



## Master's Programme in Irrigation Water Management

### Course Layout

#### Minimum Credit Requirements

Sr. No.	Subject	Minimum credit(s)
1.	Major	20
2.	Minor	10
3.	Supporting	07
4.	Seminar	01
5.	Research	20
	<b>Total Credits</b>	<b>48</b>
	Compulsory Non Credit Courses	06

Sr. No.	Course Number	Course Title	Credits
<b>A) Major subjects (Min.20 credits)</b>			
1.	IWM-511	Water resources planning and management	2 + 1 = 3
2.	IWM-512	Soil Water Plant environmental relationship	2 + 1 = 3
3.	IWM-513	Agro meteorological applications in IWM	2 + 1 = 3
4.	IWM-521	Crop water requirements and irrigation scheduling	2 + 1 = 3
5.	IWM-522	Farm irrigation systems and design	2 + 1 = 3
6.	IWM-523	Soil and water quality for irrigation	2 + 1 = 3
7.	IWM-531	Economic issues in water resources management	1 + 1 = 2
<b>B) Minor Subjects (Min. 10 credits)</b>			
1.	IWM-514	Cropping systems and sustainable agriculture	1 + 1 = 2
2.	IWM 516	Social issues in water resources management	1 + 1 = 2
3.	IWM 517	Watershed development and management	2 + 1 = 3
4.	IWM-524	Application of remote sensing & GIS in agriculture	2 + 1 = 3

<b>C) Supporting Subjects (Min. 07 credits)</b>			
1.	STAT-512	Experimental design	2 + 1 = 3
2.	IWM-525	Applied Mathematics for IWM	1 + 1 = 2
3.	IWM- 532	Computer applications in irrigation water management	1 + 1 = 2
<b>D) Seminar (01 credit)</b>			
	IWM-507	Seminar - I	0 + 1 = 1
<b>E) M.Sc. Research (20 credits)</b>			
		Research Work	0+20= 20
<b>F) Non Credit Compulsory Courses</b>			
1.	PGS-501	Library and Information Services	0+1=1
2.	PGS-502	Technical Writing and Communications Skills	0+1=1
3.	PGS-503	Intellectual Property and its Management in Agriculture	1+0 =1
4.	PGS-504	Basic Concepts in laboratory Techniques	0+1=1
5.	PGS-505	Agriculture Research, Research Ethics and Rural Development Programmes	1+0 =1
6.	PGS-506	Disaster Management	1+0=1

## Course Contents

**Course Title: WATER RESOURCES PLANNING AND MANAGEMENT**

**Course No. IWM-511**

**2+1=3**

### **Syllabus:**

#### **UNIT I**

Concepts of Irrigation. Necessity, advantages and disadvantages of Irrigation, and historical background of irrigation in India, Hydrologic process, Estimation of parameters of hydrologic cycle – rainfall, runoff and soil water balance. India's water resources and their development. Water needs for different sectors- present and future. Irrigation scenario in Maharashtra state.

#### **UNIT II**

Infiltration characteristics, soil moisture constants. Irrigation Systems multidisciplinary approach, role of each discipline. Duty and delta of crop, duty at various places, factors affecting duty, certain important terminology for canal irrigation: GCA & CCA, Reservoir storage terminology, Distribution system for canal command area, Methods of land leveling.

#### **UNIT III**

Hydraulics of open channel flow; terminology. Design of open channel, Field channel, outlet (chak design), minors, water distribution structures. Approach methodology for conducting survey and formulation of projects.

#### **UNIT IV**

Performance and Bench marking of irrigation projects. Modern Irrigation charges, acts and laws. Principles of command area development in India: Composition and functions. Experiences of CADAs after their inception, Water User's Association.

#### **UNIT V**

Groundwater-concepts, water bearing formations, types, properties of aquifers- Transmissivity, Storage coefficient, Specific Yield, Specific retention, Application of groundwater flow equation, identification of boundaries and recharge and its assessment, techniques, conjunctive utilization.

### **Suggested Readings:**

Irrigation Engineering and hydraulics Structures by S.K. Garg.

Irrigation Theory and Practices by A.M. Michael

On farm development works. WALMI Publ. No. 12, 1986.

Operation and management of irrigation system WALMI Publ. No. 20, 1987.

Special course on "Diagnostic Analysis for Trainers", WALMI, Aurangabad (May 27- July 6, 1985).

Warabandi for Irrigated Agriculture in India. Pub. No. 146, Central Board of Irrigation and Power, New Delhi, June, 87.

Warabandi systems and its infrastructure. Pub. No. 157, Central Board of Irrigation and Power, New Delhi, April 1982.

