes and its association with coupled human – environment system

2.To provide fundamental understanding about current and future satellite missions and weather forecasting

3.To utilize satellite-based observations to monitor the environment, meteorological processes/phenomena and air quality

Course content

Module	**Topic**	**L**	**T**	**P**
1.	**Fundamentals of Meteorological and atmospheric remote sensing** The objective of this module is to gain familiarity with fundamentals of meteorological and atmospheric process through remote sensing. Following topics will be introduced in the module. Principles of Geoinformatics in Meteorology and Atmospheric sciences, Operational and future satellite missions for aerosols, clouds and trace gases (Terra/Aqua MODIS, Calipso, Cloudsat, AURA OMI, INSAT series etc.), Atmospheric Radiative transfer	4		
2.	**Weather observation from space** The objective of this module is to gain familiarity with satellite image interpretation for identification of various weather and atmospheric phenomena. Following topics will be introduced in the module. Satellite Image interpretation (Visible, IR and Water vapor), Identification of cloud type, water vapour, precipitation and atmospheric aerosols from satellite imagery	2	4	
3.	**Application of Satellite–derived parameters in Meteorology and atmospheric sciences**	8	10	

	The objective of this module is to gain familiarity with applications of satellite derived parameters for various domains. Following topics will be introduced in the module. Atmospheric aerosols, trace gases and Air quality Tropical cyclones (satellite tracking of cyclones, Dvorak's technique, genesis and intensity), Cyclone warning system in India and dissemination Fog phenomena Atmosphere-Ocean interactions (El Nino, La Nina, ENSO, IOD (Indian Ocean Dipole) Indian summer monsoon–Onset, Active/Break cycles, retreat Weather Forecasting and data assimilation			

Lab

Module	Topic	**L**	**T**	**P**
1.	Introduction to SBDART and OPAC			2
2.	Satellite image interpretation for identifying cloud types, water vapor, atmospheric aerosols, phenomena etc.			4
3.	Introduction to Grid Analysis and Display System (GrADS)			8
4.	**Group project** The objective of this module is to give hands on experience on tools and techniques learnt throughout the course. Students will undertake a group project on relevant topics. This module will consist of requisite data download, data processing, analysis and final presentation at the end of the semester			14
	Total	**14**	**14**	**28**

Evaluation criteria

- Test 1: Written test (at the end of teaching of modules 1 and 2) - 20%
- Test 2: Written test (at the end of teaching of modules 3) - 20%
- Test 3: Written test [at the end of the semester, full syllabus] – 30%
- Final presentation of group project (at the end of the semester) - 30%

Final presentation of group project will be evaluated on following basis –

- Novelty of the work (10%)
- Oral presentation skills and logical flow of information (10%)

Viva (10%)

Learning outcomes

By the end of the course, students will:

– command a critical understanding of physical principles behind meteorological and atmospheric remote sensing [test 1 and 2]
– be able to interpret satellite images for various meteorological and atmospheric phenomena [test 2]
– be able to interpret information from various satellite derived parameters [test 3]

– enhance their knowledge in satellite remote sensing and ready to use this to achieve their professional career goals

Pedagogical approach

Lectures, lab exercises, tutorials, visits

Course Reading Materials

1. Ahrens C.D. (1999) Meteorology today, Brooks/Cole, 6th edition.
2. Cobb A.B. (2003) Weather Observation Satellites, Rosen Publishing Group.
3. Kelkar R.R. (2007) Satellite Meteorology, B S Publications, Hyderabad.
4. Kidder S.Q. and Vonder T.H. (1995) Satellite Meteorology–An Introduction, Haar Academic Press, New York
5. Wallace J.M and Hobbs P.V. (2006) Atmospheric Science; An introductory survey book, 2nd addition, Academic press, Elsevier

Advanced Reading Material

Advanced reading material will be provided to the students as and when required.

Recommended journals for reference

1. Advances in Meteorology
2. Atmospheric Environment
3. Climate Dynamics
4. Journal of Geophysical Research
5. Geophysical research letters

Additional information

Student responsibilities: Attendance, Feedback, discipline

Course Reviewers

Dr Shailesh Kumar Kharol

Air Quality Research Division | Direction recherche sur la qualité de l'air
Environment and Climate Change Canada / Environnement et Changement climatique Canada
4905 Dufferin Street | 4905, rue Dufferin, Toronto, Canada

Dr. P. L. N. Raju

NE-SAC, ISRO, Shilong, Meghalaya

Course title: Geocomputation			
Course code:	**No. of credits:** 3	**L-T-P: 22-8-24**	**Learning hours:** 42
Pre-requisite course code and title (if any): NRG172, NRG163, NRE111			
Department: **Department of Natural Resources**			
Course coordinator(s): Dr Neeti	**Course instructor(s):** Dr Neeti/Dr. Deepty		
Contact details:			
Course type: Elective	**Course offered in:** semester 3		

Course description

The volume and complexity of available spatial data are many times difficult to analyze using traditional analytical modeling methods. Therefore, there is an increasing need to exploit the power of computational environments to analyze geographic phenomena with a minimum of simplifying assumptions. This course provides introduction to the use of computational intelligence methods for exploring, analyzing, modeling and simulating geographic phenomena. Techniques discussed include spatial optimization, pattern recognition, machine learning techniques and simulating complex spatiotemporal systems. Four major areas of geocomputation are discussed in this course.

