JP College of Engineering

Run by DMI Sisters
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Ayikudy-627852, Tenkasi (Dist), Tamil Nadu, India.

Department of Civil Engineering

Academic Year 2022-2023

Odd Semester

OAI 551 ENVIRONMENT AND AGRICULTURE

Lecture Notes

Regulation 2017

Mr. G. Baskar Singh

DEPARTMENT OF CIVIL ENGINEERING

DEPARTMENT VISION & MISSION STATEMENT

VISION:

To build young Technocrats by imparting their technical knowledge in the field of Civil Engineering, by laying the foundation for future engineers, who can meet the demands of industry and community effectively in all part of civil works and to make significant contribution in the economic development of the state, region and nation.

MISION:

M1: To adopt valuable teaching methods and implement high quality education to maximize Engineering knowledge for students.

M2: To promote innovative and original thoughts in the minds of civil engineers.

M3: To provide facilities to the students and faculty members to enhance the understanding and implementation of recent trends in the Civil Engineering field.

M4: To produce Civil Engineering graduates with good ethical skills and managerial skills to become as successful professionals and entrepreneurs.

M5: To promote advanced technology, Industry Institute interaction, research and consultancy in Civil Engineering department with global linkages.

PROGRAMME EDUCATIONAL OBJECTIVIES:

PEO 1: To educate the graduates with the basic and advanced knowledge in civil engineering and to apply the fundamentals of mathematics, science, management and computing in engineering principles.

PEO 2: To motivate themselves in getting engineering position and practice with structural design, construction industries in private and government sectors at the national and international levels.

PEO 3: To succeed and prepare the civil engineering graduates in lifelong independent learning and work effectively on team based projects to become good entrepreneurs and conduct themselves ethically, socially in their professional environment.

PEO 4: Graduates will be made aware of causes of impacts due to the development and also to identify remedial measures if necessary.

PEO 5: To prepare students to become successful design engineers, R&D scientists. Civil Engineering Graduates will exhibit interest in leading to professional licensure or higher studies in engineering that provides for continued development of their technical ability and management skills.

PROGRAMME OUTCOMES:

1. **Engineering Knowledge:** Able to apply the knowledge of Mathematics, Science, Engineering fundamentals and an Engineering specialization to the solution of complex Engineering problems.
2. **Problem Analysis:** Able to identify, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions using first principles of Mathematics, Natural sciences, and Engineering sciences.
3. **Design / Development of solutions:** Able to design solution for complex Engineering problems and design system components or processes that meet the specified needs with appropriate considerations for the public health and safety and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Able to use Research - based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Able to create, select and apply appropriate techniques, resources, and modern Engineering IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations.
6. **The Engineer and society:** Able to apply reasoning informed by the contextual knowledge to access societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional Engineering practice.
7. **Environment and sustainability:** Able to understand the impact of the professional Engineering solutions in societal and environmental context, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Able to apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice.
9. **Individual and Team work**: Able to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Able to communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project Management and Finance:** Able to demonstrate knowledge and understanding of the engineering and management principles and apply these to ones own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Lifelong learning**: Able to recognize the needs for, and have the preparation and ability to engage in independent and life-long learning in the broadest contest of technological change.

PREFACE

This Lecture notes has been developed with the objective to emphasize on the importance of environment and agriculture on changing global scenario and the emerging issues connected to it. And also assist an efficient primary reference for graduate students in Civil Engineering. Environmental Engineering and Agriculture engineering.

It covers the course syllabus of ***Open Elective I- Environment and Agriculture for III BE, V Semester Civil & Mechanical students in 2017 regulations(CBCS pattern) of Anna University.***

Chapter 1 provides Environmental concerns of basic information on the Environmental basis for agriculture and food, Land use and landscape changes, Water quality issues, Changing social structure and economic focus, Globalization and its impacts and Agro ecosystems.

Chapter 2 deals with the Environmental impacts of Irrigation development and watersheds, mechanized agriculture and soil cover impacts, Erosion and problems of deposition in irrigation systems, Agricultural drainage and downstream impacts, Agriculture versus urban impacts.

Chapter 3 is Climate change signs like Global warming and changing environment, Ecosystem changes, Changing blue-green- grey water cycles, Water scarcity and water shortages, Desertification.

Chapter 4 presents the details of Ecological diversity, wildlife and agriculture, GM crops and their impacts on the environment, Insets and agriculture, Pollination crisis, Ecological farming principles, Forest fragmentation and agriculture, Agricultural biotechnology concerns.

Chapter 5 furnishes details on emerging issues of Global environmental governance, alternate culture systems, Mega farms and vertical farms. Virtual water trade and its impacts on local environment, Agricultural environment policies and its impacts, Sustainable agriculture.

SYLLABUS

UNIT-1 ENVIRONMENTAL CONCERNS

Environmental basis for agriculture and food - Land use and landscape changes- Water quality issues - Changing social structure and economic focus - Globalization and its impacts- Agro ecosystems.

UNIT-II ENVIRONMENTAL IMPACTS

Irrigation development and watersheds - mechanized agriculture and soil cover impacts - Erosion and problems of deposition in irrigation systems - Agricultural drainage and down- stream impacts-Agriculture versus urban impacts.

UNIT-III CLIMATE CHANGE

Global warming and changing environment - Ecosystem changes-Changing blue-green-grey water cycles – Water scarcity and water shortages - Desertification.

UNIT-IV ECOLOGICAL DIVERSITY AND AGRICULTURE

Ecological diversity, wild life and agriculture - GM crops and their impacts on the environment - Insects and agriculture - Pollination crisis - Ecological farming principles Forest fragmentation and agriculture Agricultural biotechnology concerns.

UNIT-V EMERGING ISSUES

Global environmental governance - alternate culture systems Mega farms and vertical farms - Virtual water trade and its impacts on local environment - Agricultural environment policies and its impacts - Sustainable agriculture.

NOMENCLATURE/ABBREVIATION

BT	-	Bacillus Thuringiensis
CAP	-	Common Agriculture Policy
CEA	-	Controlled Environment Agriculture
CGIAR	-	Consultative Group on International Agricultural Research
DNA	-	Deoxyribo Nucleic Acid
EIA	-	Environmental Impact Assesment
ET	-	Evapotranspiration
EU	-	European Union
FAO	-	Food and Agriculture Organization
GE	-	Genetic Engineering
GEF	-	Global Environment Facility
GEG	-	Global Environmental Governance
GI	-	Genetic Improvement
GM	-	Genetically Modified
GMO	-	Genetically Modified Organism
ICID	-	International Commission on Irrigation and Drainage
ICM	-	Integrated Crop Management
IEG	-	Independent Evaluation Group
IPBES	-	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	-	Intergovernmental Panel on Climate Change
IPM	-	Integrated Pest Management
IUCN	-	International Union for Conservation Of Nature
LCA	-	Life-Cycle Assessment
LEISA	-	Low External Input System Agriculture

NOMENCLATURE/ABBREVIATION

MEA	-	Multilateral Environmental Agreement
OECD	-	Organization for Economic Co-Operation and Development
UN	-	United Nations
UNDP	-	United Nations Development Program
UNEP	-	United Nations Environment Program
WTO	-	World Trade Organization
IUCN-CEM	-	International Union for Conservation of Nature Commission for Ecosystem Management

UNIT I

ENVIRONMENT CONCERNS

Environmental basis for agriculture and food- Land use and landscape changes-water quality issues- Changing social structure and economic focus-Globalization and its impacts Agro ecosystems.

1.1. ENVIRONMENTAL BASIS FOR AGRICULTURE AND FOOD

1.1.1. Introduction:

This section of course examines the relationship between agriculture production and the environment and the way in which this impact is influenced and should be influenced by agriculture policies. This relationship is of particular interest to economists because many of the environmental impacts of agriculture give rise to various forms of market and government failure.

Government failure is indicated by the fact that the highest levels of assistance to the agricultural sector distort farming practices to the detriment of the environment of particular interest, therefore, is how environmental externalities and public goods will be affected by CAP (Common Agriculture Policy) reforms. Where market failures exist even after the reduction of support, then specific interventions to limit negative externalities and develop the supply of public goods by agriculture can be justified.

- The introductory topics are:
  - ✓ Linkages between agriculture and the environment.
  - ✓ Environmental indicators
  - ✓ The evolution of European Union(EU) and Irish policies towards agriculture and the environment.

1.1.2. Interactions between Agriculture and the Environment

1. **Soil quality (Sustainability Concerns)**

The issues here are contamination, erosion, desertification, nutrient supply and moisture balance.

- Soil can be damaged by changes in land use practices such as deforestation, the removal of hedgerows, overgrazing, neglect of soil conservation methods or the farming of uncultivated land.
- Soil erosion is a particularly acute problem in Mediterranean countries.

2. Water quality and quantity (pollution concerns)

The issues here include leaching of nutrients and pesticides, water extraction and drainage and flooding.

- Contamination of both ground and surface waters caused by high levels of production and use of manure and chemical fertilizers is a serious problem, particularly in areas of intensive livestock or specialized crop production.
- Water quantity problems arise in regions where water consumptions exceed critical levels in relation to available water resources.
- A growing area of farmland in Europe in irrigated, and agriculture is the most significant user of water in the Mediterranean parts of Europe.
- How best to allocate limited supplies of water among competing uses in an urgent issues of concern.

3. Air quality (pollution concerns)

The issues here emission of greenhouse gases and ammonia.

- At Europe Union(EU) level, agriculture is responsible for about 8% of total greenhouse gas emissions but is the principal source of methane (from cattle production) and nitrogen oxide (from grazing livestock) contributing around 40% of these two gases.

4. Biodiversity(conservation concerns)

Issues include genetic, species and ecosystem diversity

- The intensification of agriculture has led to a widespread reduction of species and habitats.
- However, about two-fifths of the Europe Union's(EU's) agricultural area remains under low intensity systems-mainly either grazing land under various systems of livestock management or permanent crops under traditional management.

- The support semi-natural habitats and wildlife species of conservation importance, but may face the threat of abandonment or of intensification.
- These threats may be intensified in a future environment of high food prices in response to growing food and biofuels demand.

5. Landscape (amenity concerns)

- The marginalization of agricultural land can lead to its abandonment if farming ceases to be viable.
- Alternatively, intensification of agriculture can lead to the loss of important landscape features such as hedges and ponds, the enlargement of fields and the replacement of traditional farm buildings with industrial structures.
- Rights of access may be restricted in the interests of more efficient farming.

6. Food safety and animal welfare concerns

The issue here is the effect of agricultural practices on human health rather than the physical environment. There is also concern about the consequences for the quality and safety of the food supply of the increasing use of pesticides and drugs, leading to encouragement to organic farming.

1.2. LAND USE AND LANDSCAPE CHANGES

1.2.1. Definition

Land use change is a process by which human activities transform the natural landscape, referring to how land been used. Usually emphasizing the functional role of land for economic activities.

