PLANNING AND DESIGN OF SURFACE IRRIGATION SYSTEM

ENAE 365

Lecture	**: 3**	**Year : III**
Tutorial	**: 1**	**Part : II**
Practical	**: 1**	

Course Objectives:
The objective of this course is to provide students with fundamental and applied knowledge of irrigation engineering, with a focus on the planning, analysis, and design of surface irrigation systems and associated hydraulic structures.

1 Introduction (2 hours)

- 1.1 Comparison of irrigation system and their relative merits
- 1.2 Selection of irrigation system
- 1.3 Components of surface irrigation system
- 1.4 Advantages and limitations of surface irrigation system

2 Crop Water Requirement and Scheduling (5 hours)

- 2.1 Soil properties affecting irrigation (Texture, structure)
- 2.2 Soil moisture concepts (Field capacity, permanent wilting point, available water)
- 2.3 Factors affecting canal duty
- 2.4 Crop water requirement
- 2.5 FAO CropWat
- 2.6 Consumptive use
- 2.7 Root zone depth
- 2.8 Irrigation scheduling

3 Design of Surface Irrigation Methods (7 hours)

- 3.1 Principles of surface irrigation
  - 3.1.1 Phases of surface irrigation (Advance, recession and infiltration phases)
  - 3.1.2 Infiltration opportunity time
  - 3.1.3 Infiltration characteristics and models
- 3.2 Border irrigation design
  - 3.2.1 Border width and length
  - 3.2.2 Slope requirement
  - 3.2.3 Unit discharge
  - 3.2.4 Time of advance
  - 3.2.5 Design based on infiltration characteristics

3.3 Basin irrigation design
- 3.3.1 Suitable soil and crops
- 3.3.2 Basin size and shape
- 3.3.3 Depth of irrigation
- 3.3.4 Inflow rate selection
- 3.3.5 Design criteria for level basin

3.4 Furrow irrigation design
- 3.4.1 Furrow spacing
- 3.4.2 Furrow length
- 3.4.3 Stream size selection
- 3.4.4 Erosion control
- 3.4.5 Design for row crops
- 3.4.6 Cutback irrigation method
- 3.4.7 Surge irrigation

3.5 Sustainable irrigation practices

4 Design of Irrigation Canal System (4 hours)

4.1 Design based on maximum permissible velocity
4.2 Comparison of Lacey's and Kennedy's theories
4.3 Garret's and Lacey's diagram applied to channel design
- 4.3.1 Components of canal cross-section: Side slope, berm
- 4.3.2 Free board, bank width, barrow pit, spoil bank

4.4 Lining of irrigation channels, types of lining
- 4.4.1 Comparison of different lining materials
- 4.4.2 Design of lined canals
- 4.4.3 Maintenance of irrigation channels
- 4.4.4 Seepage control

4.5 Water allocation and distribution strategies

5 Underground Pipe Line Conveyance System (5 hours)

5.1 Purpose and advantages
5.2 Materials of underground pipe line and their properties
5.3 Design of underground pipeline
- 5.3.1 Design velocities
- 5.3.2 Pipe diameter
- 5.3.3 Frictional head loss
- 5.3.4 Design of pump stand
- 5.3.5 Surge and water hammer protection
- 5.3.6 Air vents

5.4 Ancillary structures and devices in underground pipeline
5.5 Installation of underground pipeline
5.6 Tunnel boring machine (TBM) technology: Concept, relevancy for water resources projects in Nepal

6 Evaluation of Surface Irrigation Systems (2 hours)

6.1 Uniformity and efficiency concepts
6.2 Application efficiency
6.3 Distribution efficiency
6.4 Water use efficiency
6.5 Field performance evaluation

7 Command Area Development and Planning (7 hours)

7.1 Purpose and importance of land development in command area
7.2 Principle of command area planning
7.3 Consolidation of land holding and its importance
7.4 Integrated development of command area
7.5 On-farm development works: Field channels; Drainage systems; Farm roads
7.6 Problems in command areas: Waterlogging; Salinity; Inequitable water distribution
7.7 Participatory irrigation management (PIM)
7.8 Role of water user associations (WUAs)
7.9 Preparation of project plan for command area
7.10 Sustainable irrigation planning