Course objectives

1. To understand advanced techniques useful for pattern recognition in remotely sensed data.
2. To develop knowledge of tools, techniques, and methods used in spatial simulation
3. To develop skills on applications of spatial optimization techniques for problem solving
4. To understand spatio-temporal models for gridded image time series

Course content

Module	**Topic**	**L**	**T**	**P**
1.	Machine learning algorithms for classification and regression: Artificial Neural Network, Decision tree classification, SVM, Random Forests	4	2	
2.	Spatial Optimization: Location modelling: Facility location, Route location and location choice modelling	4	2	
3.	Spatial simulation: cellular automata models, agent base models (Netllogo)	8		
4.	Time Series Analysis: classification, components, concept of stationarity, decomposition of time series, trend detection and slope estimation, ARIMA	4	2	
5.	Applications of Data Analytics in Geoinformatics	2	2	
	Labs			
1.	Classification and regression using ANN			2
2	Classification and regression using SVM			2
3	Classification and regression using Decision Tree and RF			2
4	Mapping spatial entities (e.g., traffic, land use/landcover)			4
5	Analyzing spatial patterns and behavior			2

6	Simulating Spatial Changes			6
6	Decomposition of time series			2
7	Detection of trend and estimation of slope using parametric and non-parametric approach			2
8	Fitting ARIMA model			2
	Total	**22**	**8**	**24**

Evaluation criteria:

Test1: Written Test: 20% [Module 1,4,5] (learning outcome 1,4,5)

Test2: Written Test: 20% [Module 2, 3] (learning outcome 2,3)
Lab Assignments/Tutorials: 20% (All the learning outcomes)
Test3: Written Test 40% (All the learning outcomes)
(Test 3 include entire syllabus)

Learning outcomes

Students will be able to

1. Able to apply machine learning algorithm on a dataset and interpret the result
2. Explain how complex spatial models can address solving and understand environmental and social and management challenges
3. Describe the range of tools and techniques that fall within the collection of spatial analytical models
4. Critically analyse a time series data and provide important findings based on them
5. Apply the techniques taught in the class on geospatial dataset

Pedagogical approach

The course will be delivered through class lectures, lab exercise and tutorials.

Course Reading Materials

Module 1:

Lantz, B. (2013). *Machine learning with R*. Packt Publishing Ltd. (Chapter 5,6,7, 11)

Module 2: Chan, Y., 2005. *Location, transport and land-use: modelling spatial-temporal information*. Springer Science & Business Media.

Module 3: Longley, P. and Batty, M., 2003. *Advanced spatial analysis: the CASA book of GIS*. ESRI, Inc..

Module 4: Makridakis, S., Wheelwright, S. C., & Hyndman, R. J. (2008). *Forecasting methods and applications*. John wiley & sons.

Module 5 Karimi, H. A. (2014). *Big Data: techniques and technologies in geoinformatics*. CRC Press.

Advanced Reading Material

1. Weng, Q. (Ed.). (2018). *Remote Sensing Time Series Image Processing*. CRC Press.
2. Bishop-Taylor, R., Tulbure, M. G., & Broich, M. (2018). Evaluating static and dynamic landscape connectivity modelling using a 25-year remote sensing time series. *Landscape Ecology*, *33*(4), 625-640.

3. Maxwell, A. E., Warner, T. A., & Fang, F. (2018). Implementation of machine-learning classification in remote sensing: An applied review. *International journal of remote sensing*, *39*(9), 2784-2817.

Additional information

Magazines

1. Coordinates
2. GIM International
3. GIS World

Student responsibilities

Attendance, feedback, discipline etc

Annexure 3

Course title: Economic and financial evaluation of water infrastructure			
Course code: WSW xxx	**No. of credits: 4**	**L-T-P: 42**-14-0	**Learning hours: 56**
Pre-requisite course code and title (if any): Basic calculus and linear algebra			
Department: Department of Regional Water Studies			
Course coordinator(s): TBD	**Course instructor(s):** TBD		
Contact details: TBA			
Course type: Core	**Course offered in:** Semester 2		

Course description

A beginner's course to develop understanding of basics of water economics and able to conduct financial evaluation of water infrastructure and related services for decision-making.