Landscape change is a dynamic process. Landscape modification changes the spatial configuration of native vegetation. The extent of modification influences the proportion of edges, size and shape of a fragment. With increasing, clearing, the distance between patches increases and landscape connectivity decreases.

1.2.2. Causes of Landscape

- Land cover and land use patterns of Earth reflect the interaction of human activities and the natural environment.
- Human population growth together with the competitive land use causes land scarcity, conversion of wild lands to agriculture and other uses.

- As the anthropogenic factor has an important impact on land use and land cover changes. Given this human influence, especially during the past 100 years, the recent period has been called the Anthropogenic Age.
- Human influence on the land and other natural resources is accelerating because of rapid population growth and increasing food requirements.
- The increasing agricultural intensity generates pressure not only on land resources, but also across the whole environment.
- These factors make agriculture a top priority sector for both economic and environment policy.

The relationship among agriculture, ecosystems and environment were proposed as new contributions to country and landscape planning and management. Many of the processes of land evolution and transformation are almost unnoticeable when viewed over shorter periods, but in the long term they may well lead to changes in the carrying capacity, water balance, and usability of the landscape.

Rural, forestry and aesthetic changes may affect different components of territory, and modifications of rural areas are certainly an important variable in the planning of landscape. ***Changes in land use and climate are two major global developments projected for the future.***

- During the past two decades three phenomena are re-drawing the configuration of rural areas.
    - The mechanization, the accelerating end of traditional rural life and an increase in the mobility of individuals.
    - In fact, in many developed countries, a particular land-cover change pattern has taken place: plains are being increasingly utilized for human activities, while mountain areas are being abandoned and are undergoing natural reforestation processes.
    - These generalized patterns can have significant impacts on biodiversity distribution and conservation.

1.2.3. Global scenario of Land use and Land Cover.

The global land area is 13.2 billion ha. Of this, 12% (1.6 billion ha) is currently in use for cultivation of agricultural crops, 28% (3.7 billion ha) is under forest, and 35% (4.6 billion ha) comprises grasslands and woodland ecosystem.

The worlds cultivated area has grown by 12% over the past 50 years. Globally, about 0.23 ha of land is cultivated per head of the world's population. In 1960, it was 0.5 ha of cropland per capita worldwide. In Europe, about one half of the land is farmed and arable land is most common form of agricultural land.

Twenty five percent of Europe's land is covered by arable land and permanent crops, 17% by pastures and mixed mosaics, and 35% by forests. The average amount of cropland and pasture land per capita in 1970 was 0.4 and 0.8 ha and by 2010 this had decreased to 0.2 and 0.5 ha per capita, respectively.

Such a state is a result of dynamic land use and land cover changes. Humans have altered land cover for centuries, but recent rates of change are higher than ever.

Land use change reflected in land cover change and land cover change is main component of global environmental change, affecting climate, biodiversity, and eco system services, which in turn affect land use decision.

Land use change is always caused by multiple interacting factors. The mix of driving forces of land use change varies in time and space. Highly variable ecosystem conditions driven by climatic variations amplify the pressure arising from high demand on land resources technology can affect labor market.

Demographic factors, such as increase and decrease of population, and migration patterns have a large impact on land use Life cycle features arise and affect rural as well as urban environments. They shape the trajectory of land use change, which it affects the household's economic status.

The development of the present ecosystems in the postglacial period depended on significant changes in climate. Wong in the postglacial period, about 10,000 years ago, created the conditions of a back migration of individual species from their refuges, where they were protected during the glacial periods. After the neolithic revolution, human society began to influence more noticeably the development of natural ecosystems. About half of the ice free land surface has been converted or substantially modified by human activities.

- Forest covered about 50% of the Earth's land area 8000 years ago, as opposed to 30% today. Agriculture has expanded into forests, savannas, and steppes in all parts of the world to meet the demand for food and fiber.

The central and north Europe was almost completely naturally covered by forests. Only high mountain and alpine rocky localities were without forest cover. Nowadays Europe is a mosaic of landscapes. reflecting the evolutionary pattern of changes that land use has undergone in the past. The greatest concentration of farmland is found in Eastern Europe, where also Slovakia lies, with more than half of its land area in crop cover.

During the past three centuries, in many developing countries and countries with transition economies, growing demand for food due to an increasing population has caused a substantial expansion of cropland, accompanied by shrinking primary forests and grassland areas. Based on many studies, in China between 1700 and 1950. cropland area increased and forest coverage decreased.

In India, between 1880 and 2010, cropland area has increased (from 92 to 140.1 million ha), and forest land decreased (from 89 to 63 million ha). But in the past 50 years, over world rapid urbanization has been Migration in its various forms is the most important demographic factor causing land use change at time scales of a couple of decades. Rapid economic growth is accompanied by a shift of land from agriculture to industry, infrastructure, road network, and residential use. Countries in East Asia, North America, and Europe have all lost cultivated land during their periods of economic development.

The dramatic growth and globalization of China's economy and market since economic reforms in 1978 have brought about a massive loss of crop lands, most of which were converted to urban areas and transportation routes during 1978-1995.

1.3. WATER QUALITY ISSUES

1.3.1. Introduction

The agricultural sector is by far the biggest user of freshwater. In Africa and Asia, an estimated 85-90% of all fresh water used is for agriculture. According to estimates for the year 2000, agriculture accounted for 67% of the world's total freshwater withdrawal, and 86% of its consumption. We use the water to irrigate crops and although a large percentage of the water returns from the fields, often it has been changed and is carrying soil and dissolved compounds.

While agriculture is not the only activity with the potential to affect fresh water negatively, it is a very important one. There may be surface runoff of pesticides, fertilizers and manure, or leaching of nitrogen into groundwater, the fate of which is discharged to surface water bodies. This means dissolved contaminants will find their way into lakes, rivers or the ocean.

Other activities that present risks to water include manufacturing, forestry, mining, waste disposal and runoff from urban areas.

1.3.2. Soil Water Relation

- Land and water are linked together through the Hydrologic cycle.

Although the atmosphere may not be a great storehouse of water, it is the superhighway used to move water around the globe. Liquid water is changed into water vapour with 90% due to evaporation and 10% due to transpiration.

This water vapour rises into the atmosphere on warm air currents Cooler temperatures high in the atmosphere cause vapour to condense into clouds. Strong winds move the clouds around the world until the water falls as precipitation. Precipitation that falls on land completes the cycle of fresh water and results in either runoff or groundwater.

Since most water that falls on the land eventually makes its way to either a ground water or a surface water source, anything that happens on the landscape can have a big impact on the quality of the water.

1.3.3. Impacts to Water

Runoff is simply water that is transported over the earth's surface. As it flows, it may move into the ground, evaporate into the air, be stored in lakes and reservoirs, or be extracted for agricultural or other human uses.

- Infiltration is the penetration of water on the soil, or ground surface, into the ground.
- Once it has infiltrated, water is held as soil moisture or groundwater.
- Sub-surface flow is the flow of water underground, in unsaturated soil and aquifers
- Subsurface water may return to the surface by way of a spring. by being pumped to the surface, or eventually seeping into the oceans. Groundwater tends to move slowly, and is replenished slowly, so it can remain in aquifers for up to thousands of years.

Since most water that falls on the land eventually makes its way to either a ground water or a surface water source, anything that happens on the landscape can have a big impact on the quality of the water.

- There may be surface runoff of pesticides, fertilizers and manure, or leaching of nitrogen into groundwater, the fate of which is discharge to surface water bodies.
- This means dissolved contaminants will eventually find their way into lakes, rivers or the ocean.
- Much of the phosphorus that is moved from agricultural lands is bound to soil particles.
- It may not be a problem in this form, once deposited in fresh water sediments, there may be slow release of phosphorus in a dissolved form that can be readily taken up by aquatic plants.
- The effects of deposition may be felt for many years after the source is removed or controlled.
- Notice that airborne dust with adsorbed phosphorus and organic matter can travel great distances before being deposited by gravity or with precipitation.

  - Point and non-point sources
  - Sediments
  - Nutrients
  - Pesticides

1. Point and non-point sources

A fundamental distinction is made between two kinds of water contamination - point and non-point sources. A point source is one that can be located, whereas we are unable to locate the origin of a non-point source pollutant exactly. Unfortunately, this distinction is not always as simple as it sounds.

- Wind erosion is a good example of non-point source additions.
- Some wind eroding particles will inevitably land in water.
- In addition to being an important component of sediment, soil particles may also be a source of adsorbed nutrients and possibly pesticides, which dissolve after deposition.

- Despite the fact that this runoff stream will discharge into:
    - A body of water at an identifiable point
    - Sediments and nutrients are being picked up from a large area.
- This would be considered a non-point source. So would urban runoff, even though it usually spills into receiving waters at identifiable locations.

But a below-ground plume from a leaking gas tank which enters an aquifer that then discharges into a river would probably be considered a point source, even though contamination of the river would be over its entire area of contact with the polluted aquifer.

2. Sediments

- Water quality problems can arise from suspended solids, which cause turbidity and form deposition of solids, called sedimentation.
- Sediment that enters fresh water is usually the result of wind and water erosion from cultivated areas or stream bank erosion, which can have a variety of causes.

Turbidity refers to how clear the water is. The greater the amount of total suspended solids in the water, the murkier it appears and the higher the measured turbidity. Increased turbidity may limit the growth of bottom-rooted aquatic plants and favors the growth of algae. It can result in reduced visibility for animals that use sight to find food.

- Disinfection of drinking water is much less effective in waters high in particulates, because pathogens can be shielded or protected from the particles.
- By blocking light penetration, large algal populations can eliminate all competition from plants rooted in the sediments.
- The high oxygen demand of algal mats, leads to lower diversity of aquatic organisms in a water body of this sort.
- Increased sedimentation also leads to in filling of reservoirs, which shortens the life expectancy of dams.
- Where soil erosion rates are high, costly maintenance is often required to keep irrigation ditches and canals free of sediment.
- Sediments may also cause:
    - Clogging of waterways

- Producing flooding
- Alteration of flow patterns
- The formation of new channels that may interfere with other land use activities.

➢ Many fish species require gravelly stream bottoms for spawning.

➢ Sediments may blanket these gravel beds, interfering with normal reproduction.

➢ Plant nutrients, particularly phosphorus, and pathogens are sometimes associated with the suspended fraction.

➢ As sediments settle, changes in chemistry occur that can promote the release of these nutrients.

3. Nutrients

When plant nutrients from synthetic fertilizers or organic fertilizers, decomposed crop residues, and agricultural waste products, such as wastewater from dairies, run off into fresh water, they speed up the Eutrophication of water bodies.

➢ Eutrophication is the process by which lakes gradually age and become more productive.

➢ This process normally occurs over very long periods of time and its acceleration can have a range of negative impacts.

➢ The nutrients of greatest concern are nitrogen and phosphorus.