**IWM-511 WATER RESOURCES PLANNING AND MANAGEMENT 2+1=3****Theory:**

Unit No.	Lecture No.	Topics to be covered	Weightage in Marks
I	1	Historical background of irrigation	5
	2	Concept of command area development	5
	3	Irrigation scenario in India & state	5
II	4	Irrigation systems approach	5
	5	Multidisciplinary approach	5
	6-7	Irrigation Distribution criteria	5
	8-9	Canal irrigation	10
III	10-11	Hydraulics of open channel	10
	12-13	Field channel, outlet (Chak design)	10
	14	Water distribution structure	5
IV	15	Formulation of projects	5
	16	Irrigation laws and acts	5
	15-16	Experience of CADA	10
	17-18	Water user association	10
V	19-20	Groundwater-concepts, water bearing formations, types, properties of aquifers	10
	21	Application of groundwater flow equation	5

**Practical:**

1	Reconnaissance survey of a chak
2-3	Topographic survey of a chak
4-5	Planning and design of chak size
6-7	Study of field channel, outlets in the command
8-9	Design of open channel
10	Study of water distribution practices- RWS, Shejpali, Warabandi
11	Management of 1 cusec flow on the farm
12-15	Visit to WUAs and study of participatory irrigation management
16-18	Visit to a irrigation project

**Course Title: SOIL WATER PLANT ENVIRONMENT RELATIONSHIP****Course No. IWM-512****2+1=3****Syllabus:****UNIT I**

Soil characteristics in relation to irrigation, soil hydraulic properties. Soil water properties - water structure, energy concepts of soil water, redox potential, soil water

movement under saturated and unsaturated conditions, solute transfer in soil- Effect of solute on water movement, driving force, hydraulic conductivity, soil salinity and alkalinity, salt balance of the profile.

## UNIT II

Function and structure of root, root growth in relation to soil physical environment, Processes involved in root growth, constraints involved in root growth, movement and uptake of ion, uptake properties of root, pathways of cell to cell, cell wall, root-shoot relationship, ion uptake mechanism, plant growth in terms of yield availability.

## UNIT III

Plant water relations, role of water in plants, concept of water potential, components of water potential and their measurements, water relationships of cell and whole plant, water and ion uptake and movement mechanism in plant systems, water loss through plants (transpiration) and factors affecting transpiration, Soil strength, soil water status, soil temperature, soil aeration status, variation of water potential and flux in soil plant system.

## UNIT IV

Soil-water-plant-atmosphere continuum, energy balance at crop surface and measurement of crop evapotranspiration, weather parameters and measurements, climatic factors influencing crop water loss, aridity indices, water stress in relation to plant physiological processes, influence of water stress on crop yield.

### Suggested Readings:

Doorenbos, J. and Pruitt, W.O. 1975. Crop water requirements. FAO Irrigation and Drainage, paper 24, Rome Italy.

Hillel D. Environmental soil physics

Hillel, D. 1977. Soil and water: Physical principles and processes. Academic Press. Inc. New York.

Richards, L.A. 1975. Retention and transmission of water in soil. Year Book of Agriculture. 14-151.

Slatyer, R.O. 1967. Plant water relations. Academic Press, New York.

Turner, A.K. Willatt, S.T., Wilson, J.H. and Jobling, G.A. 1984. Soil water management IDP, Canberra, Australia.

## IWM-512 SOIL WATER PLANT ENVIRONMENT RELATIONSHIP 2+1=3

### Theory:

Unit No.	Lecture No.	Topics to be covered	Weightage in Marks
I	1 & 2	Soil characteristics for irrigation	10
	3	Soil moisture characteristics	5
	4- 6	Soil water properties & its movement	15
II	7-10	Plant water relations, concept of potential	20
	11	Water & ion uptake	5

	12	Transpiration	5
III	13-15	Soil –water-plant continuum	20
IV	16-17	Weather parameters and its measurement	10
	18-19	Water stress	10

**Practical:**

1-2	Study of soil profile and soil horizon
3-4	Preparation of soil moisture characteristic curve
5-6	Study of soil water movement under saturated conditions
7-8	Study of soil water movement under unsaturated conditions
9-10	Study of solute transfer in soil
11-12	Measurement of evapotranspiration losses
13-14	Estimation of evapotranspiration losses by climatic approach
15-16	Measurement of canopy temperature,
17-18	Study of leaf water potential

**Course Title: AGROMETEOROLOGICAL APPLICATIONS IN IRRIGATION WATER MANAGEMENT**

**Course No. IWM-513**

**2+1=3**

**Syllabus:**

**UNIT I**

Meaning and scope of agricultural meteorology; components of agricultural meteorology; role and responsibilities of agricultural meteorologists.

**UNIT II**

Importance of meteorological parameters in agriculture; efficiency of solar energy conversion into dry matter production; meteorological factors in photosynthesis, respiration and net assimilation; basic principles of water balance in ecosystems; soil-water balance models and water production functions.

**UNIT III**

Crop weather calendars; weather forecasts for agriculture at short, medium and long range levels; agromet advisories, preparation, dissemination and economic impact analysis; use of satellite imageries in weather forecasting; synoptic charts and synoptic approach to weather forecasting.