Course objectives

1. Lay the foundation for understanding economic concepts in water
2. To learn the concept of water pricing
3. Understand financial appraisal methods

Course content

Module	**Topic**	**L**	**T**	**P**
1.	**Introduction to water economics** 1.1 Characteristics of water as an economic good- Infrastructure, Incentives and Institutions 1.2 1.3 Relevance and interaction of different streams of economic theory to water resources **Market failure in the water sector** 1.4 Externalities in the context of water resources	10	0	0
2.	2.1 Basic macro-economic- GDP/GNP, Fiscal policies, monetary policies, financial institutions.	4	2	0
3.	**Financial evaluation methods** 3.1 Introduction to inflation, discount rates, price index, base year, depreciation 3.2 Cash flow diagram and financial mathematics 3.3 Financial performance indicators- NPV, payback period, equalised annual cost, CBR, IRR 3.4 Depreciation methods, tax considerations 3.5 Risk and Uncertainly 3.6 Social-cost benefit analysis and its applications. Hands on with few water toolkits.	12	8	0
4.	**Water Pricing-** Water Availability and Use in India by different sectors- Agricultural, Domestic and Industrial; over time and future projections. 4.1 Economic concepts like Law of Demand, Elasticity of Demand and its relevance to pricing water; Introduction to consumer and producer surplus; Opportunity costs; Externalities- positive and negative	12	4	0

	4.2 Economic methodologies for estimation of demand and value of water in different sectors 4.3 Measures for improving water use efficiency in Agriculture including economics of irrigation efficiency and resource conserving technologies, Ground water use and exploitation- current vs future, Impacts of Prices of inputs and outputs other than water. 4.4 Tariff structures: Concepts like Fixed charges vs volumetric pricing. 4.5 Different tariff structures in different Indian cities for domestic and Industrial water. 4.6 Cost recovery: - Concepts like marginal cost pricing, fixed and operating costs, full cost pricing of water, problems faced by Indian water utilities			
5.	**Financing Water Infrastructure and Services** 5.1 Elements of financing- equity, Debt, grants, insurance and regulations 5.2 Parties to financing and partnership models, 5.3 Irrigation financing including role of water user associations	4		0
	Total	42	14	0

Evaluation criteria: Group work, presentation, and individual assignment will be part of learning process to improve understanding.

Test 1: Written test [at the end of teaching of modules 1 and 2] -- 10%

Test 2: Submission of assignment [end of module 3] - 20%

a. Any cases from the water sector for undertaking a cost benefit analysis.
b. b. Structure of submission: The assignment will consist of introduction, background of the study location, methodology, followed by analysis and conclusion
c. Indicators of assessment: structure (weightage: 10% clarity in the steps for estimation of the results (weightage: 70%); datasets used (weightage: 10%)
d. conclusion (weightage: 10%);

Test 3: group assignment and a role play game will be conducted linking water related issues in the context of India [at the end of teaching of module 3, 4 and 5] -- 40%

Assignments will be given as an individual or group to judge the clarity of the methods they have learnt and its area of application

Test 4: Written test [at the end of the semester, full syllabus] -- 30%

Learning outcomes: Upon completion of the course the student will be able to-

1. Understand the basics of economics of water [test 1]
2. Able to handle financial evaluation [test 2]
3. Able to conduct simple policy analysis in water-related issues. [test3 and test 4]

Pedagogical approach: Class interaction, teaching and discussion, group assignment, case studies presentation and role play

Reading Materials (* = compulsory readings)

Tietenberg, T. 2001 Environmental and Natural Resource Economics. Addison Wesley Publication

Briscoe, John, and R. P. S. Malik. *India's water economy: Bracing for a turbulent future*. New Delhi: Oxford University Press, 2006.

Module 1

*Tietenberg, T. 2001 Environmental and Natural Resource Economics. Addison Wesley Publication

*Olmstead, S.M. (2010). The economics of water quality. Review of Environmental Economics and Policy, 4(1): 44-62. https://doi.org/10.1093/reep/rep016.

Green, Colin. *Handbook of water economics: principles and practice*. John Wiley & Sons, 2003.

Zilberman, David, and Leslie Lipper. "10 The economics of water use." *Handbook of environmental and resource economics* (2002): 141.

Krishna Raj (2017) "Economics of Water: Understanding India's Water Balance in a Globalized Economy" Productivity Journal Vol. 57 No 4, January-March 2017.

Module 2

*Tietenberg, T. 2001 Environmental and Natural Resource Economics. Addison Wesley Publication

Green, Colin. *Handbook of water economics: principles and practice*. John Wiley & Sons, 2003.

Whittington, Dale. "The economic benefits of potable water supply projects to households in developing countries." (1994).

Module 3

Handbook for the Economic Analysis of Water Supply Projects 1999. Economics and Development Resource Center. Asian Development Bank.

Sam Godfrey, Pawan Labhasetwar, Satish Wate. "Greywater reuse in residential schools in Madhya Pradesh, India—A case study of cost–benefit analysis". Resources, Conservation and Recycling 53 (2009) 287–293

Fahimuddin. " Drinking Water Collection And Cost-Benefit Analysis Of A Rural Water Supply Scheme In Uttarakhand State".. Journal of Rural Development, Vol. 31, No. (1) pp. 1 – 15; NIRD, Hyderabad.

Grimsey, D., & Lewis, M. K. (2002). Evaluating the risks of public private partnerships for infrastructure projects. *International journal of project management*, *20*(2), 107-118.

Furlong, Casey, Saman De Silva, Kein Gan, Lachlan Guthrie, and Robert Considine. "Risk management, financial evaluation and funding for wastewater and stormwater reuse projects." *Journal of environmental management* 191 (2017): 83-95.