➢ Their excessive presence can lead to increased plant biomass, usually in the form of undesirable aquatic plants and algae.

➢ As aerobic microbes decompose dead plant material, there is an increase in the demand for dissolved oxygen.

➢ The resulting oxygen depletion can cause fish kills and loss of other aquatic animal life.

➢ Algae are most often the dominant plants in eutrophic waters.

Under conditions of unchecked algae growth, mats of algae may physically block water intakes and reduce the attractiveness of water bodies for recreation.

➢ It can also create unpleasant tastes and odours in drinking water.

- Some species of cyanobacteria, commonly referred to as blue- green algae, produce compounds that can be toxic to livestock.

i. Limiting Nutrients

- Limiting nutrients are an important factor in the biology of fresh water.
- The height of the water can't be greater than the height of the shortest which, in this case, is represented as nitrogen.
- In farming systems, nitrogen and phosphorus are most often the limiting factors to crop growth and are usually added in large quantities to maximize yields.
- In most freshwater systems, phosphorus is usually the limiting growth factor.
- Even small additions of phosphorus can stimulate algae and other plant growth.
- Nitrogen may be limiting in some streams and is usually limiting in estuaries.
- The migration of these important plant nutrients from agriculture to fresh water can radically upset the biological equilibrium of a water body.

ii. Nitrogen

- Some forms of nitrogen can be harmful to fish and animals.
- Dissolved ammonia gas in water can be toxic to fish species. When no oxygen is present, most inorganic nitrogen is in the form of ammonia gas. This is particularly true at high pH levels.
- High nitrate levels are generally not a problem in surface water where it is usually taken up rapidly by plants and algae, but it can be a concern in groundwater.
- Nitrite is a reduced form of nitrogen that is usually unstable in the environment and the human body.
- Under certain circumstances it can be produced by the reduction of nitrates in sufficient quantities to cause illness or even death.
- Blue baby syndrome, or methemoglobinemia, is the best understood manifestation of nitrite toxicity.
- Infants under the age of one year and persons with specific gastro-intestinal disorders are particularly susceptible to high levels of nitrate in drinking water that comes from nutrient-rich wells

- High nitrate levels in water and forage can also be fatal to ruminant animals.

4. Pesticides

- Modern agriculture relies heavily on the use of pesticides to maintain yields.
- It has been estimated that without pest management, pre-harvest crop losses would average 40 per cent.

Unfortunately, free lunches are hard to come by and there are a number of environmental risks posed by pesticide use.

- The greatest risk of pesticide use is to non-target organisms.
- These include species that we consider beneficial or desirable, including ourselves.
- Through the development of pesticide resistance and the elimination of predators due to broad-spectrum compounds, we may aid the emergence of new pest species.

i. Pathogens

Pathogens is a broad term for disease-causing organisms. In water, we are generally concerned about several species of bacteria, viruses and parasites, the most common of which are listed here. Most of these are transported to water from fecal matter, either from animals or people.

- Biological contamination of groundwater supplies occurs most often by contaminants entering the water by way of the well- head itself.
- Runoff containing manure, fertilizer, and animal remain that reaches the groundwater can contaminate the entire aquifer.

This is how the municipal well in Walkerton, Ontario was contaminated.

Shallow wells are more likely to contain biological contaminants than deep wells, indicating that leaching of pathogens through coarse- textured soils is probably another pathway for disease-causing organisms to pollute groundwater. The risks associated with ingestion can be very high for rural families who rely on untreated drinking water sources.

In Alberta, 86 per cent of dugouts tested in a pilot study had coliform detections. Of those, 71 per cent exceeded Canadian Drinking Water Guidelines for total coliforms and 68 per cent had detectable levels of fecal coliforms. Interestingly, 42 per cent of farmers surveyed did not treat their dugout drinking water and 27 per cent had never had their water tested.

ii. Organic compounds

- The decomposition of organic compounds is another major source of nitrogen and phosphorus.
- The most common sources of organic matter loading are runoff from farmyards and cultivated fields and waste waters.
- Waste water may include wash waters from livestock facilities or processing facilities for agricultural products.
- In addition to raising nutrient levels, organic compounds are also a carbon food source for aerobic, decomposing bacteria.
- Once again, increases in these bacterial populations create higher demand for the oxygen dissolved in water.
- As oxygen levels fall, other organisms requiring oxygen such as fish are unable to compete and populations may decline.
- High levels of dissolved organic carbon and suspended organic matter also create greater challenges for water treatment systems.
- Organic compounds often impart unpleasant tastes and odours to water that can be difficult and costly to remove.

iii.Hazardous chemicals

- There are various other substances that can originate from agricultural operations and pose risks to water quality.
- Fuels such as diesel and gasoline, motor oils and other petroleum- based products such as paint thinners may contaminate fresh water when spilled or disposed of improperly.
- There is some potential for accumulation of heavy metals in agricultural soils that can be taken up by crops.
- Copper and zinc are used as animal feed additives and can accumulate in soils receiving heavy applications of manure.

- Cadmium and zinc from fertilizers, particularly phosphorus products, may also build up in soils.
- More recently, concerns have been raised about the addition of pharmaceuticals to fresh water through runoff and wastewaters.
- The presence of low levels of antibiotics in water has been linked to the emergence of drug-resistant pathogens.
- It has been documented that a variety of substances that are applied to agricultural fields have the potential to disrupt endocrine function in aquatic organisms.
- The major areas of concern are associated with pesticides and certain pharmaceuticals that have been fed to livestock and may be present in livestock manure.

1.4. CHANGING SOCIAL STRUCTURE AND ECONOMIC FOCUS

Agriculture has changed dramatically since the end of World War and fiber productivity has soared due to new technologies, mechanization, increased chemical use, specialization, and government policies that favored maximizing production and reducing food prices. These changes have allowed fewer farmers to produce more food and fiber at lower prices.

Although these developments have had many positive effects and reduced many risks in farming, they also have significant costs. Prominent among these are topsoil depletion, groundwater contamination, air pollution, greenhouse gas emissions, the decline of family farms, neglect of the living and working conditions of farm laborers, new threats to human health and safety due to the spread of new pathogens, economic concentration in food and agricultural industries, and disintegration of rural communities.

1.4.1. Sustainable agriculture

- A growing movement has emerged during the past four decades to question the necessity of these high costs and to offer innovative alternatives.
- Today this movement for sustainable agriculture is garnering increasing support and acceptance within our food production systems.
- Sustainable agriculture integrates three main goals environmental health, economic profitability, and social equity.

- A variety of philosophies, policies and practices have contributed to these goals, but a few common themes and principles weave through most definitions of sustainable agriculture.

Agricultural sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs.

Therefore, long-term stewardship of both natural and human resources is of equal importance to short-term economic gain.

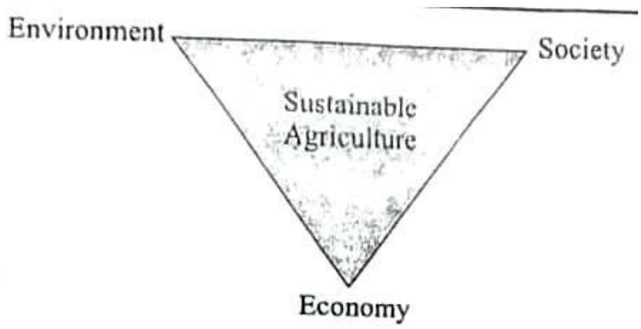


Fig. Sustainable agriculture gives equal weight to environmental, social, and economic concerns in agriculture

Stewardship of human resources includes consideration of 'social responsibilities such as working and living conditions of laborers, the needs of rural communities, and consumer health and safety both in the present and the future.

Stewardship of land and natural resources involves maintaining or enhancing the quality of these resources and using them in ways that allow them to be regenerated for the future. Stewardship considerations must also address concerns about animal welfare in farm enterprises that include livestock.

1.4.2. Impact of Agroecosystems on sustainable agriculture

- An agroecosystem and food systems perspective is essential to understanding sustainability.
- Agroecosystems are envisioned in the broadest sense, from individual fields to farms to ecozones.
- Food systems, which include agroecosystems plus distribution and food consumption components, similarly span from farmer to local community to global population.

- An emphasis on a systems perspective allows for a comprehensive view of our agricultural production and distribution enterprises. and how they affect human communities and the natural environment.
- A systems approach also gives us the tools to assess the impact of human society and its institutions on farming and its environmental sustainability.
- Studies of different types of natural and human systems have taught us that systems that survive over time usually do so because they are highly resilient, adaptive, and have high diversity.
- Resilience is critical because most agroecosystems face conditions (including climate, pest populations, political contexts, and others) that are often highly unpredictable and rarely stable in the long run.

Adaptability is a key component of resilience, as it may not always be possible or desirable for an agroecosystem to regain the precise form and function it had before a disturbance, but it may be able to adjust itself and take a new form in the face of changing conditions.

Diversity often aids in conferring adaptability, because the more variety that exists within a food system, whether in terms of types of crops or cultural knowledge, the more tools and avenues a system will have to adapt to change.

An agroecosystem and food system approach also implies multi- pronged efforts in research, education, and action. Not only researchers from various disciplines, but also farmers, laborers, retailers, consumers, policymakers and others who have a stake in our agricultural and food systems have crucial roles to play in moving toward greater agricultural sustainability.

Finally, sustainable agriculture is not a single, well-defined end goal. Scientific understanding about what constitutes sustainability in environmental, social, and economic terms is continuously evolving and is influenced by contemporary issues, perspectives, and values.

Example:

Agriculture's ability to adapt to climate change was not considered a critical issue 20 years ago, but is now receiving increasing attention. In addition, the details of what constitutes a sustainable system may change from one set of conditions (e.g., soil types, climate, labor costs) to another, and from one cultural and ideological perspective to another, resulting in the very term "sustainable" being a contested term.

Therefore, it is more useful and pertinent to think of agricultural systems as ranging along a continuum from unsustainable to very sustainable, rather than placed in a sustainable/unsustainable dichotomy.

1.4.3. Sustainable Agriculture and the Management of Natural Resources

- When the production of food and fiber degrades the natural resource base, the ability of future generations to produce and flourish decreases.
- The decline of ancient civilizations in Mesopotamia, the Mediterranean region.
- A sustainable agriculture approach seeks to utilize natural resources in such a way that they can regenerate their productive capacity, and also minimize harmful impacts on ecosystems beyond a field's edge.

One way that farmers try to reach these goals is by considering how to capitalize on existing natural processes, or how to design their farming systems to incorporate crucial functions of natural ecosystems. By designing biologically-integrated agroecosystems that rely more on the internal cycling of nutrients and energy, it is often possible to maintain an economically viable production system with fewer potentially toxic interventions.

Example:

Farmers aiming for a higher level of environmental sustainability might consider how they can reduce their use of toxic pesticides by bringing natural processes to bear on limiting pest populations.

