Module 2 – (L5) Sustainable Watershed Approach & Watershed Management Practices

Watershed Management

Prof. T. I. Eldho
Department of Civil Engineering,
IIT Bombay

Lecture No - 5

Agricultural Practices & Watershed Management
L5 – Agricultural Practices & Watershed Management

- **Topics Covered**
  - Watershed Ecology and agro-ecosystems, Soil and Water conservation management practices,
  - Sustainable land management practices, Crop management, Nutrient & Pest Management,
  - Integrated Farming, Case Study.

- **Keywords:** Agro-ecosystems, agriculture management, Nutrient & pest management, integrated farming.

---

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay

Photo, A.K. Singh, 2002
Sustainable Agriculture Management

- **Watersheds** in many parts of the world are experiencing pressure from high population growth, climate, land use change & over-exploitation of natural resources.

- To stop degradation of natural resources, understanding of Sustainable Agricultural Management Practices is necessary –
  - Dealing with upstream and downstream resources management challenges
  - To identify sustainable land use practices
  - To increase sustainable agriculture production
  - Increase opportunity of rural livelihood
Agriculture Water Management

- Interactions & Interplay between Food, People & Nature Sectors
- **Food sector:** produces bio-mass, influences eco-system positively / negatively
- Major use is **consumptive:** Major / micro irrigation; excess use is largely recycled.
- Fertilizers, pesticides - non-point source of pollution. Needs of people sector are relatively small. Saving of 1cm/ha/day= w/s for 1000 persons.
- Agri: Mun: Industrial:: 70: 15: 15, India - 85: 8: 7.
- For sustainable agriculture – irrigation is essential
Agriculture Water Management

- Global withdrawal of water for agriculture, industry and municipal use, and total use, in liters and gallons per capita per day, 1900-95
- Irrigated area covers about 40% of arable land in the world; Rainfed area the rest.

Ref: www.fao.org
India’s agriculture & Irrigation

- India has 2% of world’s land, 4% of freshwater, 16% of population, and 10% of its cattle.
- Geographical area = 329 Mha of which 47% is cultivated, 23% forested, 7% under non-agri. use, 23% waste land.
- Per capita availability of land 50 years ago was 0.9 ha, could be only 0.14 ha in 2050.
- Out of cultivated area, 40% is irrigated which produces 55% food; 60% is rain-fed producing 45% of about 250 M t of food.
- In 40 years (ultimate), proportion could be 50:50 producing 75:25 of 500 M t of required food.

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Agriculture related Issues

- Increase in agricultural growth rate in India – (0.3% - 3.5%)
- First Green Revolution (1970s)
  - Introduction of new high yielding varieties
- Second Green Revolution (1980s)
  - Concentration on genetic engg. through organized input management, farmer services & extension
- Some of the negative trends in spite of positive trends
  * Per hectare yield is low
  * Infrastructure facilities are poor
  * Neglecting management aspects totally
  * Non-mechanized & unscientific farming

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Agriculture related Issues...

Major Constraints are

- Decline in per capita land availability
- Stress in water resources
- Degradation of soils
- Lack of efficient water management
- Mono-cropping
- Lack of Crop Management
- Negligence of sustainable agriculture
- People’s apathy – scientific farming!
Watershed Ecology & Agro-ecosystems

- Agro-ecosystems - subset of ecosystems that defines functional representation of coherent agricultural activity - includes interaction of living & non-living components involved.

- Agro-ecological zones - defined as land unit carved out of agro-climatic zones based on major climate super imposed on length of growing period (moisture availability)

- India has 20 agro-ecological regions & 60 agro-eco sub regions. Each agro-eco sub region has further been classified into eco unit at district level for developing long term land use strategies.

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Zones are delineated based on physiography, soil, length of growing season and bioclimate of the region.

Nomenclature:
For example AER zone “A13Eh1”
A stands for Physiography
13 stands for soil scale
Eh stands for bioclimatic zone
1 stands for length of growing period

AER zone A13Eh1 is referred as Western Himalayas, shallow skeletal soils, hyper arid climate with length of growing period less than 60 days.
Need for Agro-ecological Classification

- To assess yield potentialities of different crops, crop combination in agro ecological regions/zones.
- To formulate future plan of action involving crop diversification.
- To disseminate agricultural research and agro-technology to other homogenous areas.
- To determine the crop suitability for optimization of land use in different agro-ecological regions/zones.
Soil and Water Conservation measures

- **Soil Conservation** - principles
  - Rainfall of high intensity - erodes top fertile soil of land - need to be stopped by scientific measures.