Module 4

*Dinar, Ariel, and Kurt Schwabe, eds. *Handbook of Water Economics*. Edward Elgar Publishing, 2015.

*Dinar, Ariel, Víctor Pochat, and José Albiac-Murillo, eds. *Water pricing experiences and innovations*. New York: Springer International Publishing, 2015.

*Murty, Maddipati Narasimha, A. J. James, and Smita Misra. *Economics of water pollution*. Oxford University Press, 1999.

Whittington, Dale. "Possible adverse effects of increasing block water tariffs in developing countries." *Economic Development and Cultural Change* 41, no. 1 (1992): 75-87

Isha Ray. "'Get the Price Right': Water Prices and Irrigation Efficiency". Economic and Political Weekly, Vol. 40, No. 33 (Aug. 13-19, 2005), pp. 3659-3668

Tushaar Shah, Neha Durga, Shilp Verma and Rahul Rathod. " Solar Power as Remunerative Crop" Water Policy Research Highlight-10. IWMI.

N. Nagaraj, K. Shankar and M. G. Chandrakanth. “Pricing of Irrigation Water in Cauvery Basin: Case of Kabini Command” Economic and Political Weekly, Vol. 38, No. 43 (Oct. 25-31, 2003), pp. 4518-4520
Rogers, Peter, Ramesh Bhatia, and Annette Huber. *Water as a social and economic good: How to put the principle into practice*. Stockholm: Global Water Partnership, 1998..
Um, WooChong. "2007 Benchmarking and Data Book of Water Utilities in India." (2007).
Gupta, Anjali Sen. "Cost Recovery in Urban Water Services: Select Experiences in Indian Cities." (2011).
Module 5
Water, and Sanitation Program (World Bank). South Asia. *Running water in India's cities: a review of five recent public-private partnership initiatives*. Water and Sanitation Program, 2014.
Dwivedi, Gaurav. "Public private partnerships in water sector." (2010).)
Additional readings
Balasubramanya, Soumya, Barbara Evans, Richard Hardy, Rizwan Ahmed, Ahasan Habib, N. S. M. Asad, Mominur Rahman et al. "Towards sustainable sanitation management: Establishing the costs and willingness to pay for emptying and transporting sludge in rural districts with high rates of access to latrines." *PloS one* 12, no. 3 (2017): e0171735.
Vaidyanathan, A. *Water resource management: institutions and irrigation development in India*. Oxford University Press, 1999.

Additional information (if any)

Student responsibilities

The students are expected to submit assignments in time and come prepared with readings when provided.

Prepared by: Sukanya Das, Department of Policy Studies, Meera Bhatia Mehrotra(Guest Faculty), Department of Regional water studies.

Course Reviewers:

1. Dr Soumya Balasubramanya, Research Group Leader - Water Innovations in Transforming Economies, IWMI, Colombo
2. Dr. Krishna Raj,Professor, Center for Economic Studies and Policy (CESP), Institute for Social and Economic Change (ISEC),Bangalore
3. Prof Paul.P Appasamy, Honorary Professor, Madras School of Economics

Course title: Introduction to geoinformatics			
Course code: WSW 172	**No. of credits:** 4	**L-T-P:** 34-10-24	**Learning hours:** 56
Pre-requisite course code and title (if any): None			
Department: Department of Regional Water Studies			
Course coordinator(s): Sherly M A		**Course instructor(s):** Sherly M A	
Contact details: sherly.ma@terisas.ac.in			
Course type: Compulsory Core		**Course offered in:** Semester 1	

Course description

This course introduces the participants to the fundamentals of geospatial technology (Surveying, Remote Sensing, GIS and GPS). This course is intended to introduce the applications of Remote Sensing & GIS techniques in water resources management.

Course objectives

i. To provide a strong fundamental understanding of the GIS and remote sensing technologies.

ii. To understand the basic principle underlying the GIS/model-based management of water resources and environment.

Course content

Module	Topic	L	T	P
1.	**Introduction to Surveying and Remote Sensing** • Elements of Surveying: Basic principle of surveying, Types of surveying, Levelling, Minor instruments of surveying • Introduction to Photogrammetry • Introduction to Remote Sensing: Electromagnetic Radiation (EMR), EMR spectrum and its properties, EMR wavelength regions and their applications • Atmospheric windows, Interaction of EMR with atmosphere and the surface; Sensors and Satellite Resolutions: Spectral, Spatial, Temporal and Radiometric • Digital image: Optical Sensor, Panchromatic & Multispectral Image and its properties, Spectral signatures, Vegetation and Bare soil	10	2	8
2.	**Introduction to GIS and GPS** • Introduction to Geographical information system, concept of spatial and non-spatial data • GIS data model: Raster and Vector • Map: Scale, Projection and Datum, Map design, Rectification and Georeferencing • Introduction to GPS: Single point positioning and Differential positioning • Spatial data: Entry, topology and editing	14	4	14
3.	**GIS and Remote Sensing methods relevant to water resources** • Map algebra: Local, Neighbourhood, Zonal operations • Extraction of water info from topographical maps; Extraction of water Indices using band combination • Digital Image Classification & Land use / land cover mapping	10	4	2
	PRACTICALS 1. Familiarisation with relevant surveying instruments			