8 Land Leveling and Field layout (2 hours)

8.1 Importance of land leveling
8.2 Types of land leveling-plane and profile
8.3 Field layout design
8.4 Land grading and farm layout
8.5 Laser land leveling
8.6 Community farming concept

9 Design of Headworks (8 hours)

9.1 River stages and suitable location of headworks
9.2 Component parts of weir/barrage (Detail drawing)
9.3 Bligh's, Lane's and Khosla's seepage theories for foundation
9.4 Design of weir and barrage with sloping glacis (Crest, length and thickness of impervious floor)
9.5 Design of under sluice and silt excluder
9.6 Design of head regulator (Crest, length and thickness of impervious floor)
9.7 Design considerations of settling basin and silt ejector

10 Modern Techniques and Innovations in Irrigation (3 hours)

10.1 Automation and AI in surface irrigation
10.2 Use of models and simulation tools
10.3 Climate change adaptations

Tutorial **(30 hours)**

1. Water requirement and duty calculations
2. Design of border irrigation, design of furrow irrigation, basin irrigation numerical
3. Kennedy and Lacey design problems
4. Design of underground pipeline
5. Efficiency calculation
6. Land leveling and grading
7. Design of weir with sloping glacis
8. Design of under sluice and settling basin
9. Design of head regulator and cross regulator

Practical **(15 hours)**

1. Selection of optimal cropping pattern based on soil and climatic condition
2. Estimation of water requirement of selected cropping pattern for given command area
3. Use of CropWat model by FAO for irrigation scheduling
4. Delineation of optimal canal alignment on topographical map of given command area
5. Design of canal conveyance system for given command area
6. Design of underground pipe line for given command area
7. Preparation of rotational schedule for given canal outlet
8. Design problems on land grading and farm layout

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	2	3
2	5	6
3	7	10
4	4	8
5	5	6
6	2	4
7	7	6
8	2	4
9	8	10
10	3	3
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Michael, A. M. (2016). Irrigation: Theory and practice. Vikas Publishing House.
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WATERSHED MANAGEMENT AND PLANNING

ENAE 366

Lecture	**: 3**	**Year : III**
Tutorial	**: 2**	**Part : II**
Practical	**: 1**	

Course Objectives:

The objective of this course is to familiarize and equip students with the principles and practices of watershed management and planning, focusing on engineering-based problem-solving approaches. The course emphasizes the sustainable management and development of Nepal's agro-ecosystems, river systems, and agri-food systems.

1 Introduction (6 hours)

1.1 Classification and geomorphological characteristics of watershed
1.2 Delineation of watershed boundary and coding
1.3 Analysis of watershed: Shape, size, drainage network and relief
1.4 Integrated sub-watershed management planning and its participatory application
1.5 Basin approach of integrated watershed management
1.6 Evolution of watershed management policies and practices in Nepal
1.7 Outcomes of policy and programs: Community forestry, agro-forestry, conservation agriculture, conservation engineering, community empowerment

2 Land Capability Classification (5 hours)

2.1 Importance and application of land capability classification
2.2 Land capability classification scheme
2.3 Land capability sub-classes and units
2.4 Interpretation and use of land capability maps
2.5 Identification of land capability classes in the field

3 Environment Issues and Sustainable Watershed Management (7 hours)

3.1 Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) and their application in the watershed planning process
3.2 Point and non-point sources of water pollution and mitigation measures
3.3 Climate change, carbon sequestration and carbon trading related issues
3.4 Upstream and downstream linkages, payment for environmental services, equitable benefits sharing
3.5 Coordination mechanism and integration of agriculture, forestry, and water resource interventions in integrated sub-watershed management plan

3.6 Emerging problems of Chure watershed and strategies to mitigate the watershed degradation problems of Chure region
3.7 Watershed models and modeling

4 Sedimentation (6 hours)

4.1 Sediments
4.2 Sediment transport in stream flow
4.3 Types of sediment load
4.4 Assessment of sediments load
  4.4.1 Types of sediment samplers
  4.4.2 Location and frequency of sampling
  4.4.3 Sediment observation posts- location and observation
  4.4.4 Analysis of sediment samples
4.5 Estimation of sediment yield of watershed