**UNIT IV**

Concept, definition, types of drought and their causes; prediction of drought; crop water stress index, crop stress detection; air pollution and its influence on vegetation.

**UNIT V**

Concepts of mechanistic and deterministic models; general features of dynamical and statistical modelling techniques; weather data and phenology-based approaches to crop modelling; validation and testing of models.

**UNIT VI**

Climatic change, greenhouse effect, CO<sub>2</sub> increase, global warming and their impact on agriculture; concept and types of drought; climate classification, agro-climatic zones and agro-ecological regions of India.

**Suggested Readings:**

**IWM-513 AGROMETEOROLOGICAL APPLICATIONS IN IRRIGATION WATER MANAGEMENT** **2+1=3**

**Theory:**

Unit No.	Lecture No.	Topics to be covered	Weightage in Marks
I	1 & 2	Meaning and scope of agricultural meteorology	10
II	3	Importance of meteorological parameters in agriculture	5
	4	Photosynthesis, respiration and net assimilation	5
	5	Basic principles of water balance in ecosystems	5
III	6-8	Weather forecasts, agromet advisories	20
IV	10	Drought and their causes, types and prediction	10
	11-12	Air pollution and its influence on vegetation	10
V	13-14	Concepts of mechanistic and deterministic models	10
	15-16	Water stress	10
	17-18	Concepts of mechanistic and deterministic models	10
VI	19	Climatic change & its impact on agriculture	5

**Practical:**

1-3	Preparation of crop weather calendars, crop weather diagram
4-7	Development of simple regression models for weather, pest and disease relation in different crops
8-10	Crop simulation models
11-13	Preparation of weather based agro-advisories
14-15	Agroclimatic classification
16-18	Use of automated weather station (AWS)

**Course Title: CROP WATER REQUIREMENT AND IRRIGATION  
SCHEDULING 2+1 =3  
Course No. IWM-521**

**Syllabus:**

**UNIT I**

Different terminologies used in irrigation water management, soil moisture constants, energy states of soil water, water movement in soil translocation, water uptake, soil water potentials, hysteresis, evapotranspiration,

**UNIT II**

Criteria for scheduling of irrigation, different approaches to irrigation scheduling, climatological approach - methods for estimation of ET, measurement of ET – lysimeter, soil moisture measurement approach, methods for measurement of soil moisture/tension- tensiometer, neutron probe, infrared moisture meter, Pressure plate apparatus

**UNIT III**

Consumptive and conjunctive use of water, irrigation requirement, water requirement, factors affecting irrigation water requirement, effective rainfall, irrigation and water use efficiencies, irrigation practices for major crops, quality of irrigation water, rain water harvesting.

**UNIT IV**

Crop response functions to irrigation, matching of net irrigation demand to water supply characteristics through modification of irrigation technology.

**UNIT V**

Cropping pattern and cropping intensity. Crop water requirement planning in relation to changing Scenario of input availability.

**Suggested Readings:**

Doorenbos, J. and Pruitt, W.O. 1975. Crop water requirements. FAO Irrigation and Drainage, paper 24, Rome Italy.

Integrated Water Management for Crop Production. Edited by B.N. Shinde and N.N. Firake

Irrigation: Theory and Practice by A.M. Micheal



**IWM-521 CROP WATER REQUIREMENT AND IRRIGATION SCHEDULING**

**2+1 =3**

**Theory:**

Unit No.	Lecture No.	Topics to be covered	Weightage in Marks
I	1 &2	Terminologies used in irrigation water management	5
	3 & 4	energy states of soil water, water movement in soil translocation	5
	5 & 6	soil water potentials	10
II	7 & 8	Criteria for scheduling of irrigation	20
	9 & 10	methods for estimation of ET	20
III	11 & 12	irrigation practices for major crops	20
	13 & 14	methods of drainage, quality of irrigation water	10
IV	15 & 16	water management under controlled conditions	5
V	17 & 18	crop water requirement planning for changing scenario	5

**Practical:**

1.	Determination of field capacity of soil by pressure plate apparatus
2.	Determination of PWP of soil pressure plate apparatus
3.	Determination of bulk density by core sampler method
4.	Determination of hydraulic conductivity of soil by constant head method
5.	Determination of infiltration rate of soil by double ring infiltrometer
6.	Measurement of soil moisture by using soil moisture meter
7-8	Measurement of irrigation water by using 90 <sup>0</sup> V notch, Parshall flume, weirs and repogal
9-10	Fertigation through different fertigation devices
11-12	Estimation of ET <sub>o</sub> by empirical methods
13-14	Study of different techniques in rain water harvesting
15-16	Design of farm ponds
17-18	Visit to IWM and Water Management farm MPKV Rahuri

**Course Title: FARM IRRIGATION SYSTEMS AND DESIGN**

**Course No. IWM-522**

**2+1 = 3**

**Syllabus:**

**UNIT I**

Farm resources inventory, land leveling, Water measuring devices: weirs/notches, parshall flume, cut throat flume, orifices.