Example:

By planting hedgerows along field edges, or ground covers between rows, thereby providing habitat for insects and birds that prey on the pests, or by planting more diverse blends of crops that confuse or deflect pests. Maintaining a high degree of genetic diversity by conserving as many crop varieties and animal breeds as possible will also provide more genetic resources for breeding resistance to diseases and pests.

Conservation of resources critical for agricultural productivity also means taking care of soil so that it maintains its integrity as a complex and highly structured entity composed of mineral particles, organic matter, air, water, and living organisms.

- Farmers interested in long-term sustainability often prioritize caring for the soil, because they recognize that a healthy soil promotes healthy crops and livestock.

- Maintaining soil functioning often means a focus on maintaining or even increasing soil organic matter.

- Soil organic matter functions as a crucial source and sink for nutrients, as a substrate for microbial activity, and as a buffer against fluctuations in acidity, water content, contaminants, etc.

Furthermore, the buildup of soil organic matter can help mitigate the increase of atmospheric CO, and therefore climate change Another important function of soil organic matter is inducing a better soil structure, which leads to improved water penetration, less runoff, better drainage, and increased stability, thereby reducing wind and water erosion.

Due to a high reliance on chemical fertilizers, agroecosystem has been disconnected from the internal cycling of key plant nutrients such as nitrogen and phosphorus. Phosphate minerals for fertilizer are currently mined, but global reserves are predicted to sustain food production for only another 50 to 100 years. Consequently. phosphate prices are anticipated to rise unless new reserves are discovered and innovations in recovery of phosphates from waste are developed.

The recycling of nitrogen and phosphorus (at the farm and regional scale), improving efficiencies of fertilizer applications, and relying on organic nutrient sources (animal and green manures) are important elements of sustainable agriculture. Recycling of nutrients is facilitated by a diversified agriculture in which livestock and crop production are more spatially integrated. For these reasons, extensive mixed-crop-livestock systems, particularly in developing countries, could significantly contribute to future agricultural sustainability and global food security

- In many parts of the world, water for agriculture is in short supply and/or its quality is deteriorating.

- Overdraft of surface waters results in disturbance of key riparian zones, while overdraft of groundwater supplies threatens future irrigation capacity.

- Salinization, nutrient overloads, and pesticide contamination are widespread water quality issues.

Selection and breeding of more drought- and salt-tolerant crop species and hardier animal breeds, use of reduced-volume irrigation systems, and management of soils and crops to reduce water loss are all ways to use water more efficiently within sustainable agroecosystems.

- Modern agriculture is heavily dependent on non-renewable energy sources, especially petroleum.
- The continued use of these non-renewable sources cannot be sustained indefinitely, yet to abruptly abandon our reliance on them would be economically catastrophic.

In sustainable agriculture, the goal is to reduce the input of external energy and to substitute non-renewable energy sources with renewable sources (e.g., solar and wind power, biofuels from agricultural waste, or, where economically feasible, animal or human labor).

1.4.4. Sustainable Agriculture and Society

Agroecosystems cannot be sustainable in the long run without the knowledge, technical competence, and skilled labor needed to manage them effectively. Given the constantly changing and locality- specific nature of agriculture, sustainability requires a diverse and adaptive knowledge base, utilizing both formal, experimental science and farmers' own on-the-ground local knowledge. Social institutions that promote education of both farmers and scientists, encourage innovation, and promote farmer-researcher partnerships can increase agricultural productivity as well as long-term sustainability

1.4.5. Conclusion

Social, economic, and environmental sustainability are closely intertwined and necessary components for a truly sustainable agriculture.

Example:

Farmers faced with poverty are often forced to mine natural resources like soil fertility to make ends meet, even though environmental degradation may hurt their livelihoods in the long run. Only by creating policies that integrate social, environmental, and economic interests can societies promote more sustainable agricultural systems.

1.5. GLOBALIZATION AND ITS IMPACTS ON AGRICULTURE

1.5.1. Introduction

Globalization refers to increases in the movement of finance, inputs, output, information, and science across vast geographic areas. The gains from globalization increase net income in many places and facilitate decreases in levels of poverty and may thereby increase levels of food security. However, there is an implication of frictionless movement and perfect knowledge that understates the requirements for benefiting from globalization.

These trends have been underway throughout history. As reflected in the previous chapter, they have moved unusually rapidly in recent times because the cumulative breakthroughs in basic science have allowed an extraordinary acceleration in the reduction of transfer costs. Real costs of information transfer and shipment of goods have declined rapidly, while perishability and bulk have been drastically reduced. Concurrently, increases in per capita income in many regions. , and in the total size of the market, have allowed scale economies to be achieved for myriad new products, most of which involve value added processes that themselves require investment and improved technology. These rapid changes have allowed a great increase in specialization in agriculture, and consequently lower costs and rapid growth in trade.

- Globalization can greatly enhance the role of agriculture as an engine of growth in low-income countries by making it possible for agriculture to grow considerably faster than domestic consumption.
- It also increases the potential for agriculture:
    - To increase food security through enlarged multipliers
    - To the massive
    - Employment-intensive
    - Non-tradable rural non-farm sector.

With such potential benefits, it is important to understand what is required for participation and to ensure that the poor and hungry are lifted out of poverty and hunger by these processes.

1.5.2. Competing in the context of globalization

Three features characterize competing in the current globalization context:

1. Cost reductions in one place have immediate impacts in other places

Cost reduction and associated production increase constantly occurs in agriculture, and the pace is accelerating, partly due to the forces of globalization. Thus, lower prices are often rapidly transmitted to producers who have not participated in cost reduction. If they have not experienced cost reduction in other endeavours either, they will experience a decline in income, eventually reverting to minimum subsistence agriculture. All too many of the least-developed countries fall into this category. They become poorer and more food insecure.

2. Cost reduction largely derives from technological advance

Cost-reducing technological change is the product of applied research, which increasingly depends on constantly advancing basic research. countries that are not rapidly expanding and improving their agricultural research capacity will not experience cost reductions and hence as others reduce costs, and prices decline, incomes of the non-innovators will decline. Nowhere is this more dramatic than in Africa, which has suffered from increasingly efficient production of first oil palm, then cocoa, and now coffee from Asian countries that have been spending on research. Benefiting from research is now far more complex than a few decades ago.

Basic research is moving far faster than ever before, constantly changing the context for applied research. Private firms are responsible for a much larger absolute and relative share of agricultural research than in the past. To benefit from modern biological science, complex relations between low-income and high-income countries must be, developed and even more complex relations between private sector and public sector research.

The first requisite for benefiting from research externalities is a strong national research system. Rate of return analysis shows that all low-income countries are vastly under-investing in applied agricultural research, particularly Africa. For countries, the role of the Consultative Group on International Agricultural Research (CGIAR) should become far more important than in the past as a link to basic research, private sector research and high-income countries.

Well operating markets in low-income countries are concentrated in major cities with reasonably good physical infrastructure and hence at least moderate transaction costs. Undertaking international trade is constantly decreasing in cost. Thus major urban markets in low-income countries are increasingly open to foreign competition. Agricultural production in these countries takes place in rural areas that are frequently deficit in physical infrastructure.

Hence foreign sources of competition may face low transport costs while domestic producers in low-income countries may face transport costs. Such costs are reduced by investment in physical infrastructure - most notably roads, but also communications. However, improved infrastructure also facilitates the movement of imported goods further into the rural economy, posing the threat of increased competition to local production.

- Globalization has greatly increased the returns to roads and consequently radical to reductions in costs.
- Rural roads in low-wage, low-income countries can be built over half the cost in labour and roughly half the cost represented by the food consumed by labour from their wages.

3. WTO rules constrain the extent to which countries can protect themselves

Created to facilitate the processes of globalization, the WTO works to reduce trade barriers and to enforce agreed rules. However, the protectionist measures of the past are being allowed to continue in high-income countries, whilst many low-income countries are opening their borders to, often subsidized, imports

1.5.3. The Commodity Composition Of Agriculture

Globalization has allowed agricultural production to grow much faster than in the past. A few decades ago fast growth was somewhat over 3 percent per year. Now it is 4 to 6 percent. However, these higher rates of growth involve a substantial change in its composition. The bulk of growth initially came from basic food staples when the scope for export markets is limited, whereas there is now a swing towards much higher value commodities.

Explosive growth in income of high-income countries means that large aggregates of production can now occur in what were previously small niche markets. High quality coffee and tea are examples. The market for horticulture exports has also grown immensely and can continue to grow.

As exports of high-value agricultural commodities increase and the multipliers to per capita income develop, domestic demand for high- value livestock and horticulture will increase rapidly. Thus, even in quite low-income countries, around half the increments to agricultural production will be high value horticulture and livestock for both export and domestic use. As a result, the role of cereal production will become relatively less important.

As the production mix moves more towards export crops and high-value crops and livestock, the rate of return for investments that reduce transaction costs will increase rapidly. The same is true for investments in all the value-added enterprises. There is, however. a caveat on value added. Much of such activity is through capital- intensive processes. There are also complexities in marketing. Both will give a comparative advantage to high-income countries. Low-income countries need to pay attention to comparative advantage at every step in the chain from producer to consumer and should not attempt components in which they lack a comparative advantage.

Cereals play an important role in food security in a global economy. The cost of shipping is declining. Two forces in developing countries may lead to increased cereal imports. First, globalization and specialization may lead to an increase in the area planted to high-value commodities and potentially result in a decline in the area planted to cereals if either increased intensity of production (i.e. double cropping) or extensification are not possible. Second, any shift of income distribution towards the low-income, food insecure, will shift the demand schedule upwards. Thus, low-income countries may be beneficiaries of declining cereal prices, even while they lose from declining prices of other agricultural commodities.

1.5.4. Converting The Benefits of Globalization into Food Security

- A major element in ensuring food security is increased incomes of poor people.
- The marginal propensity of the poor to spend on food is high.
- The primary means by which low-income people increase their incomes and hence their food security is through increased employment.
- It is agricultural growth that reduces poverty, and agriculture's impact is dependent on growth rates that are considerably higher than population growth rates.

The latter are indirect, working through their impact on the demand for rural non-tradables that occupy a high proportion of the total labour force and the bulk of the poor, food insecure.

- The great majority of persons below the poverty line work in the rural non-farm sector.
- They include many with a small tract of land that is insufficient to provide minimum subsistence.
- The rural non-farm sector uses very little capital and hence is highly employment-intensive.
- It produces goods and services that are dominantly non-tradable, that is they are dependent on local sources of demand.

- Agricultural growth is the underlying source of that demand growth.

The agricultural demand shows strong growth multipliers since the rural non-farm sector also tends to spend substantially on itself. This sector is highly elastic in supply, as would be expected of a labour-intensive sector in a low-wage economy. The supply of rural non-tradables is highly elastic, mainly because labour is the primary input and labour is elastic in supply as long as incomes are low or underemployment is endemic.