	2. Introduction to ERDAS IMAGINE 2011; File formats. Import / Export of files using ERDAS IMAGINE 3. Study of the Spectral Signature of water and other relevant features 4. Display, analysis and interpretation of black & white images, grey image, pseudo image and FCC 5. Introduction to GIS and GPS software tools 6. Map rectification- Define projection and Reprojection 7. Digital database creation -Point features, Line features, Polygon features 8. Data editing-Removal of errors -Overshoot & Undershoot, Snapping, Topology Creation 9. Feature base: Dissolving, Merging; Layer base: Clipping, Intersection and Union 10. Spatial and Attribute query and Analysis; Map algebra / Math in Raster			
	Total	**34**	**10**	**24**

Evaluation criteria:

- Test 1: 10% [module no. 1] [5-6 week]
- Test 2: 10% [module no. 2] [10-12 week]
- Practical: 30% [Regular practical exercises-10%, viva-voce-5%, Exam-15%] [End of Semester]
- Tutorial: 10% [Assignments] [End of Semester]
- End-term exam: 40% [modules 1-3] [End of Semester]

Learning outcomes

- Learning of the basics of surveying, remote sensing, GIS and GPS
- Experience with software relevant to remote sensing, GIS and GPS
- Introduction to selective methods in GIS and remote sensing relevant to water resources management

Pedagogical approach

The course will be delivered through class lectures, lab exercises and tutorials.

Course Reading Materials

- Punmia, B.C., Jain, A. K. and Jain, A. K. (2016), Surveying Vol. I, 17th edition, Laxmi Publications (P) Ltd., New Delhi, India.
- Jensen J. R. (2009), Remote Sensing of the Environment: An Earth Resource Perspective, 2nd edition, Pearsons, New Delhi
- Lillesand T. M., Kiefer, R.W. and Chipman, J. W. (2008), Remote Sensing and Image Interpretation, 6th edition, John Wiley & Sons, New Jersey, USA.
- Chang K.-T. (2006), Introduction to Geographic Information Systems, 1st edition, McGraw-Hill, New York, 2006.
- Burrough, P. A., McDonnell, R. A. and Lloyd, C. D. (2015). Principles of Geographical Information Systems, 3rd edition, Oxford University Press, Oxford, UK.

Advanced Reading Material

- Shamsi, U. M. (2005), GIS Applications for Water, Wastewater, and Stormwater Systems, Taylor and Francis, London.

- Lyon, J. G. (2002), GIS for water resources and watershed management. Lyon JG (ed), 1st edition, Taylor & Francis, London.
- Chen, Y. (2004), GIS and Remote Sensing in Hydrology, Water Resources and Environment, IAHS Press, Centre for Ecology and Hydrology, Wallingford, UK.
- Engman, E. T. and Gurney, R. J. (1991), Remote sensing in hydrology, 1st edition, Chapman and Hall, London.

Recommended journals for reference

Advances in Water Resources
Asian Journal of Geoinformatics
Journal of Water Resources Planning and Management
International Journal of Geoinformatics
International Journal of Remote Sensing

Additional information

Student responsibilities

Classes will be interactive. Students are expected to be regular in attendance, participation, and submission of assignments. They must come prepared with readings when required.

Prepared by: Sherly M. A., Department of Regional Water Studies.

Course reviewers:

1. Dr. S. P. Aggarwal, FIE, Scientist/Engineer "SG" & Head, Water Resources Department, Indian Institute of Remote Sensing, ISRO, Dept. of Space, Govt. of India, 4, Kalidas Road, Dehradun, Uttarakhand - 248 001, India.
2. Prof. R. D. Garg, Professor, Department of Civil Engineering, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand - 247667, India.

Course title: Qualitative research methods and technical writing			
Course code: WSW xxx	**No. of credits:** 3	**L-T-P**: 14-14-28	**Learning hours:** 56
Pre-requisite course code and title (if any): None			
Department: Department of Regional Water Studies			
Course coordinator(s): TBD		**Course instructor(s):** TBD	
Contact details: TBD			
Course type: Core		**Course offered in:** Second semester	

Course description

This course introduces students to the basics of qualitative research methods and equip them with the skills, techniques, and knowledge required to sensitively design, carry out, read, analyse and report qualitative research. As part of the course we reflect upon the nature of qualitative research required for resource management with specific focus on water resources management. The course also includes practical sessions on critical analysis of published papers and mock projects to provide students with hands on opportunity to comprehend terms like data type, sampling, survey tools, data analysis, research ethics and data interpretation. Alongside, the course shall provide exposure to proposal and research report writing and communication skills through presentations, readings,

discussion and practical clinics. The course demands extensive reading and considerable time investment by the students to engage in discussions, work on assignments and conduct individual fieldwork.