**UNIT II**

Surface irrigation methods and their classification, Different irrigation efficiencies. Factor influencing irrigation methods. Advantage and disadvantages and selection criteria of irrigation methods, irrigation efficiencies. Design concepts for border, furrow and check basin methods. Hydraulics of advance and recession of water front. Surge flow irrigation technique. Evaluation of surface irrigation systems and practices.

**UNIT III**

Concept of pressurised irrigation, Types of pressurised irrigation systems. Micro-irrigation; Concept, advantages and limitations, components, pipe distribution network. Preliminary design criteria of pressurized irrigation systems, estimation of water requirement, Pumps; types, discharge capacity of pumps

**UNIT IV**

Drip design procedure: Selection of emitters, design of lateral, manifold, submain, main and pump, Head loss through emitter, lateral. Drip design problems. Case studies on vegetables, sugarcane and orchard crops. Filtration : necessity, phenomenon, types, filtration capacity.

**UNIT V** Fertigation. Care and maintenance of system. Clogging of emitters, acidification, chlorination. Cost estimation Evaluation. Concepts of some latest technologies.

**UNIT VI**

Sprinkler irrigation systems: Concept, advantages and limitations. System components, layouts, types of sprinkle systems. Uniformity coefficient. Design and layouts of system, Selection of nozzles, Case studies.

**Suggested Readings:**

Design of trickle irrigation by D. Karmeli and J. Keller.

Design, Operation and Maintenance of Drip Irrigation, MPKV Pub. No.55

Drip Irrigation by R.K. Sivanappan, O.Padmakumari and V. Kumar.

Finkel HJ. 1983. *Handbook of Irrigation Technology*. Vols. I-II. CRC

Irrigation: Theory and Practice by A.M. Micheal

Ivan E Henk. 1951. *Irrigation Engineering*. Vol. I. John Wiley & Sons.

Karmeli D, Peri G & Todes M. 1985. *Irrigation Systems: Design and*

*Land and Water Management Engineering* by V.V.N. Murthi

Rydzewski 1987. *Irrigation Development Planning*. John Wiley & Sons.

Sprinkle and Trickle Irrigation by Jack Keller and R.D. Bliesner

Sprinkler Irrigation by R.K. Sivanappan 1987.

Surface Irrigation : Systems and Practice by Melvyn kay

Trickle Irrigation design by Jack Keller and D. Karmeli.

Trickle Irrigation for Crop Production: Design, Operation and Management by F.S.

Nakayama and D.A. Bucks.

**Theory:**

Unit No.	Lecture No.	Topics to be covered	Weightage in Marks
I	1	Farm resources inventory	5
	2	Water measuring devices	10
II	3	Different irrigation efficiencies	5
	4	Selection criteria of surface methods	5
	5	Design concepts of surface irrigation methods	10
	6	Evaluation of surface irrigation methods	5
III	7-8	Concept and types of pressurized irrigation systems	10
	9-10	Micro-irrigation components, control head, pipe distribution network,	10
IV	11-12	Design and layout of drip irrigation system	10
	13-14	Filtration	5
V	15-16	Fertigation	5
	17-18	Cost estimation of PIS	5
VI	19-20	Sprinkler irrigation systems	5
	21	Design procedure for sprinkler systems	10

**Practical:**

1.	Preparation of contour map of an irrigation field
2.	Land leveling and grading calculations for surface irrigation
3.	Flow measurement by different measuring devices
4.	Preparation of border, furrow and check basin layouts and determination of irrigation efficiencies.
5.	Evaluation of surge flow technique
6-7	Study of microsprinkler, sprinkler and raingun irrigation system components functions and testing
8	Study of drip irrigation system components- functions and testing
9	Study of pressure-discharge relationship of sprinkler nozzles and drippers
10	Case study on Design & layout of sprinkler system
11	Case study on Design & layout of drip irrigation system
12	Determination of uniformity coefficient and emission uniformity
13	Fertilizer application through ventury and fertilizer tank
14	Acidification and chlorination of drip system

**Course Title: SOIL AND WATER QUALITY FOR IRRIGATION**

**Course No. IWM 523      CREDITS: 2+1=3**

**Syllabus:**

**UNIT I**

Processes and factors of soil formation, Types of soils, soil physical and chemical properties, Texture, structure, soil reaction (pH), soil air, soil temperature, soil degradation-salinity, alkanity, sodicity, acidity, soil pollution.

**UNIT II**

Characteristics of saline, saline-sodic soils, crop tolerance to salinity and alkalinity, acid soils, Effects of salts on plant nutrient availability in problem soils, fertilizer and cultural management in saline and alkali soils, G.R., L.R. use of brackish water for irrigation. Management practices for improving the soil conditions.