- It is demand that constrains growth of the sector and that demand comes from high agricultural growth rates.
- That the impact of agriculture on poverty is indirect is consistent with the three or four year lag noted before the full impact on poverty.

That it works through the rural non-farm consumer-goods sector is consistent with the finding that agriculture has little impact on poverty decline when land distribution is highly unequal - usually associated with absentee landlords who have quite different consumption patterns from those of peasant farmers.

For a major effect on employment, agriculture must grow substantially faster than population growth. If it is to grow in the 4 to 6 percent rates required for achieving employment levels essential to food security, then major components of agriculture must be exported.

- This will include the traditional bulk exports such as cotton, coffee, tea, oil palm, and non-traditional exports including horticulture.
- Globalization requires constant reduction in costs through research and its application as well as constantly declining transaction costs through constantly increasing investment in rural infrastructure.
- Without these a nation cannot compete: it is no accident that it is African nations that suffer the most from declining commodity prices.

1. **Opening The Economy To Trade And Market Forces**

The benefits of globalization flow from trade. are given below.

- Exports require imports, but trade restrictions tend to drive up the cost of exports through higher costs of vital inputs and technology.
- Comparative advantage needs to be seen for each component of a supply chain, not just for the final product.

- Customs inefficiencies and corruption and a myriad other bureaucratic constraints are just as stifling as tariffs and all need to be dealt with.

However, opening to global market forces does little good if costs are not being constantly reduced. Put differently, if the result of global forces interacting with domestic investment and policy is to leave comparative advantage with subsistence production, no amount of opening of markets will help.

2. Investing in agricultural research and dissemination

- Low-income countries need to invest far more than at present in agricultural research and technology dissemination.
- Without such investment, opening markets will do little good for agriculture and hence for poverty reduction and food security.
- Identifying supporting mechanisms such as research and training to minimize the exclusion of small resource poor farmers from value chains is also important.

3. Investing in rural infrastructure

Given the deplorable state of rural infrastructure in low- income countries, massive investments are needed Investment in other economic risk reduction services such as insurance, irrigation, storage is also likely to be required.

- Lack of such investment gradually shifts comparative advantage back towards subsistence production at very low-income and little multiplier to the rural non-farm sector.

Winters notes that "the transaction costs of trade with remote villages are often so great that it can be cheaper for grain mills to buy from distant commercial growers than from small farmers located in the region." However, improved infrastructure also lowers the final cost of imports in the producing areas.

4. Facilitating private sector activity

- All too often forgotten in these days of removing public sector constraints is the role that the public sector plays in conjunction with the private sector, especially in exports.
- It is not enough to remove bureaucratic constraints.
- Private sector investors in low-income countries tend to search for quick turnover, particularly in trade.

Initially, governments have to play a role in assisting the private sector by participating in the costs of market analysis, assisting in the development of trade associations that can diagnose needs, developing and enforcing grades and standards, meeting health regulations of high- income importers, diagnosing special niche markets and carrying out analysis of constraints.

In the case of most low-income countries, such efforts are sometimes financed by foreign aid programs, in a sense acting as public sector. Such efforts need to facilitate private sector action and gradually low-income countries need to play that role themselves, rather than relying on foreign aid.

1.6. AGRO ECOSYSTEMS

Definition

An Agroecosystem is the basic unit of study in Agroecology. and is somewhat arbitrarily defined as a spatially and functionally coherent unit of agricultural activity, and includes the living and nonliving components involved in that unit as well as their interactions.

Example:

A typical example of artificial ecosystem is a cultivated field or agro-ecosystem. This is a natural system altered by men through agricultural activity.

1.6.1. Characteristics of Agro Ecosystems

- Simplification: a farmer favours a plant species, removing all other animal or plant species which could damage it.
- The energy intake employed by men in the form of machinery. fertilizers, pesticides, selected seeds, processings.
- The biomass (harvest) which is removed when ripe.

This makes the ecosystem an open system, which means it depends from external processes to reintroduce fertilizing substances suitable to nourish a new growth and development process of organic material (plants).

- A natural ecosystem, instead, self-fertilizes as the biomass remains in its original setting.
- The introduction of pollutant substances which:

- In the case of intensive agriculture.
- Are chemical fertilizers.
- Antiparasitics
- Other chemical non biodegradable substances which accumulate in the ecosystem or which seep in the subsoil

➢ In some cases getting to the point of seriously polluting groundwaters, seas and rivers.

➢ An agroecosystem can be viewed as a subset of a conventional ecosystem.

➢ An agroecosystem lies in the human activity of agriculture.

➢ An agroecosystem is not restricted to the immediate site of agricultural activity (e.g. the farm).

➢ It includes the region that is impacted by this activity, usually by changes to the complexity of species assemblages and energy flows, as well as to the net nutrient balance.

Traditionally an agroecosystem, particularly one managed intensively, is characterized as having a simpler species composition and simpler energy and nutrient flows than "natural" ecosystem.

➢ Agroecosystems are often associated with elevated nutrient input, much of which exits the farm leading to eutrophication of connected ecosystems not directly engaged in agriculture.

1.6.2. Structure and Functions of Agricultural Ecosystems

Agricultural lands (also called Greenswards) are areas where the vegetation is dominated by grasses and other herbaceous (non- woody) plants.

➢ Agriculture lands occupy about 24% of the earth's surface.

➢ Agriculture lands occur in regions too dry for forests and too moist for deserts

➢ The annual rainfall ranges between 25- 75 cm, Usually seasonal

1. Biotic components

i. Producer Organisms

- In agriculture land, producers are mainly grasses, though, a few herbs & shrubs also contribute to primary production of biomass.
- Some of the most common species of grasses are:
- Brachiaria sp., Cynodon sp., Desmodium sp., Digitaria sp.

ii. Consumers

- In a agriculture land, consumers are of three main types;

a) Primary Consumers

- The primary consumers are herbivores feeding directly on grasses. These are grazing animals such as
- Cows, Buffaloes, Sheep, Goats, Deer, Rabbits etc.
- Besides them, numerous species of insects, termites, etc are also present

b) Secondary Consumers

- These are carnivores that feed on primary consumers (Herbivores)
- These include;-Frogs, Snakes, Lizards, Birds, Foxes, Jackals etc.

c) Tertiary Consumers

- These include hawks etc. which feed on secondary consumers.

iii. Decomposers

- These include wide variety of saprotrophic micro- organism like: Bacteria; Fungi; Actinomycetes.
- They attract the dead or decayed bodies of organisms & thus decomposition takes place
- Therefore, nutrients are released for reuse by producers.

2. Abiotic components

i. These include basic inorganic & organic compounds present in the soil & aerial environment.

ii. The essential elements like C, H, N, O, P,S etc. are supplied by water, nitrogen, nitrates, sulphates, phosphates present in soil & atmosphere.

➢ Services and dis-services of Agro-ecosystem is shown in figure 1.6.

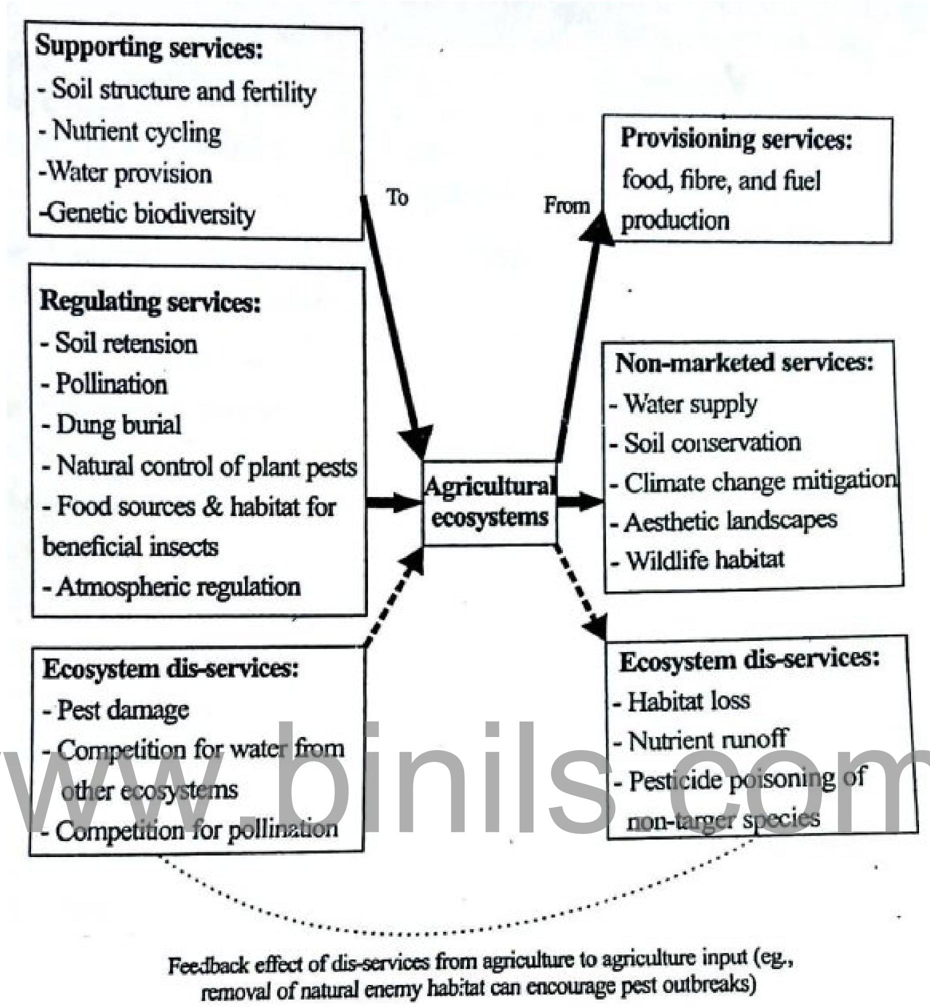


Fig. 1.6 Ecosystem services and dis-services to and from agriculture

1.6.3. Agro-Ecosystems Management

The Agro-ecosystems Specialist Group promotes sustainable agricultural practices and agrobiodiversity management under changing climatic conditions and encourages ecosystem based approaches and resource conservation technologies for transforming agriculture as a sustainable enterprise.

1. Objectives of Agro-Ecosystems Management

➢ Understand the complex and interconnected linkages between agriculture, biodiversity and ecosystem management.

➢ Conduct ecological risk assessment of agroecosystems under changing climatic conditions.

- Integrate landscape ecology and ecosystem based approaches to support agrobiodiversity and ecosystem services of agricultural systems.
- Manage wetlands for sustainable agriculture, aquaculture and other ecosystem services.

Foster sustainable and resource conservation technologies (i.e. organic agriculture, low external input system agriculture (LEISA), integrated crop management (ICM) and ecological agriculture etc.) to enhance the productivity of existing farmlands and reduce the environmental trade-offs.