5 Reservoir Sedimentation (4 hours)

5.1 Distribution of sediments in reservoir
5.2 Prediction of sediment distribution
5.3 Factors affecting silting of reservoir
5.4 Rates of reservoir sedimentation
5.5 Reservoir sedimentation control

6 Evaluation of Land Degradation (5 hours)

6.1 Definition of land degradation
6.2 Causes of land degradation: Natural and anthropogenic causes; Socio-economic factors
6.3 Forms of land degradation
  6.3.1 Physical degradation
  6.3.2 Chemical degradation
  6.3.3 Productivity loss
  6.3.4 Vegetation degradation
6.4 Assessment of land degradation
6.5 Visual methods for identifying signs of soil erosion and productivity loss

7 Watershed Management Planning (7 hours)

7.1 Sub-watershed and micro-watershed prioritization
7.2 Concept of Integrated watershed management planning
7.3 Data needs for watershed management plan
  7.3.1 Hydro-meteorological data
  7.3.2 Geological and geomorphological data
  7.3.3 Agricultural data
  7.3.4 Socio-economic data

7.4 Synthesizing watershed information into a coherent plan
7.5 Formulation of project proposal

8 Watershed Management Works (5 hours)

8.1 Factors affecting watershed management
8.2 Watershed management practices
8.3 Steps in watershed management
8.4 Participatory monitoring and evaluation of watershed management works
8.5 Restoration of rivers and lakes
8.6 Theory and practices of agro-forestry in Nepal, and criteria for selection of agro-forestry species with respect to ecological zone of Nepal

Tutorial (30 hours)

1. Socio- economic questionnaire design and development
2. Data collection using the prepared questionnaire
3. Analysis and interpretation of collected data
4. Preparation of watershed management plan of any watershed in the vicinity

Practical (15 hours)

1. Delineation of watershed boundary using topographical maps and aerial photographs and determination of geographical characteristics of watershed
2. Preparation of slope map
3. Identification of data needs and hydro- meteorological gauging of watershed
4. Runoff gauging and estimation of water yield
5. Sediment gauging and analysis
6. Compilation of geological, hydrological, meteorological, land system, land use, soil, agricultural and socio- economic information of a watershed
7. Prioritization of watershed for conservation and protection

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	6	9
2	5	6
3	7	9
4	6	9
5	4	6
6	5	6
7	7	9
8	5	6
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Suresh, R. (2002). Soil and water conservation engineering. Standard Publishers and Distributors.
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FARM MACHINERY DESIGN AND TESTING

ENAE 367

Lecture	**: 3**	**Year : III**
Tutorial	**: 2**	**Part : II**
Practical	**: 1**	

Course Objectives:

The objective of this course is to provide students with knowledge of agricultural machinery design principles used in crop production, tillage, intercultural operations, harvesting, and processing. It aims to develop skills in designing farm tools considering field conditions, soil, crops, and power sources. The course also trains students in testing and evaluating machinery for performance, efficiency, durability, and safety, while familiarizing them with relevant standards and encouraging innovation for locally appropriate, cost-effective farm machinery solutions.

1 Agricultural Machinery Production (4 hours)

1.1 Principles of agricultural machine design and design parameters: Force, stress, reliability, factor of safety, limit, fit and tolerances and farm machinery design procedure

1.2 General properties of critical components of farm machinery, material selection criteria, principle and purpose of heat treatment and its processes, and ferrous and non- ferrous metal

2 Force Analysis on Tillage Tools (3 hours)

2.1 Measurement of soil resistance

2.2 Forces acting on tillage implement

3 Power Transmission and Safety (3 hours)

3.1 V-belt, chain, rope, gear, shaft, hydraulic drives and joints

3.2 PTO drives

3.3 Concept and application of overload safety device

4 Land Preparation Machineries (10 hours)

4.1 Design of mould board, share; Standard dimension of plow share and landside; and determination of loads for design of plow standard

4.2 Disk tools and their design considerations: Design of disk tools for disk harrow and disk plough, spacing in multi disk implements

4.3 Design of soil engaging tools in cultivators- shovel, sweep and design of shank

4.4 Action of rotary tillage machines, soil reactions in rotary tillage tools, design considerations for rotavator blades and rotavator blade arrangement and configuration