**UNIT III**

Sources of water for irrigation. Quality and compositions of irrigation water, evaluation of irrigation water- salinity, sodium carbonate, bicarbonates, chlorides, fluorides and boron hazards.

**UNIT IV**

Effect of water quality on soil properties and plant growth. Use of saline water for crop production, Methods and models for assessing the suitability of saline water for irrigation and crop production. Management principles and practices for safe use of saline water.

**Suggested Readings:**

Daji, J.A., J.R. Kadam and N.D. Patil. 1999. A text book of Soil Science, Media promoters and publishers Mumbai.

Dakshinamurthi, C. Advances Soil Physics, ICAR, Publication, New Delhi.

Ghildyal B.P. and R.P. Tripathi. Soil Physics. Wiley eastern Ltd., New Delhi.

Hillel, D. 1980. Application of Soil Physics, Academic Press, New York.

Kadam, J.R. and B.P. Ghildyal 1992. Dictionary of Soil and Water Management Nirali Prakashan Pune-2.

Mortvedt, J.J., Shuman, L.M., Cox, F.R. and Weich, R.M. (ed) 1991. Micronutrients in Agriculture, Soil Science Society of America.

Oswal, M.C. 1994. Soil Physics-Oxford IBH, New Delhi.

Rhoades, J.D., A. Kandiah and A.M. Mashali. 1992. The use of saline waters for crop production, FAO, 48.

Richards, L.A. 1968. Diagnosis and improvement of saline and alkali soils. Hand book No.60.

Singh, Dhyan, Chhonkar, P.K. and Pandey, R.N. 1999. Soil Plant Water Analysis. A methods manual I.A.R.I. New Delhi.

**Theory:**

Unit No.	Lecture No.	Topics to be covered	Weightage in Marks
I	1	Processes and factors of soil formation, physical and chemical properties of soils,	10
	2	soil degradation	10
II	3 & 4	Characteristics of soils	10
	5	crop tolerance to salinity and alkalinity	5
	6	nutrient availability in problem soils	5
	7& 8	fertilizer and cultural management in saline and alkali soils	10
	9	Characteristics of saline, saline-sodic soils, crop tolerance to salinity and alkalinity	10
	10	Acid soils, Effects of salts on plant nutrient availability in problem soils	5
	11	Fertilizer and cultural management in saline and alkali soils,	5
	12	G.R., L.R. use of brackish water for irrigation.	5
III	13	Quality of irrigation water	5
	14	Use of saline water for crop production	5
	15&16	Methods and types of drainage.	5
IV	17	Methods and models for assessing the suitability of saline water for irrigation and crop production	5
	18	Management principles and practices for safe use of saline water.	5

**Practical:**

1	Determination of pH of soil extract and irrigation water
2	Determination of electrical conductivity of soil extract and irrigation water
3	Determination of carbonates and bicarbonates in soil extract and irrigation water
4	Determination of chlorides in soil extract and irrigation water
5	Estimation of SO <sub>4</sub> (Sulfate) in soil extract and irrigation water
6	Estimation of calcium and magnesium in soil extract and irrigation water
7	Determination of sodium and potassium in soil extract and irrigation water
8	Determination of BOD from irrigation water
9	Determination of COD from irrigation water
10	Estimation of iron, manganese, copper and zinc from in soil extract and irrigation water (atomic absorption spectrometer)
11	Determination of fluorides in soil extract and irrigation water

**Course Title: ECONOMIC ISSUES IN WATER RESOURCES MANAGEMENT****Course No. IWM-531****1+1=2****Syllabus:****UNIT I**

Basic concepts of production function with water as a input. Production relationship ( Factor - Product Relationship ). Three regions of production function.

**UNIT II**

Maximization of net returns with water as in important input. Tools of farm management, scope and importance, farm planning and budgeting, economic measures of water use efficiency

**UNIT III**

Importance of irrigation in an agrarian economy, Economic issues related to marketing and finance. Role of co-operations in irrigation development, economic changes due to irrigation infrastructure development. The genesis of growth and utilization of irrigation

**UNIT IV**

Irrigation Development Corporations Irrigation policy, Sectoral distribution of Plan Allocation for irrigation.

**Suggested Readings:**

Economic Surveys of India and Maharashtra.

Economics of Irrigation by Colin Clark

Fundamentals of Farm Business and Management by Johl and Kapur.

Irrigation and Agricultural Development by U.M. Jha.