- **Biological Measures**
  - Conservation tillage
  - Deep tillage
  - Conservation farming

- **Mechanical Measures**
  - Terracing
  - Water Disposals
  - Other low cost measures
Water conservation

- **Principle** (according to rainfall state)
  1. *Where precipitation is less than crop requirements:* strategy includes land treatment to increase run-off onto cropped areas, following water conservation, use of drought-tolerant crops - suitable management practices.
  2. *Where precipitation is equal to crop requirements:* strategy is local conservation of precipitation, maximizing storage within the soil profile, & storage of excess run-off for subsequent use.
  3. *Where precipitation is in excess of crop requirements:* strategy is to reduce rainfall erosion, to drain surplus run-off and store it for subsequent use.
Sustainable Land Management Practices (SLM)

- SLM - knowledge based system - helps to integrate land, water, biodiversity & environmental management to meet rising food & fiber demand while sustaining ecosystem services and livelihood to meet requirement for growing population.

- SLM – Enhances productive capabilities of land in cropped and grazed areas

- Action to stop reverse degradation or at least to mitigate adverse effect of earlier misuse

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Objectives - SLM practices

- To increase land productivity
  - Replenish soil nutrient by liming and organic inputs
  - Maintain soil cover - cover crops & residue recycling

- To provide adequate quantity of water
  - Use crop, forage or tree species with higher water use efficiency

- To maintain water quality
  - Protect vegetative filter areas in the riparian zone to remove excess sediment and nutrients

- TO reduce flooding and flood damage
  - Plant deep rooted vegetation to enhance infiltration and water consumption by the plants

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Sustainable Agriculture – Crop Husbandry

- **Crop Husbandry** - practice of growing & harvesting crops- scientific principles - careful management & conservation of resources
  - Includes Soil enrichment, usage of hybrid and improved seeds and better cropping pattern

- **Techniques for improved crop production** are
  - Soil enrichment by bio-fertilization
  - Introduction of micro-nutrient management
  - Usage of hybrid seeds
  - Achieving optimum plant population
  - Timely and effective weed control
  - Pest management

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
SA - Nutrient Management

- **Nutrient management** is important to-
  - Tackle problems - use of inorganic fertilizers
  - Stop weed growth
  - Avoid crop diseases
  - Improve crop yield

- **Nutrient management** includes-
  - Disseminate knowledge of nutrient & its function to plant growth
  - Assessment of nutrient availability
  - Nutrient management - supply deficient nutrient to soil - also avoid excess use - to protect environment
Nutrient and its Functions

- Two basic types of nutrient –
  - Macro nutrient – Available in soil in larger %( ex. Nitrogen, Phosphorous, Potassium, Sulphur, Ca, Mg)
  - Micro nutrients – available in soil in minute % ( eg. Fe, Cu, Zn, Mn, Cl etc. )

- Functions of nutrient
  - Involvement in photosynthesis and produces carbohydrates
  - Early root formation and growth
  - Helps plants to survive in bitter environmental conditions
  - Increasing water use efficiency
  - Important role in reproduction of plants
Assessment of Nutrient

- **Traditional soil tests**
  - Tests like pH, nitrogen, phosphorous, potassium, electric conductivity etc. Should be performed every 3 to 5 years

- **Nitrate test**
  - Pre-plant nitrate test- for additional nitrogen
  - Deep nitrate test-how much nitrogen has already leached below the crop rooting zone

- **Traditional Plant Tests**
  - Chlorophyll meter: to quickly determine nitrogen status (without destroying any plant tissue)

- **Irrigation Water Tests**
  - Electric conductivity and pH tests
Pest Management

Objective of Pest Management:
- How pest management interrelates with climate, water, crop & soil management – for producers understanding
- Incorporating them into pest management decision making process

Necessity
- Critical component of conservation practices
- Negative impacts of pesticides
- Ground and surface water deterioration due to non point source pesticide contamination
- Environmental risks, Ex: burning crop residue for disease and insect control

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Integrated Pest Management (IPM)

- IPM - approach to pest control that combines biological, cultural & other alternatives to chemical control with the judicious use of pesticides
- IPM - To maintain pest levels below damaging levels

Goals of IPM:
1. Maximum use of naturally occurring control forces in the pest’s environment
2. First focus on non-chemical measures
3. Use of chemical pesticides only for preventing severe damage
Sustainable Agricultural Practices

- Biomass management – (eg. Crop rotation)
- Better conservation practices (land & water)
- Conservation buffers: forest buffers, grassed waterway, filter strip, vegetative barriers, conservation barrier for wind etc
- Crop husbandry
- Nutrient management
- Integrated pest management
- Use of molecular biology
- Use of genetic engineering – hybrid & improved seeds
Integrated Farming System - IFS

- **Mixed farming system** that combines crop and livestock enterprises in a supplementary and/or complementary manner.
- **Integration** of various agricultural enterprises viz., cropping, animal husbandry, fishery, forestry etc. - great potentialities in the agricultural economy.
- Components: Crops, livestock, birds and trees
- Crop may have subsystem - monocrop, mixed/intercrop, multi-tier crops of cereals, legumes (pulses), oilseeds, forage etc.
- **IFS** – Maximize food production – Overall development of a watershed

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Integrated Farming System...