- Popularize information technology for precision farming and sustainable agroecosystem management.
- Encourage adaptive and climate resilient agricultural practices to enhance the food production and nutritional quality under changing climatic conditions.
- Recommend sustainable use of agro-residues for multipurpose environmental benefits.
- Formulate sustainable strategies to restore degraded system for agricultural extensification.

- Support International Union for Conservation of Nature (IUCN) for preparing policy briefs, status reports and action plans or above themes for various governmental and intergovernmental agencies.

2. Action Plans

- Create a network of vibrant and active group of professionals (scientists, academicians, policy makers etc.) working on above themes from various agro-climatic regions of the world.
- Publish quarterly Newsletter on 'Agricultural Ecosystems'.
- Conduct workshops, training/ awareness/sensitization programs etc. on sustainable agriculture, climate resilient agriculture, agrobiodiversity management, agroforestry, integrated nutrient management, ecological pest management, sustainable resource conservation technologies etc. with the active involvements of various regional/national/and international agricultural organizations.

- Involve members of 'Young Professionals Network' of International Union for Conservation of Nature commission for Ecosystem Management (IUCN-CEM) and other IUCN commissions for various activities of the group.
- Prepare policy briefs and status reports on various aspects of agricultural ecosystems (i.e. sustainable agriculture practices for various agro-climatic regions of the world, conservation and management strategies for agrobiodiversity, climate resilient crop varieties, climate resilient agriculture etc.)
- Support the activities of IUCN-CEM and also provide voluntary helps for the ongoing and forthcoming regional/global assessments of various agencies such as UN, IPBES, UNDP**,** IPCC, FAO etc.

TWO MARK QUESTIONS AND ANSWERS

Unit 1-Environmental Concerns

1. What is the scope of the environmental basis for agriculture and food?

This section of the course examines the relationship between agricultural production and the environment and the way in which this impact is influenced and should be influenced by agricultural policies

2. What is the link between the environment and agriculture?

a. Soil quality (sustainability concerns)

b. Water quality and quantity (pollution concerns)

c. Air quality (pollution concerns)

d. Biodiversity (conservation concerns)

e. Food safety and animal welfare concerns

f. Landscape (amenity concerns)

3. Define the landscape and land use changes.

Land use change is a process by which human activities transform the natural landscape, referring to how land has been used, usually emphasizing the functional role of land for economic activities.

Landscape change is a dynamic process. Landscape modification changes the spatial configuration of native vegetation.

The extent of modification influences the proportion of edges, size and shape of a fragment. With increasing, clearing, the distance patches increases and landscape connectivity decreases.

4. Write the causes of landscape and land use changes.

- Land cover and land use patterns on Earth reflect the interaction of human activities and the natural environment.
- Human population growth together with the competitive land use causes land scarcity, conversion of wild lands to agriculture and other uses.
- As the anthropogenic factor has an important impact on land use and land cover changes. Given this human influence, especially during the past 100 years, the recent period has been called the Anthropogenic Age.
- Human influence on the land and other natural resources is accelerating because of rapid population growth and increasing food requirements.
- The increasing agricultural intensity generates pressure not only on land resources, but also across the whole environment.

5. Discuss the Global scenario of Land Use and Land Cover.

The global land area is 13.2 billion ha. of this, 12% (1.6 billion ha) is currently in use for cultivation of agricultural crops, 28% (3.7 billion ha) is under forest, and 35% (4.6 billion ha) comprises grasslands and woodland ecosystems. The world's cultivated area has grown by 12% over the past 50 years. Globally, about 0.23 ha of land is cultivated per head of the world's population. In 1960, it was 0.5 ha of cropland per capita worldwide. In Europe, about one half of the land is farmed and arable land is the most common form of agricultural land.

6. What is the relation between soil and water?

Since most water that falls on the land eventually makes its way to either a ground water or a surface water source, anything that happens on the landscape can have a big impact on the quality of the water.

7. What are the factors competing the context of globalization?

a. Cost reductions in one place have immediate impacts in other places.

b. Cost reduction largely derives from technological advance.

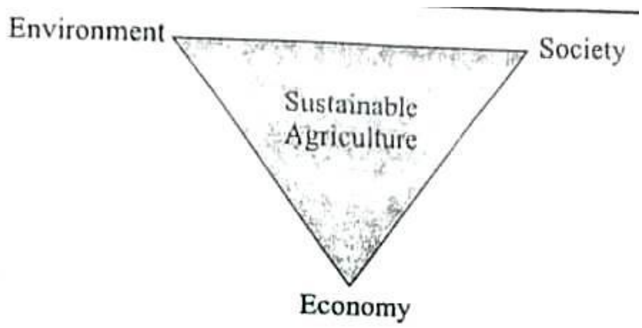
c. WTO rules constrain the extent to which countries can protect themselves

8. What is sustainable agriculture?

Agricultural Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. Therefore, long-term stewardship of both natural and human resources is of equal importance to short- term economic gain.

Sustainable agriculture integrates three main goals-environmental health, economic profitability, and social equity.

9. Show the diagrammatic representation of sustainable agriculture.



10. Mention the benefits of globalization into food security.

a. Opening the economy to trade and market forces

b. Investing in agricultural research and dissemination

c. Investing in rural infrastructure

d. Facilitating private sector activity

11. Define Land use and Landscape?

Landscape data documents how much of a region is covered by forests, wetlands impervious surfaces, agriculture, and other land and water types. Land use show people use the landscape-whether for development, conservation, or mixed uses. The different types of land cover can be managed or used quite differently

12. What is meant by changing pattern of land use?

Land use is the varying activities executed by humans to exploit the landscape. such as hunting or ploughing. More common practices are unplanned extensions of agricultural land hat violate the connectivity of landscapes in originally stable ecosystems. Land that is more amenable for conversion is that located adjacent to the city boundary, along the, highway Conversion of agricultural land to urban uses is a continuous phenomenon whose rate is stimulated.

13. Write a short note on land use classification?

The land use classification in India is as follows:

i. Geographical Area

ii. Reporting area for land utilization

a) Forests

b) Area under non-agricultural uses

c) Barren and Un-culturable land

d) Permanent Pasture and other grazing land

e) Culturable waste land

f) Fallow land

g) Net Irrigated area

h) Gross Irrigated area

14. What are the driving forces for land use change?

The intensification of human activities seeking to ensure the food supply and improve the income of the growing population is the major proximate driver of land use change. The associated human activities that drive LUC are expansion of agriculture land, free livestock grazing, wood extraction for fuel wood and charcoal-making and settlement expansion. The processes of LULCC have directly impacted the biodiversity and ecosystem service

15. What is the difference between land use and landscape?

Land use

Land use shows how people use the landscape - whether for development, a region is covered by forests, wetlands, conservation, or mixed uses land use cannot be determined from satellite imagery.

Landscape

- Land cover data documents how much of a region is covered by forests, wetlands, impervious surfaces, agriculture, and other land & water types
- Land cover can be determined bi analyzing satellite and aerial imagery

16. Illustrate the impact of land use change on biodiversity?

As the human population continues to increase, demand for more agricultural land is one of the main drivers of habitat loss and degradation. This change inland use presents the greatest immediate threat to biodiversity Forest-specialist species and species with narrow ranges are disproportionately lost from ecological communities when land is converted from natural to human dominated habitats In particular, birds are highly sensitive to urban land use and the number of bird species declines as human population density increases

17. Define ecosystem?

Ecosystems are entire living communities of plants and animals that, although diverse in nature, share common characteristics. These primarily relate to the climate and soil seen in the ecosystem. Climate, soils and vegetation interact closely to produce the characteristic nature of an individual ecosystem

18. What are the basic components of ecosystem?

There are four basic components in an ecosystem:

Abiotic Components

Producers at the base

Consumers in the chain

Decomposers and Nutrient cycling

19. What is water quality index?

Water quality index (WQ1) is valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment technique to meet the concerned issues. In spite of absence of a globally accepted composite index of water quality, some countries have used and are using aggregated water quality data in the development of water quality indices.

20. Challenges faced due to water Quality-Globally?

Water quality is one of the main challenges that societies will face during the21st century. threatening human health, limiting food production, reducing ecosystem functions, and hindering economic growth. Water quality degradation translates directly into environmental, social and economic problems.

Furthermore, newly emerging pollutants like personal care products and pharmaceuticals, pesticides, and industrial and household chemicals, changing climate patterns represent a new water quality challenge, with still unknown long-term impacts on human health and ecosystems.

21. Quality issues in agriculture and industry?

Farms discharge large quantities of agrochemicals, organic matter, drug residues, sediments and saline drainage into water bodies. Improperly managed agricultural activities may impact surface water by contributing nutrients pesticides, sediment, and bacteria, or by altering stream flow. Fertilizer and pesticide use, tillage, irrigation, and the drainage can affect water quality and hydrology.

Industry is a huge source of water pollution, it produces pollutants that are extremely harmful to people and the environment Pollutants from industrial sources include: Asbestos, Lead. Mercury, Nitrates. Phosphates. Sulphur Viscous oils and petrochemicals

22. Define Globalization?

Globalization is the spread of products, technology, information, and jobs across national borders and cultures In economic terms it describes an interdependence cf nations around the globe fostered through free trade. It can raise the standard of living improving access to goods and services Globalization is a social cultural, political, and legal phenomenon

23. How Globalization impact agriculture?

Competition from global brands due to opening of sector

Prices in global markets able to impact local prices e g-sugar industry

GM crops issues

Patenting of local products by multinational brands eg- Jamun, Neem, Turmeric

Cash crop demand increase farmer focus on these crops. But demand and price of these crops may fluctuate This has major implication when farmer deviate from food crops. This have issues for countries food security.

Globalization has indirectly led to industrial growth. This needs land and resultantly increase in displacement of farmers.

24. Illustrate the linkage between the environment and agriculture?

Interaction between environment and agriculture is based on following Indicators:

i. Soil quality (sustainability concerns)

ii. Water quality and quantity (pollution concerns)

iii. Air quality (pollution concerns)

iv. Biodiversity (conservation concerns)

v. Landscape (amenity concerns)

vi. Food safety and animal welfare concerns

25. Is agriculture bad for environment?

Fertilizers and animal manure, which are both rich in nitrogen and phosphorus, are the primary sources of nutrient pollution from agricultural sources. Livestock farming has a vast environmental footprint. It contributes to land and water degradation, biodiversity loss, acid rain, coral reef degeneration and deforestation. Nowhere is this impact more apparent than climate change livestock farming contributes 18% of human produced greenhouse gas emissions worldwide

26. What environmental problems arise from food production?

Agriculture is the single largest contributor of ammonia pollution as well as emitting other nitrogen compounds. There are a number of important issues in agricultural food reduction and consumption that have significant impacts on the environment and human health such as soil bio diversity, desertification water use and water pollution, energy, climate change, chemicals, food safety and biotechnology.