Course objectives

- To introduce students to the broad tenets of qualitative research.
- To develop skills in the use of tools and techniques required for conducting qualitative research.
- To plan, conduct, present and discuss qualitative research study.
- To appreciate the need for interdisciplinary research for water resources management and understand the ways in which qualitative research can be integrated with quantitative research.
- To enable students to apply the skills to writing proposals and research/project reports.

Course content

Module	Topic	L	T	P
1.	**Introduction to qualitative research** This module helps in understanding the concept and types of research with special attention on qualitative research. It will also include ethics of research and IRB processes. Through this module, students will be able to understand the individual values of the researcher relating to honesty and frankness and personal integrity. The module will also help to orient the students regarding the researcher's treatment of other people involved in the research, relating to informed consent, confidentiality, anonymity and courtesy. Further, the course will draw focus on the differentiation between qualitative and quantitative research with proper exemplification of various studies related to water resources management. • Types of research • Qualitative Vs quantitative research • Need and application of qualitative research in water resources management • Ethics of research • Practical exercises (reading and discussion)	2	2	4
2.	**Designing research proposal** Through this module the student shall be familiarized with the various steps involved in developing a research proposal. The student shall be asked to identify a research problem and develop a proposal. • Defining the research problem • Developing research objectives and questions • Literature review • Choosing the appropriate methods • Sample and sampling methods • Ethical considerations and researcher's role • Expected research impact	2	2	6
3.	**Qualitative research tools and techniques** This module focuses on techniques for data collection in qualitative research. The method of preparation of interview and discussion guides, and questionnaire for survey shall be discussed in this module.	4	4	10

	The students will be encouraged to think on the research problem that they have proposed in the previous module and develop a plan for the field work. • Ethnography, case study, participant observation • Structured, semi-structured and in-depth interview • Focus Group Discussion • Survey and Questionnaire Design • Participatory Rural Appraisal (PRA) • PRA Field Exercises (Transect walk, resource mapping, institution and stakeholder mapping) • Developing a matrix according to sample type and nos. • Practical exercise (field work and data collection)			
4.	**Qualitative data collection and analysis** This module focuses on qualitative data collection and analysis through practical exercises on transcription and content analysis. Subjectivity in interpretation and evaluator biases and its impact on research outcomes are also explained. • Developing data collection and management plan • Steps of analysing qualitative data • Analysis of text and document	2	2	

5.	**Technical writing and research communication**
	• Plagiarism and similarity
	• Understanding different styles of writing
	• Writing project report, dissertation, proposal, blogs and newspaper articles
	  • Audience, purpose and strategy
	  • Use of infographics (tables, graphs, charts and visuals)
	  • Reference styles – Using referencing software
	  • Understanding the peer review process
	• Writing Detailed Project Report (DPR)
	• Preparing presentation and presentation skills
	• Practical exercise - Developing articles, blogs etc. through class assignments, developing research reports
		4	4	8

		14	14	28

Evaluation criteria:

- Test 1: Research proposal design: 20% (At the end of Module 1 and 2)
  Students will be asked to define a research problem related to water, draft research objectives and research questions, define the research methodology and sampling technique that they would use for studying the research problem and spell out the expected outcomes of the research.
- Test 2: Class assignment (literature review) :20%
  Students would carry out and write the literature review chapter for the research topic that they have identified.
- Test 3: Research report writing :40% (At the end of modules 3,4 and 5)
  Students shall write a detailed report on the research work carried out by them. The report will have an introduction, literature review, methodology, results and discussion, conclusion and references as different sections.

- Test 4 : Final Presentation: 20%
  Students will have to make a 15 minutes presentation of their work. It would have a format similar to a research proposal defence.

Learning outcomes

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

- independently design and conduct a qualitative research
- describe, distinguish and apply qualitative research tools like interviewing, focus group discussions, participant observation, participatory rural appraisal etc.
- organise, analyse and interpret data
- write research proposals and reports

Pedagogical approach

The pedagogical approach taken for the course is a combination of lectures, writing workshops and field exercises with an emphasis on participatory and practical learning.

Course Reading Materials

- Bryman, Alan. (2012) Social Research Methods, Oxford University Press, New Delhi
- Corbetta P. (2003) Social Research, Theory, Methods and Techniques, Sage Publication, New
  Delhi
- Cresswell JW (2014) Research Design, Qualitative, Quantitative and Mixed Method Approach,
  Sage: New Delhi
- Czaja, R. and Blair, J., 2005, Designing surveys: A guide to decisions and procedures, 2nd edition, Thousand Oaks and London: Pine Forge.
- Flick, Uwe. (2014) The Sage Hand Book of Qualitative Data Analysis (Edited). Sage: New Delhi
- Grosh, M. and Glewwe, P., 2000, eds., Designing household survey questionnaires for developing
  countries: Lessons from 15 years of the living standards measurement study. Washington, D.C.:
  World Bank.
- Groves, RM., Floyd Fowler J. Jr., Couper MP., Lepkowski James M., Singer E., Tourangeau R.
  2009, Survey methodology, 2nd edition, Hoboken: Wiley.
- Hammersley, M., 1992, What's wrong with ethnography? London: Routledge. Scheyvens R. and
  Storey, D., 2003, eds., Development fieldwork: A practical guide, London: Sage (chapter 4).
- Kothari CR (2004) Research Methodology, Methods and Techniques, New Age International
  Publication Limited: New Delhi
- Robson C., 1993, Real world research: A resource for social scientists and practitioner researchers. Oxford: Blackwell (chapter on analysing qualitative data).
- Sarantakos, S. (1998) Social Research. Macmillan Press: Australia
- Walliman, N. (2011) Research Methods, The Basics. Routledge: UK
- Silverman D. 2006, Interpreting qualitative data: Methods for analysing talk, text and interaction,
  3rd edition, London: Sage