- **Inter, Mixed & Strip Cropping**
  - **Inter Cropping:** Crops grown in space available in b/w plants:
    - Ex: Turmeric can be grown in Mango gardens – improves soil fertility.
  - **Mixed cropping:** Alternative rows of different crops – improve crop yields, preserve soil fertility
  - **Strip Cropping:** Long strips are used for growing crops on leveled beds

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Watershed Based - Sustainable Agriculture Management – Case Study

- **Adarsha Watershed** - Kothapally village, Shankarpally, Rangareddy, Andhra Pradesh, India, spread over 465 ha, developed by ICRISAT.

- **Objective:** link strategic research in Natural Resource Management (NRM) with development research - to increase productivity of rain fed agriculture, through enhanced efficiency of natural resources while maintaining the resource base.

- To increase systems productivity through adoption of improved soil, water, nutrient & pest management.
Case study: **Strategy**

- Linking strategic research with watershed development to enhance effectiveness of community participation.
- Multi-disciplinary & multi-institutional consortium approach for watershed based development projects.
- "Islanding approach" - micro-watersheds as upfront demonstrations managed by farmers with technical backups.
- On-farm strategic research conducted in partnership with farmers and NGO’s

**Watershed Details:** 270 farmers out of which 136 are small landholding (up to 1 ha), 60 are medium (1-2 ha) and 74 large land holding (above 2 ha) farmers.

www.icrisat.org/journal/agroecosystem/v2i1/v2i1adarsha.pdf

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Case study: Watershed Details

- Annual rainfall - about 800mm (85% of it occurs during June-Oct.).
- Soils are predominantly (90%) black soils.
- Soil depth varies from 30-90 cm.
- General slope of the land is about 3%.
- Crops grown - Sorghum, Maize, Cotton, Sunflower, Pigeon-pea, Soybean in rainy season & Sorghum, Sunflower, Vegetables in post rainy season under rain fed condition. Some area under Turmeric, Onion and Rice cultivation under well irrigation.

www.icrisat.org/journal/agroecosystem/v2i1/v2i1adarsha.pdf

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Case study: Watershed Interventions

- Continuous weather monitoring – automatic weather stations
- Scientific soil analysis – classification – suitability to crops
- Cropping system analysis - crop yield & cost analyzed
- Cropping according to soil, cost effective, better crop yield
- Inter cropping
- Use of Nitrogen fixing plants
- Vermi composting, organic farming
- Integrated pest control
- Capacity building & training to farmers

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Case study: Impacts

- Crop yield considerably improved
- Considerable improvement in water availability including groundwater
- Integrated nutrient & pest management
- Continuous monitoring – satellite – RS & GIS
- Holistic watershed management – land, water, agriculture & people
- Role model of Integrated sustainable watershed management through Sustainable agriculture management

**Capacity building and training – People participation – Socio economic upliftment**

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
References

- www.conservationinformation.org
- http://www.eldoradochemical.com/fertiliz1.htm
- scon-ing.org/DOC/publication1.doc
- http://agricoop.nic.in
- www.icrisat.org/journal/agroecosystem/v2i1/v2i1adarsh.pdf

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Tutorials - Question!

- **Illustrate necessity of sustainable agriculture management practices.**
  - Identify the components
  - Scientific interventions
  - Identify the problems
  - Identify role of molecular biology & genetic engineering.
  - Importance of nutrient management.
  - Role of integrated pest management.

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Self Evaluation - Questions!

- Discuss agriculture water use and compare World and Indian Scenarios.
- What are the major constraints in achieving watershed based sustainable agriculture management?
- Discuss the agro-ecological classification in India and its importance.
- Illustrate sustainable land management practices.

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
Assignment- Questions?.

- Discuss Indian Agriculture & Irrigation scenarios.
- Explain watershed ecology & agro-systems.
- Explain important issues in soil and water conservation.
- Discuss the importance of nutrient and integrated pest management and related issues.

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
For your Watershed area, study the scope for Integrated Farming Systems (IFS).

**Identify suitable IFS practices for the area for Integrated Sustainable Agriculture Management?**

- Carry out stakeholder analysis
- Consider traditional practices of farmers
- Suggest scientific methods
- Identify soil/water conservation measures
- Identify proper monitoring and evaluation strategy and involve local people
WATERSHED MANAGEMENT

THANK YOU

Dr. T. I. Eldho
Professor,
Department of Civil Engineering,
Indian Institute of Technology Bombay,
Mumbai, India, 400 076.
Email: eldho@iitb.ac.in
Phone: (022) – 25767339; Fax: 25767302
http://www.civil.iitb.ac.in