REVIEW QUESTIONS

1. Discuss in detail about Water quality issues with agriculture.

2. Explain the impact of agriculture in landscape and land u changes in a detailed manner.

3. How agriculture is Changing social structure and economic focus? Discuss the significance of sustainable agriculture.

4. Write the detailed note on agroecosystem and the factors influencing it.

5. Elaborate the agricultural impact on water, how it can be addressed by sustainable agriculture?

UNIT II

ENVIRONMENTAL IMPACTS

Irrigation development and watersheds-mechanized agriculture and soil cover impacts - Erosion and problems of deposition in irrigation systems - Agricultural drainage and downstream! impacts - Agriculture versus urban impacts.

2.1. ENVIRONMENTAL IMPACTS OF IRRIGATION DEVELOPMENT AND WATERSHEDS

The environmental impacts of irrigation relate to the changes in quantity and quality of soil and water as a result of irrigation and the effects on natural and social conditions in river basins and downstream of an irrigation scheme. The impacts stem from the altered hydrological conditions caused by the installation and operation of the irrigation scheme.

- The irrigation that grows crops, especially in dry countries, can also be responsible for taxing aquifers beyond their capacities.
- Groundwater depletion is embedded in the international food trade, with countries exporting crops grown from overexploited aquifers and setting up potential future food crises if the aquifers run dry.
- Main problems resulting in the non-sustainability of irrigation and drainage schemes and appropriate mitigation measures.

2.1.1. Direct Effects

An irrigation scheme draws water from groundwater, rivers, lakes or overland flow, and distributes it over an area. Hydrological, or direct, effects of doing this include:

- Reduction in downstream river flow.
- Increased evaporation in the irrigated area.
- Increased level in the water table as groundwater recharge in the area is increased and flow increased in the irrigated area.
- Irrigation has immediate effects on the provision of moisture to the atmosphere, inducing atmospheric instabilities and increasing downwind rainfall, or in other cases modifies the atmospheric circulation.
- Delivering rain to different downwind areas.

- Increases or decreases in irrigation are a key area of concern in precipitation shed studies.
- That examine how significant modifications to the delivery of evaporation to the atmosphere can alter downwind rainfall.

2.1.2. Indirect Effects

Indirect effects are those that have consequences that take longer to develop and may also be longer-lasting. The indirect effects of irrigation include the following:

1. Waterlogging
2. Soil salination
3. Ecological damage
4. Socioeconomic impacts

- The indirect effects of waterlogging and soil salination occur directly on the land being irrigated
- The ecological and socioeconomic consequences take longer to happen but can be more far-reaching.

Some irrigation schemes use water wells for irrigation. As a result, the overall water level decreases. This may cause water mining. land/soil subsidence, and, along the coast, saltwater intrusion.

Irrigated land area worldwide occupies about 16% of the total agricultural area and the crop yield of irrigated land is roughly 40% of the total yield. In other words, irrigated land produces 2.5 times more productive than non-irrigated land.

2.1.3. Adverse Impacts

1. Reduced River flow

The reduced downstream river flow may cause:

i. Reduced downstream flooding.

ii. Disappearance of ecologically and economically important wetlands or flood forests.

iii. Reduced availability of industrial, municipal, household, and drinking water

iv. Reduced shipping routes

- Water withdrawal poses a serious threat to the Ganges. In India, barrages control all of the tributaries of the Ganges and divert roughly 60 percent of river flow to irrigation.

v. Reduced fishing opportunities

- The Indus River in Pakistan faces scarcity due to over- extraction of water for agriculture.
- The Indus is inhabited by 25 amphibian species and 147 fish species of which 22 are found nowhere else in the world. It harbors the endangered Indus River dolphin, one of the world's rarest mammal's.
- Fish populations, the main source of protein and overall life support systems for many communities, are also being threatened.

vi. Reduced discharge into the sea

- Which may have various consequences like coastal erosion (e.g. in Ghana and salt water intrusion in delta's and estuaries (e.g. in Egypt, see Aswan dam).
- Current water withdrawal from the river Nile for irrigation is so high that, despite its size, in dry periods the river does not reach the sea.
- The Aral Sea has suffered an "environmental catastrophe" due to the interception of river water for irrigation purposes.

2. Increased groundwater recharge, waterlogging, soil salinity

Increased groundwater recharge stems from the unavoidable deep percolation losses occurring in the irrigation scheme. The lower the irrigation efficiency, the higher the losses. Although fairly high irrigation efficiencies of 70% or more (i.e. losses of 30% or less) can occur with sophisticated techniques like sprinkler irrigation and drip irrigation, or by well managed surface irrigation, in practice the losses are commonly in the order of 40% to 60%. This may cause the following issues:

- Rising water tables.
- Increased storage of groundwater that may be used for irrigation, municipal, household and drinking water by pumping from wells.
- Waterlogging and drainage problems in villages, agricultural lands, and along roads - with mostly negative consequences. The increased level of the water table can lead to reduced agricultural production.

- Shallow water tables - a sign that the aquifer is unable to cope with the groundwater recharge stemming from the deep percolation losses
- Where water tables are shallow, the irrigation applications are reduced. As a result, the soil is no longer leached and soil salinity problems develop
- Stagnant water tables at the soil surface are known to increase. The incidence of water-borne diseases like malaria, filariasis, yellow fever, dengue, and schistosomiasis (Bilharzia) in many areas.
- Health costs, appraisals of health impacts and mitigation measures are rarely part of irrigation projects, if at all.

To mitigate the adverse effects of shallow water tables and soil salinization, some form of water table control, soil salinity control, drainage and drainage system is needed.

As drainage water moves through the soil profile it may dissolve nutrients (either fertilizer-based or naturally occurring) such as nitrates, leading to a buildup of those nutrients in the ground-water aquifer.

High nitrate levels in drinking water can be harmful to humans, particularly infants under 6 months, where it is linked to "blue-baby syndrome".

3. Reduced downstream river water quality

Owing to drainage of surface and groundwater in the project area, which waters may be salinized and polluted by agricultural chemicals like biocides and fertilizers, the quality of the river water below the project area can deteriorate, which makes it less fit for industrial, municipal and household use

- It may lead to reduced public health. Polluted river water entering the sea may adversely affect the ecology along the sea shore.
- The natural buildup of sedimentation can reduce downstream river flows due to the installation of irrigation systems.
- Sedimentation is an essential part of the ecosystem that requires the natural flux of the river flow.
- This natural cycle of sediment dispersion replenishes the nutrients in the soil, that will in turn, determine the livelihood of the plants and animals that rely on the sediments carried downstream.

Case studies

The benefits of heavy deposits of sedimentation can be seen in large rivers like the Nile River. The sediment from the delta has built up to form a giant aquifer during flood season, and retains water in the wetlands.

- The wetlands that are created and sustained due to built up sediment at the basin of the river is a habitat for numerous species of birds.
- Heavy sedimentation can reduce downstream river water quality and can exacerbate floods up stream.
- This has been known to happen in the Sanmenxia reservoir in China.

The Sanmenxia reservoir is part of a larger man-made project of hydro-electric dams called the Three Gorge Project In 1998, uncertain calculations and heavy sediment greatly affected the reservoir's ability to properly fulfill its flood-control function.

This also reduces the down stream river water quality. Shifting more towards mass irrigation installments in order to meet more socioeconomic demands is going against the natural balance of nature. and use water pragmatically-use it where it is found.

4. Affected downstream water users

- Downstream water users often have no legal water rights and may fall victim of the development of irrigation.
- Pastoralists and nomadic tribes may find their land and water resources, blocked by new irrigation developments without having a legal recourse.
- Flood-recession cropping may be seriously affected by the upstream interception of river water for irrigation purposes.

Case studies

In Baluchistan, Pakistan, the development of new small-scale irrigation projects depleted the water resources of nomadic tribes traveling annually between Baluchistan and Gujarat or Rajasthan, India.

After the closure of the Kainji dam, Nigeria, 50 to 70 percent of the downstream area of flood-recession cropping was lost

5. Lost land use opportunities

- Irrigation projects may reduce the fishing opportunities of the original population and the grazing opportunities for cattle.

The livestock pressure on the remaining lands may increase considerably, because the ousted traditional pastoralist tribes will have to find their subsistence and existence elsewhere, overgrazing may increase, followed by soil erosion and the loss of natural resources.

Case studies

The Manatali reservoir formed by the Manantali dam in Mali intersects the migration routes of nomadic pastoralists and destroyed 43000 ha of savannah, probably leading to overgrazing and erosion elsewhere. Further, the reservoir destroyed 120 km^2 of forest. The depletion of groundwater aquifers, which is caused by the suppression of the seasonal flood cycle, is damaging the forests downstream of the dam.

6. Groundwater mining with wells, land subsidence

When more groundwater is pumped from wells than replenished, storage of water in the aquifer is being mined and the use of that water is no longer sustainable. As levels fail, it becomes more difficult to extract water and pumps will struggle to maintain the design flow rate and consume more may energy per unit of water. Eventually it may become so difficult to extract groundwater that farmers may be forced to abandon irrigated agriculture.

➢ Some notable examples include:

- The hundreds of tubewells installed in the state of Uttar Pradesh, India, with World Bank funding have operating periods of 1.4 to 4.7 hours/day, whereas they were designed to operate 16 hours/day.
- In Baluchistan, Pakistan, the development of tubewell irrigation projects was at the expense of the traditional qanat or karez users.
- Groundwater-related subsidence of the land due to mining of groundwater occurred in the United States at a rate of 1m for each 13m that the water table was lowered.
- Homes at Greens Bayou near Houston, Texas, where 5 to 7 feet of subsidence has occurred, were flooded during a storm in June 1989 as shown in the picture

Table 2.1 Main problems resulting in the non-sustainability of irrigation and drainage schemes and appropriate mitigation measures

Problem	Mitigation Measures
Degradation of Irrigated Land	• Improve (irrigation and development) I & D operation to match demand both 'how much & when'
Salinization	• Provide drainage including disposal of water to evaporation ponds or the sea if quality of river flow adversely affected by drainage water.
Alkalization	• Maintain channels to prevent seepage, and reduce inefficiencies resulting from siltation and weeds. Allow for ace to channels for maintenance in design.
Waterlogging	• Provide water for leaching as a specific operation.
Soil Acidification	• Set up or adjust irrigation management infrastructure to ensure sufficient income to maintain both the irrigation and drainage systems. • Analyse soils and monitor changes so that potential problems can be damaged.
Reduced Socio-economic conditions	• Manage I&D to prevent disease spread.
Increased incidence of water related disease	• Educate about causes of disease.
Increased inequity	• Improve health facilities.
Weaker community infrastructure	• Allow sufficient time and money for

	extensive public participation to ensure that plans are optimal, that all sections of affected society are considered and that local institutions are in place to sustain irrigated agriculture, particularly in respect of land and water rights. • Consider markets, financial service and agricultural extension in conjunction with proposed irrigation and drainage changes. • Ensure that agricultural intensification does not preclude other economic or subsistence activity, such as household vegetables, fodder or growing trees for firewood. • Provide short-term support and/or skills for an alternative livelihood if irrigation removes existing livelihood
Poor water quality	• Define and enforce return water quality levels (including monitoring)
Reduction in irrigation water quality	• Control industrial development
Water quality problems for downstream users caused by irrigation return flow quality	• Designated land for saline water disposal; build separate disposal channels. • Educate for pesticide or sewage contamination dangers • Monitor irrigation water quality • Define ecological requirements
Ecological degradation	• Define ecological requirements

Reduced big diversity in project area	• Operate dams to suit downstream requirements and encourage wildlife around reservoirs.
Damage to downstream ecosystems due to reduced water quality and quantity	• Designate land (in law and supported by protection institutions) for flood plains; wetlands; watersheds; drainage water disposal; river corridors.
Ground water depletion	• Define and enforce abstraction regulations
Dry drinking & irrigation wells	• Monitor ground water levels
Saline intrusion at coasts	• Adjust abstraction changes
Reduced base flow/we lands	

2.2. MECHANIZED AGRICULTURE AND SOIL COVER IMPACTS

Mechanized agriculture is the process of using agricultural machinery to mechanize the work of agriculture, greatly increasing farm worker productivity. In modern times, powered machinery has replaced many farm jobs formerly carried out by manual labour or by working animals such as oxen, horses and mules.