Student responsibilities

- All readings circulated before class must be read by the students for class discussions.

- Assignments and course work must be attempted as per instructions before coming for practical clinics.
- Attendance is compulsory for all sessions

Prepared by: Dr. Fawzia Tarannum, Department of Regional Water Studies and Dr. Swarup Dutta, Department of Policy Studies

Course reviewers:
Dr. Mercian Daniel, Program Manager (Mental Health), The George Institute for Global Health, New Delhi
Dr. Manasi Mishra, Head, Research & Knowledge Management, Centre for Social Research (CSR)

Course title: Applied geoinformatics for water resources			
Course code: WSW 175	**No. of credits:** 3	**LTP distribution:** 28-6-16	**Learning hours:** 42
Pre-requisite course code and title (if any): WSW 172 (Introduction to Geoinformatics)			
Department: Department of Regional Water Studies			
Course coordinator(s): Vinay Kumar Sinha		**Course instructor(s):** Vinay Kumar Sinha	
Contact details: sinhav@terisas.ac.in			
Course type: Compulsory Core		**Course offered in:** Semester 2	

Course Description
This course introduces the participants to the fundamentals of advanced geospatial technology, namely, Remote sensing and Geographic Information Systems (GIS). It prepares the candidate for geospatial modelling and analysis for water resources.

Course objectives
The course provides skills in use of geospatial techniques and related technologies required for solving real-world problems in the context of water resources management. This course provides an overview of cutting-edge remote sensing and GIS techniques that are by and large being used by water professionals. The students will be equipped with unique knowledge and skills necessary for sustainable management of water resources.

This course will be offered to students of M.Tech. (Water Resource Engineering and Management) and pre-Ph.D. Students from other programs willing to pursue doctoral studies in water resources. The students are suggested to read different books, magazines and peer reviewed journals.

Course content

	Topic	**L**	**T**	**P**
Module 1: Remote Sensing Sensor and its application in water resources				
1	Introduction to Thermal Infrared (TIR) Remote Sensing: History of TIR remote sensing, TIR properties and Atmospheric Windows,	2		

	Thermal Radiation Laws, Thermal properties of terrain, TIR Sensors			
2	Hyperspectral remote sensing: Features and advantages, Hyperspectral remote sensing of soil and vegetation, Atmospheric correction	2	2	
3	Microwave Remote Sensing: Active and passive microwave remote sensing, Active microwave system components, RADAR Environmental Considerations, SAR remote sensing from space, RADAR Inferometry, Passive microwave remote sensing	2		
Module 2: Application of Geospatial model in water resources				
4	Introduction to Geospatial model: Flow Chart, Source of Geospatial data in Water Resources	2		
5	Digital elevation model: DEM generation, Contouring, Topography based hydrologically corrected DEM, DTM, DSM, TIN and its application in Water Resources	4	2	
6	Hydrological Cycle: Factors influencing watershed hydrology, physical processes in watershed and basic concepts of hydrological modelling	2	2	
Module 3: Geospatial models				
7	Terrain indices for Water Resources: Slope, Aspect of Slope, Curvature, Viewshed and Hillshade	2		
8	Basics of Hydrological Analysis: flow direction, flow accumulation, drainage network extraction, watershed delineation	2		
9	Geostatistical tools: Interpolation and pattern analysis	2		
10	Advanced hydrological tools: Hydrodynamic model and Soil and Water Assessment tool; Snow melts runoff modelling, Rainfall Run-off modelling, and Groundwater modelling.	8		
	PRACTICALS			
1	Terrain Analysis			2
2	Hydrological tool e.g SWAT Model			2
3	Geostatistical analysis			2
4	Hydrodynamic model e.g MIKE Flood			4
5	SRM model			4
6	GALDIT model			2
Total		**28**	**6**	**16**

Evaluation criteria

2 minor tests:	10% each
Practical:	30%
Tutorial:	10%
End-term exam:	40%

Learning outcomes

1. The student will get equipped to analyse geo-information problems encountered in professional practice and develop appropriate methods for studying and/or solving the problems, develop and design appropriate methods for geospatial framework data collection and processing.
2. The student will be able to generate, integrate, analyse and visualize spatial data within the area of water resources management.
3. The student would be able to formulate and carry out interdisciplinary research in geospatial modelling of water resources.