5 Sowing and Planting Implements (4 hours)

5.1 Design of sowing and planting implements
5.2 Design of seed metering mechanism
5.3 Design considerations for seed and fertilizer box and frame

6 Harvesting and Threshing Machineries (4 hours)

6.1 Types of reaper and their functional requirements
6.2 Design and selection of different components of a vertical conveyor reaper
6.3 Design considerations of conveyors in harvesting machines
6.4 Bond between grain and spike
6.5 Parameters of thresher drum- length, diameter, speed, beater arrangement
6.6 Design of feeding chute
6.7 Cleaning sieves and their design considerations

7 Test Codes for Agricultural Machines and Tractors (3 hours)

7.1 Purpose of test codes;
7.2 Types of test codes for agricultural machine
7.3 RNAM and ANTAM test codes; BIS test codes; Nebraska test codes
7.4 Draft, wheel slip, soil resistance, sound and vibration test

8 Testing and Evaluation Procedures (3 hours)

8.1 Preparation for tests
8.2 Specification of implements
8.3 Test conditions
8.4 Laboratory tests
8.5 Performance test
8.6 Field test
8.7 Evaluation criteria and test report format

9 Tillage, Seeding, Harvesting and Threshing Implements (8 hours)

9.1 Test codes and procedures for ploughs (M.B., Chisel, Disk), rotary tiller and disc harrow
9.2 Test codes and testing procedures for seeding and planting implements
9.3 Test codes and testing procedures for harvesting implements
9.4 Test codes and testing procedures for threshing implements

10 Tractor Performance Criteria (3 hours)

10.1 Power measurement of tractor: Spring and strain gauge dynamometers

10.2 Power estimate of an engine using engine test rig (Hydraulic or absorption) dynamometer
10.3 Engine performance and efficiency of tractor

Tutorial **(30 hours)**

1. Design problem on force analysis of tillage tools
2. Design problems on mould board plough, and disk implements
3. Design problems on cultivators, and rotary tillage implements
4. Design problems on sowing and planting equipment
5. Design problems on vertical conveyor reaper, and rice and wheat threshers
6. Design problems on hill agricultural implements

Practical **(15 hours)**

1. Visibility, noise and vibration test on farm tractors
2. Study on turning radius of general purpose farm tractor
3. Measurement of basic dimensions of tillage tools
4. Field and performance testing of seeding and planting machines
5. Field and performance testing of sprayers
6. Field and performance testing of harvesting machines
7. Study on performance testing of threshers
8. Study on operation of common types of farm implements

Assignments

1. At least three assignments on case study from farm machinery design
2. At least five assignments on case study from agricultural machinery testing

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapters	Hours	Marks distribution*
1	4	6
2, 3	6	8
4	10	12
5 ,6	8	10
7	3	4
8	3	6
9	8	10
10	3	4
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Asia and Pacific Network for Testing of Agricultural Machinery. (1998). Test codes and procedures for farm machinery.
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BIOMASS AND BIOENERGY TECHNOLOGIES

ENAE 368

Lecture	**: 3**	**Year : III**
Tutorial	**: 2**	**Part : II**
Practical	**: 1**	

Course Objectives:

The objective of this course is to introduce biomass resources and their conversion technologies for meeting energy needs in rural agricultural systems. It also focuses on the design and development of appropriate technologies for converting biomass into useful energy and value-added products, and their application in powering farm operations, tools, equipment, and agricultural machinery.

1 Biomass and Bioenergy (4 hours)

- 1.1 Introduction to biomass and classification
  - 1.1.1 Harvested biomass: First, second and third generation feedstock
  - 1.1.2 Residue biomass: Agricultural, forestry, animal and human
- 1.2 Characteristics of biomass
  - 1.2.1 Physical properties: Proximate analysis (Moisture content, volatile matter, ash content, fixed carbon), bulk and particle density
  - 1.2.2 Chemical properties: Ultimate analysis (C, H, O, N, S)
  - 1.2.3 Heating value: Lower and higher heating value
- 1.3 Bioenergy availability estimation and potential: Forest biomass and residue, agricultural residues, animal and human waste