**IWM 514 CROPPING SYSTEMS AND SUSTAINABLE AGRICULTURE****1+1=2****Theory:**

Unit No.	Lecture No.	Topics to be covered	Weightage in Marks
I	1 & 2	Basic concepts of production function, production relationship	15
	3	Three regions of production function.	5
II	4-5	Maximization of net returns with water as an in important input.	10
	6	Tools of farm management, scope and importance.	5
	7 - 8	Farm planning and budgeting.	15
	9	Economic measures of water use efficiency.	5
III	10	Importance of irrigation in an agrarian economy.	5
	11	Economic issues related to marketing and finance.	5
	12	Role of co-operations in irrigation development.	10
	13	Economic changes due to irrigation infrastructure	5

		development.	
	14	The genesis of growth and utilization of irrigation.	5
IV	15-16	Irrigation Development Corporations. Irrigation policy, plan allocation for irrigation.	15

**Practical:**

1-4	Specification and estimation of different production functions
5-7	Estimation of profit functions, working out optimal use of resources, three regions of classical production function
8-10	Economic analysis of co-operative lift irrigation projects
11-14	Estimation of growth rates of irrigated area
15-18	Estimation of irrigation potential created and utilized under different projects

**Course Title: CROPPING SYSTEMS AND SUSTAINABLE AGRICULTURE**  
**Course No. IWM 514** **1+1=2**

**Syllabus:**

**UNIT I**

Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use.

**UNIT II**

Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, mechanism of yield advantage in intercropping systems.

**UNIT III**

Above and below ground interactions and allelopathic effects; competition relations; multistoried cropping and yield stability in intercropping, role of non-monetary inputs and low cost technologies; research need on sustainable agriculture.

**UNIT IV**

Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concepts of fertilizer use in intensive cropping system. Plant ideotypes for drylands; plant growth regulators and their role in sustainability.

**Suggested Readings:**

- Palaniappan SP & Sivaraman K. 1996. Cropping Systems in the Tropics; Principles and Management. New Age.
- Panda SC 2003. Cropping and Farming Systems. Agrobios.
- Raddy SR 2000. Principles of Crop Production. Kalyani.
- Sankaran S & Mudaliar TVS. 1997. Principles of Agronomy. The Bangalore Printing & Publ. Co.
- Singh SS. 2006. Principles and Practices of Agronomy. Kalyani.
- Tisdale SL, Nelson WL, Beaton JD & Havlin JL. 1997. Soil Fertility and Fertilizer. Prentice Hall.

**IWM 514 CROPPING SYSTEMS AND SUSTAINABLE AGRICULTURE**  
**1+1=2**

**Theory:**

Unit No.	Lecture No.	Topics to be covered	Weightage in Marks
I	1 & 2	Cropping system, definition, indices and its importance, physical resources	10
	3	Soil and water management in cropping systems	5
II	4-7	Concept of sustainability in cropping systems	20
III	8	Ground interactions and allelopathic effects	5
	9-10	Multistoried cropping & yield stability	10
	11	role of low cost technologies;	10
IV	12-13	Crop diversification for sustainability	20
	14-15	concepts of fertilizer use in intensive cropping system	10
	16	Plant ideotypes for drylands, plant growth regulator	10

**Practical:**

1-2	To study the yield advantages in intercropping system
3-4	To study the aggressivity index in cropping system
5-6	To study the integrated farming system
7-8	To study the cropping system in sustainable agriculture
9-10	To study the concept of fertilizer use in intensive cropping system
11-12	To study the plant growth regulator and their role in sustainability
13-14	To study the field experiments relevant to the cropping systems
15-18	Visit to cropping systems research projects, farming system project in the university



**Course Title: SOCIAL ISSUES IN WATER RESOURCES MANAGEMENT****Course No. IWM 516****1+1=2****Syllabus:****UNIT I**

Sociology, rural sociology - meaning, characteristics of rural society. Importance of study of rural sociology as inter-disciplinary approach to water management. Culture-meaning and importance.

**UNIT II**

Rural Social Systems, Rural institution and Organizations. Diagnostics analysis and Social aspects of irrigation management- systems, with interdisciplinary approach, Identifying problems and seeking solutions for improving performance of the irrigation system.

**UNIT III**

Farmers participation in water management. Mechanisms for strengthening the participation and involvement of farmers in water management. Outlet committees, water users co-operatives. Use of Local leader in farmers participation in water management.

**UNIT IV**

Social process Type – competition, conflict, Co-operation, assimilation and accommodation.

**Suggested Readings:**

Education and Communications for Development by Danama O.P. and Bhatnagar O.P. (1980), Oxford and IBH Publishing Co. New Delhi.

Extension Education by Reddy A.S. (1976). Shree Laxmi Press Bapatla (A.P.)

Diffusion of Innovations by Rogers E.M. (1962). Free Press New York.

Lecture Notes on Farmers Participation in Irrigation Management, USA, by Brewer J.D. (1986).

Irrigation Water Management in Western Region by Dhamaner

Rural Sociology by Desai A.R.