Materials

Suggested Readings:

- Jensen J. R. (2009), Remote Sensing of the Environment: An Earth Resource Perspective, 2nd edition, Pearsons, New Delhi.
- Lillesand T. M., Kiefer, R.W. and Chipman, J. W. (2008), Remote Sensing and Image Interpretation, 6th edition, John Wiley & Sons, New Jersey, USA.
- Lo, C.P. and Yeung, A.K.W. (2009), Concepts and Techniques of Geographic Information Systems, 2nd edition, PHI Learning Private Limited, New Delhi.
- Bedient, B. P. and Huber, C. W. (2002). Hydrology and floodplain analysis, 3rd edition, Prentice Hall, USA.
- Bastiaanssen, W.G.M. (1998), Remote sensing in water resources management: the state of the art, Technical report, Colombo, Sri Lanka: IWMI. URL: http://publications.iwmi.org/pdf/H022865.pdf
- Engman, E. T. and Gurney, R. J. (1991), Remote sensing in hydrology, 1st edition, Chapman and Hall, London.
- Shamsi, U. M. (2005), GIS Applications for Water, Wastewater, and Stormwater Systems, Taylor and Francis, London.
- Lyon, J. G. (2002), GIS for water resources and watershed management. Lyon JG (ed), 1st edition, Taylor & Francis, London.
- Chen, Y. (2004), GIS and Remote Sensing in Hydrology, Water Resources and Environment, IAHS Press, Centre for Ecology and Hydrology, Wallingford, UK.

Journals

- Water Resources Management
- International Journal of Applied Earth Observation
- Hydrological Processes
- Remote Sensing of the Environment

Additional information (if any): None

Student responsibilities

Classes will be interactive. Students are expected to be regular in attendance, participation, and submission of assignments. They must come prepared with readings when required.

Course reviewers:

1. Dr. S. P. Aggarwal, FIE, Scientist/Engineer "SG" & Head, Water Resources Department, Indian Institute of Remote Sensing, ISRO, Dept. of Space, Govt. of India, 4, Kalidas Road, Dehradun, Uttarakhand - 248001, India.
2. Prof. R. D. Garg, Professor, Department of Civil Engineering, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand - 247667, India.

Annexure 4

STRUCTURE OF PG DIPLOMA IN RENEWABLE ENERGY PROGAMME (REGULAR -ONE YR)

Background, Context and Need

As part of its climate commitments as well as to enhance the energy security, Indian government has made ambitious plans to install 175 GW renewable energy capacity by the year 2022 (including 100 GW solar and 60 GW wind capacity). This would require large number of skilled professionals across the business value chain, towards project design, development, implementation and maintenance activities. It has also been observed that working professionals engaged in the conventional energy sector intend to learn about upcoming energy technologies and practices, so as to be part of the transformation happening in the Indian energy sector.

In this context, the Department of Energy and Environment at the TERI School of Advanced Studies, propose to offer a 1-year Post Graduate Diploma in Renewable Energy. The learning outcomes would include understanding of sectoral policies and regulations, energy resource assessment, selection of appropriate renewable energy technology, project design & development aspects, besides techno-commercial analysis of projects. The expected profile of the participants for the proposed programme include professionals working with energy / power utilities, private sector corporations, renewable energy companies, funding agencies, banks, cleantech entrepreneurs as well as fresh graduates.

Programme Structure and Other Features

The programme is spread over 2 semesters, comprising a set of core and elective courses, with a total of 40 credits. The student needs to opt any one of the three elective courses being offered. The minimum educational requirements for the pursuing the programme shall be graduation.

Semester 1: Renewable Energy Resources and Policies (Core)

Course Title	**Credits**
Introduction to Renewable Energy Resources	4
Introduction to Renewable Energy Technologies	4
Indian Power Sector - Organization, Policies and Regulations	4
Renewable Energy Sector - Policies, Regulations and Programmes	4
Environmental & Health Impact of Energy Use	4
TOTAL	20

Semester 2: Energy Infrastructure & Efficiency (Elective)

Course Title	**Credits**
Energy Infrastructure	4
Introduction to Basic Engineering Principles	3

Introduction to Engines	3
Energy Conservation Policies & Programmes	3
Energy Conservation and Management	4
Energy Audit Techniques	3
TOTAL	20

Semester 3: Renewable Energy Technologies (Elective)

Course Title	**Credits**
Solar Thermal Technologies	3
Solar PV Technologies	3
Passive Solar Architecture	3
Wind Energy Technologies	3
Biomass to Energy	3
Small Hydro Power Technologies	3
Other Renewable Energy Technologies (Geothermal, OTEC, Tidal, Wave, etc.)	2
TOTAL	20

Semester 4: Software Tools for Energy Analysis (Elective)

Course Title	**Credits**
Software for Renewable Energy feasibility analysis (eg. RETScreen etc.)	4
Software for Decentralized energy system planning (eg. HOMER etc.)	4
Software for Solar PV system design (eg. PVSyst etc.)	4
Software for Solar thermal system design and analysis (for eg SAM etc.)	4
Software for Building simulation (eg. TRYNSYS etc.)	4
TOTAL	20