2 Biomass Supply Chain (2 hours)

- 2.1 Biomass production, collection, transportation and storage
- 2.2 Pre-treatment of biomass
- 2.3 Bioenergy production

3 Biomass Energy Conversion (3 hours)

- 3.1 Physical conversion: Drying, pulverization, densification/pelletization
- 3.2 Biochemical conversion: Anaerobic digestion, fermentation, composting
- 3.3 Chemical conversion: Transesterification, acid hydrolysis
- 3.4 Thermochemical conversion: Pyrolysis, gasification, combustion, hydrothermal liquefaction, torrefaction

4 Fuel Pellet Production Process (3 hours)

- 4.1 Biomass for pellet production
- 4.2 Key stages for pelletization process

4.3 Status of pellet industries in Nepal

5 Biochemical Conversion Technology (9 hours)

5.1 Stages and chemistry of the fermentation process
5.2 Stages and chemistry of anaerobic digestion
5.3 Factors affecting microbial activities
5.4 Optimal environment for anaerobic digestion and fermentation
5.5 Consideration of biogas plant design
  5.5.1 Types of anaerobic digestion
  5.5.2 Site selection
  5.5.3 Size of biogas plant
  5.5.4 Design and construction of biogas plants
5.6 Biogas plants for cold climates
  5.6.1 Treatment of biogas plants for cold climates
  5.6.2 High altitude biogas reactor
  5.6.3 Integrated biogas systems

6 Thermochemical Conversion Technology (12 hours)

6.1 Principle of thermochemical process
  6.1.1 Process/chemistry and pathway
  6.1.2 Operating parameters
  6.1.3 Effects of feedstock on processes and products
6.2 Types of pyrolysis and its operation: Fast/flash, intermediate and slow
6.3 Types of biomass gasification reactors
  6.3.1 Fixed bed reactors: Downdraft and updraft
  6.3.2 Fluidized bed reactors: Bubbling, circulating and dual staged
  6.3.3 Entrained flow
  6.3.4 Comparison of the performance of various gasifier reactors
6.4 Syngas cleanup systems
  6.4.1 Issues with the raw syngas use
  6.4.2 Particle and tar removal/cracking
  6.4.3 Acid gas and trace contaminant removal
6.5 Improve cooking stoves: Design, factors affecting and performance
6.6 Technology readiness level and upscaling challenges

7 Chemical Conversion Technology (6 hours)

7.1 Chemistry and types of transesterifications
7.2 Chemistry and types of acid hydrolysis
7.3 Chemical properties of vegetable oils

7.4 Oil extraction and processing technology: Mechanical and solvent
7.5 Application of biodiesel and challenges to use in IC engines
7.6 Technology readiness level and upscaling challenges

8 Techno-Economic Analysis and Environmental Impact (6 hours)

8.1 Techno-economic analysis
- 8.1.1 Capital and operating cost of bioenergy systems
- 8.1.2 Cost comparison with fossil fuel systems
- 8.1.3 Challenges for upscaling

8.2 Environmental impact analysis
- 8.2.1 Carbon cycle and neutrality of biomass
- 8.2.2 Greenhouse gas and pollution from bioenergy systems
- 8.2.3 Waste management and resource recovery
- 8.2.4 Life cycle assessment: Concept and procedures

Tutorial (30 hours)

1. Assess the sources, types and use of biomass in your local areas
2. Case study of a fuel pellet industry of Nepal
3. Design and estimation of a biogas plant for cold climate
4. Design a gasifier plant based on the availability of biomass in your local areas
5. Conduct an economic and life cycle assessment of a bioenergy technology

Practical (15 hours)

1. Evaluation of biomass physical, chemical, and heating value
2. Production and properties analysis of fuel pellet
3. Biodiesel production by transesterification of vegetable oil
4. Production of char, oil and syngas yield from biomass pyrolysis
5. Fermentation of glucose to produce ethanol
6. Performance analysis of improved cooking stove

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	4	6
2	2	4
3	3	4
4	3	4
5	9	12
6	12	18
7	6	6
8	6	6
Total	**45**	**60**

* There may be minor deviation in marks distribution.

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1. Li, Y., Khanal, S. K. (2015). Bioenergy: Principles and applications. John Wiley & Sons.
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