**IWM 516 SOCIAL ISSUES IN WATER RESOURCES MANAGEMENT 1+1=2****Theory:**

Unit No.	Lecture No.	Topics to be covered	Weightage in Marks
<b>I</b>	1 -2	Sociology, rural sociology-meaning	15
	3 -4	Rural sociology in water management	10
<b>II</b>	5- 6	Rural Social Systems	10
	7-10	Social aspects of irrigation management	25
<b>III</b>	11-12	Farmers participation in water management	15
	13-14	Role of farmers participation	15
<b>IV</b>	15-16	Social process Type	10

**Practical:**

1,2,3	Individual/group assignment on social survey in command area.
4,5,6,7	Visits in command areas, discussions with the irrigator farmers
8,9,10	methods of sampling, diagnostics analysis of irrigation system
11,12,13	Study of physical subsystem of irrigation
14,15,16	Study of economic sub-system

**Course Title: WATERSHED DEVELOPMENT AND MANAGEMENT****Course No. IWM 517****2+1=3****Syllabus:****UNIT I**

Concept of watershed, delineation, Morphological characteristics of watershed. Types of watershed, Land capability classification, Study of raingauge chart and rainfall characteristics. Probability analysis of rainfall data. Computation of runoff volume and peak rate of runoff.

**UNIT II**

Types of soil erosion and their preventive measures. Different in situ soil and water conservation measures on arable and non arable lands. Temporary gully control structures.

**UNIT III**

Water storage structures- Nala bunds, farm ponds, percolation tanks. Preparation of plan for watershed development considering rainfall, soil and morphology of watershed.

**UNIT IV**

Integration of in situ and ex situ rainwater harvesting structures. Study of water balance in the watershed. Planning of watershed development considering the water harvesting and recycling, management of excess/deficit water.

**UNIT V**

India's watershed development program, Community participation, role of NGOs, economic evaluation and environmental impact.

**Suggested Readings:**

Isobel W Heathcote. 1998. Integrated Watershed Management: Principles and Practice. Wiley Publ.

Kenneth N Brooks, Peter F Ffolliott, Hans M Gregersen, Leonard F DeBano. 1991.

Hydrology and the Management of Watersheds. Wiley-Blackwell

Singh G. and Shastri Manual of soil and water conservation works

**IWM 517 WATERSHED DEVELOPMENT AND MANAGEMENT 2+1=3****Theory:**

Unit No.	Lecture No.	Topics to be covered	Weightage in Marks
<b>I</b>	1-2	Concept of watershed, Morphological characteristics of watershed	10
	3-4	Types of watershed, Land capability classification,	10
<b>II</b>	5-6	Rainfall characteristics. Probability analysis, Computation of runoff	10
	7-8	Types of soil erosion	15
<b>III</b>	9-10	Different in situ soil and water conservation measures	15
	11-12	Water storage structures- Nala bunds, farm ponds, percolation tanks.	15
<b>IV</b>	13-14	Study of water balance in the watershed	5
	15-16	Planning of watershed development and management	10
	17-18	Community participation, role of NGOs,	5
	19-20	economic evaluation and environmental impact	5

**Practical:**

1	Exercise on watershed delineation
2-3	Determination of morphological characteristics of watershed
4-5	Study of rainguage chart
6-7	Probability analysis of rainfall data
8	Computation of runoff volume
9	Computation of peak rate of runoff
10-11	Determination of soil loss with universal soil loss equation
12	Design of farm pond
13-14	Design of nala bund
15	Study of water balance in the watershed
16-18	Visit to watershed

**Course Title: APPLICATION OF REMOTE SENSING AND GIS IN AGRICULTURE 2+1=3****Course No. IWM 524****Syllabus:****UNIT I**

Basic principles of remote sensing, components of remote sensing signals, sensors and sensing systems : active and passive remote sensing

## **UNIT II**

Electromagnetic spectrum, characteristics of electromagnetic radiation, Energy interaction with matter; spectral features of earth's surface features; imaging and non imaging systems; framing and scanning systems; resolution of sensors;

## **UNIT III**

Sensors platforms, their launching and maintenance; data acquisition system, data preprocessing, storage and dissemination

## **UNIT IV**

Digital image processing and information extraction; microwave remote sensing; visual and digital image interpretation; introduction to Geographical Information System (GIS) and GPS.

## **UNIT V**

Digital techniques for crop discrimination and identification; crop stress detection, GIS and remote sensing for land and water resources data collection, inventory of ground water and satellite measurement of surface soil moisture and temperature; drought monitoring, monitoring of crop disease and pest infestation; soil resource inventory; land use/land cover mapping and planning; Integrated watershed development; crop yield modeling and crop production forecasting.

### **Suggested Readings:**

Colwell, R.N. (editor). Manual of Remote Sensing-Vol. I & II, Am Soc. Photogrammetry, Virginia.

Curan, P.J. Principles of Remote sensing, ELBS/Longman.

De Mess MN. 2004. Fundamental of Geographic Information System. John Wiley & Sons.

Jain, A.K. 1989. Fundamentals of Digital Image Processing, Prentice Hall of India, Lillesand T.M. and Kiffer, R.W. Remote Sensing and image interpretation, John Wiley & sons.

Majumdar, K.L. et.al. 1983. Selection of spectral bands and their widths for the Indian Remote Sensing satellite (IRS), RSP-1P/TN03/83, Space Applications Centre, Ahmedabad-380053.

Sabins, F.F. 1997. Remote Sensing-Principles and Interpretation, 3<sup>rd</sup> ed. WH Freeman

Saddle river, NJ. Kamat, D.S. and Sinha, S.K. (eds)1984. Proceedings of the Seminar on Crop Growth Condition and Remote Sensing, June 22-23, ICAR & ISRO.

Schowengerdt, R.A. 1997. Remote Sensing, Models and Methods for Image Processing, 2<sup>nd</sup> edn. Academic Press, London.

**IWM 524 APPLICATION OF REMOTE SENSING AND GIS IN AGRICULTURE** **2+1=3**

**Theory:**

Unit No.	Lecture No.	Topics to be covered	Weightage in Marks
<b>I</b>	1-2	Basics of Remote Sensing	10
<b>II</b>	3	Characteristics of Electromagnetic Radiation	10
	4	Interaction of EMR with matter, Earth's Surface	5
	5	Remote sensor in Visible, Infrared and Micro-wave Regions	
	6-7	Imaging and Non imaging Systems, Framing and Scanning System	5
<b>III</b>	8-9	Resolution of Sensor, sensor platforms	5
<b>IV</b>	10-11	Digital Image Processing	10
	12	Microwave Remote Sensing	10
	13-14	Visual and Digital Image Interpretation	10
	15-16	Introduction to GIS and GPS	10
<b>V</b>	17-18	Crop Identification, crop stress detection	5
	19	Crop Stress Detection	5
	20-21	Soil Moisture & Temperature Assessments, Inventory of Ground Water	5
	22	Soil resources inventory, Integrated Watershed Development	5

**Practical:**

1-2	Interpretation of Aerial photographs for mapping
3-4	Interpretation of satellite image for mapping
5-6	Study of image processing software
7-8	Study of image enhancement; image classification methods
9-10	Familiarization with remote sensing and GIS hardware, software and their principle of working
11-12	Comparison between ground truth and remotely sensed data
13-14	Study of GIS package
15-16	Use of GIS package for Crop acreage estimations
17-18	Use of GIS package for water resources assessment

**Course Title: APPLIED MATHEMATICS FOR IRRIGATION WATER MANAGEMENT**

**Course No. IWM 525**

**1+1=2**

**Syllabus:**

**UNIT I**

Determinants and matrix algebra :Introduction, definition and properties of determinants, expansion of determinants, theorems of determinants, products of determinants, application of determinants, Introduction, definition, properties and types of matrices, operation of matrices, inverse of a matrix, application of matrices.

**UNIT II**

Differential calculus: Concepts of limits, definition, limits of different types of functions. Differentiation principle and rules, differentiation of functions, maxima and minima and their applications, functions of more than one variable, partial differentiation, ordinary differential equations and their solution. Integral calculus: Indefinite integral and basic properties of integral, standard elementary integrals, integration by substitution and by parts. Integration of trigonometric functions, rational functions. Definite, improper, multiple integrals, application of integrations.

**UNIT III**

Linear and Non-linear relationship : Concept of linear relationship, concept of curvilinear relationship, different types of curvilinear equations such as  $Y = ae^x$ ,  $y = ab^x$ ,  $y = AX^b$ . Changing curvilinear relationship to linear relationship. Other curvilinear functions having two or three constants and evaluation of these constants. Asymptotic functions such as  $Y = a/x$ , polynomials, fitting of polynomials. Coordinate system in two and three dimensions, equation of st. line, plane surface.

**Suggested Readings:**

Elements of applied mathematics by P.N. Wartikar and J.N. Wartikar.

Mathematical hand book by F.S. Merritt.

Mathematical hand book by M. Vygodsky.

Mathematical models in agriculture: Quantitative approach to problems in agriculture and related sciences: by J. France and J.H.M. Thornley.

Introduction to mathematics for Life Scientists: by E. Batschelet.

**IWM 524 APPLIED MATHEMATICS FOR IRRIGATION WATER MANAGEMENT**

**1+1=2**

**Theory:**

Unit No.	Lecture No.	Topics to be covered	Weightage in Marks
I	1 & 2	Determinants	15
	3 & 4	Matrices	15
II	5	Limit	5

	6- 8	Differentiation	15
	9	Partial Differentiation	5
	10 - 13	Integral Calculus	20
	14	Differential equations	10
<b>III</b>	15 & 16	Linear and non-linear relationship	15

<b>Seminar (01 credit)</b>		
IWM-507	Seminar - I	0 + 1 = 1
<b>Master's Research (20credits)</b>		
	Research	0 + 20= 20