The entire of agriculture contains many examples of the use of tools, such as the hoe and the plough. The ongoing integration of machines since the Revolution however has allowed farming much become much less labor-intensive.

Current mechanised agriculture includes the use of tractors, rucks, combine harvesters, countless types of farm implements, aeroplanes and helicopters (for aerial application), and other vehicles. Precision agriculture even uses computers in conjunction with satellite imagery and satellite navigation (GPS guidance) to increase yields.

- Mechanisation was one of the large factors responsible for urbanisation and industrial economies.
- Improving production efficiency, mechanisation encourages large scale production and sometimes can improve the quality of farm produce.

- It can displace unskilled farm labour and can cause environmental degradation (such as pollution, deforestation, and soil erosion), especially if it is applied short sightedly rather than holistically.

2.2.1. The Role of Mechanization in Agricultural Sustainability

1. The importance of machines and tools in sustainable agriculture

Ensuring that agricultural and food production is sustainable is at the core of FAO's (Food and Agriculture Organization) work. Within his, sustainable mechanization plays an increasingly important role.

In essence, sustainable mechanization is the practice of introducing the proper machinery to farmers to ensure that their agricultural production is not only more environmentally sustainable but is more efficient in growing crops.

Sustainable agricultural mechanization refers to all farming and processing technologies from basic hand tools to motorized equipment. It does not just look at the technical aspects of farming, it also takes into account the effect that tools have on a farmer's outputs, from crop production along the value chain to marketable products, and in turn, the impact this has on a farmer's income.

2. Holistic View of Sustainability

Sustainable agricultural mechanization takes a holistic view on agriculture; it looks at sustainability within the technical, environmental and economic contexts. By ensuring that farming tools are environmentally sound, economically affordable, adaptable to local conditions, and resilient in terms of changing weather patterns and climate, mechanization looks to have achieving larger and better harvests and increased income or new jobs for farmers.

3. Moving on from subsistence farming

By increasing harvest outputs, mechanization means that farmers can move on from subsistence farming to market-oriented farming. This in turn appeals to the rural youth who increasingly seek employment in urban settings rather than in the fields. By easing and reducing the hard labour involved with farming, mechanization can also ensure higher outputs regardless of the age, gender or physical well-being of the farmer.

It can also relieve labour shortages, improve timeliness of agricultural operations, ensure the efficient use of resources, enhance market access by allowing farmers to sell more than just the raw product and contribute to mitigating environmental damage such as soil degradation.

Machines can allow for better practices such as reduced tillage and inter-cropping, the practice of planting different types of crops (e.g. legumes/cereals) in one field that grow simultaneously and complement each other in their growth. Rotational and inter-cropping practices reduce the risk of pests, soil degradation and the effects of unfavorable climate conditions.

4. Intensification without degradation

With the earth's growing population, there is greater demand for agricultural products. At the same time, the planet is facing serious challenges due to exploitation of natural resources and the increasing effects of climate change. Designating appropriate machines and tools to the agricultural production chain is vital to increasing output in a sustainable way.

Carefully chosen machinery can allow crops to be grown and harvested with minimum-to-no soil disturbance, ensure that the soil surface remains protected by organic cover, manage crop rotations to enhance soil health and conserve crop nutrients.

5. Fitting the tools to the needs

The type and size of machinery made available to farmers is also crucial. Past initiatives that worked with donated or subsidized machinery rather than machinery that was best suited to the situation often proved unsustainable as the repair services or replacement parts were not often available. Cheap at the outset, this solution proved unnecessarily expensive as these machines, once broken, ended up in graveyards full of tractors and equipment that could not be fixed and new ones had to be bought instead.

It is in cases such as these that it is imperative that a well- defined sustainable mechanization strategy is in place prior to its implementation. In December 2016, FAO met with local and international partner organizations to help establish a Sustainable Mechanization Framework for Africa. This framework provides best practices and strategy options that can be adapted to local conditions, a crucial element in ensuring its success.

6. Sustainable mechanization

Ensuring that farmers have access to and knowledge appropriate machinery and tools for their farming practices is critical agricultural sustainability.

2.3. EROSION AND PROBLEMS OF DEPOSITION IN IRRIGATION SYSTEMS

2.3.1. Erosion of Deposition in Irrigation Systems

Introduction

Irrigation is vital to food production in the world. However, irrigation-induced soil erosion reduces productivity of irrigated land and can cause off-site water quality problems. Surface irrigation utilizes the soil to distribute water through the field.

Water flowing over soil inherently detaches and transports sediment. Sprinkler and drip irrigation distribute water through fields in pipes, eliminating erosion from water distribution, but erosion cant still occur if water is applied faster than it can infiltrate into the soil.

The method of irrigation profoundly affects the vulnerability of the land to erosion. Because irrigated land is wetter, it is less able to absorb rainfall and runoff will therefore be higher. Field size, stream size (drop size), slope and field layout are all difficult to change and all significantly affect erosion rates.

Careful design can avoid the occurrence of erosion problems Agricultural practices affect soil structure and therefore the soil' erosivity, or the ease with which particles are dislodged.

In general land-forming for irrigation, such as land-levelling and the construction of field bunds, tends to reduce erosion.

2.3.2. Problems and Remedies of Deposition in Irrigation Systems

Problems

- Salinization is a major problem associated with irrigation because deposits of salts build up in the soil and can reach lev that are harmful to crops.
- The salts can make ground water, which may be in use drinking, saltier and unsuitable for drinking.
- It is mostly in arid and semiarid regions where the problem of high salt content deposited from irrigation threatens crops.

- Irrigation infrastructure needs to be designed to ensure that localized erosion, eg gully formation, does not occur.
- Construction activities generally expose soil to erosion. Following the completion of construction work, vegetation should be established around structures so that bare soil is not exposed to erosive forces.
- Causes of irrigation salinity is shown in the fig.2.2

Remedies

- Drip irrigation is a technique that can be used in areas where the ground water level is high and in danger of suffering from a high salt content.
- Where salinization is a problem to plants, enough water can be added to the irrigation process to leach salts away from plant roots.
- When the danger of salinization is to the water table, it is necessary to add drainage to the irrigation system away from the water table.
- Crops have different salt tolerances and their selection in relation to the salinity of the soil is an advisable practice.

- Among the common crops that have a high salt tolerance are red beets, spinach, kale, asparagus, sugar beets, barley, cotton, date palms, and some grasses used for animal feed, such as wild rye and wheat grass.

Crops that have a low tolerance for salinity include radishes, celery, green beans, fruits such as pears, apples, oranges, grapefruit, plums, apricots, peaches, strawberries, lemons, and avocados, and a number of clovers that are used for animal grazing.

- Areas in the world where farming is threatened by high salinity include the Indus Basin Pakistan where they also face the problem of a rising water table.

The Imperial Valley in California, formerly productive agricultural lands in South America, China, India, Iraq, and many other regions throughout the world are all facing the threat of losing fertile land because of salinization. After the building of the Aswan Dam in Egypt, the Nile River the surrounding fields that had been irrigated successfully for over 5,000 years became threatened by high salinity in the water.

- The main technique used to reclaim land that has developed a high salt content from irrigation is a leaching process.

- This is based on a careful analysis of the soil and the amount of water that must be applied to reach a level of acceptable salt content.
- One problem of leaching is that other nutrients needed by the crops, besides the undesirable salts, may also be leached from the soil.
- Consequently, nutrients often need to be replaced after an area is reclaimed from high salinization.

1) Hinterland Effect

- The development of irrigation schemes in developing countries is often associated with an increase in intensity of human activity in surrounding the scheme.
- This may be due to people moving into the area as a result of the increased economic activity or may be carried out by farmers and their families who are directly engaged in irrigation activities.

In either case typical activities are: more intensive rain fed agriculture; an increase in the number of livestock; and, greater use of forests, particularly for fuel wood. All these activities are liable to increase erosion in the area by decreasing vegetative cover which w have a detrimental effect on the local fertility and ecology as v well contribute to sediment related problems.

- Clearing higher non-irrigated parts of the catchment can res in a rising downstream water table.
- In areas where the groundwater is saline the higher recharge may cause higher salinity levels in the rivers and cause pressure levels in the lower irrigated areas to rise thus impeding leaching.
- This can be prevented by planting deeper rooting crops and trees on the higher lands.
- This phenomenon has been observed in Southeastern Australia.

Mitigating actions can be put in place relatively easily wit forethought as to problems that might arise. For example, allowance should be made for livestock, fuel wood or vegetable gardens within the layout of an irrigation scheme. Alternatively, protection of vulnerable areas may be necessary.

2) River morphology

- The capacity and shape of a river results from its flow, the river bed and bank material, and the sediment carried by the flow.
- A fast flowing river has more energy and is able to carry higher sediment loads (both more and larger particles) than a slow moving river.
- Hence, sediments settle out in reservoirs and in deltas where the flow velocity decreases.
- A river is said to be in regime when the amount of sediment carried by the flow is constant so that the flow is not erosive nor is sediment being deposited.
- The regime condition changes through the year with changing flows.

Reductions in low flows and flood flows may significantly alter the river morphology, reducing the capacity to transport sediment and thereby causing a build up of sediments in slower moving reaches and possibly a shrinking of the main channel. Increasing flows will have the reverse effect.

The sediment balance changes over a short distance, perhaps due to a reservoir or the flushing of a sediment control structure, major changes to the local river morphology are likely to occur.

The release of clear water from reservoirs may result in scour and a general lowering of the bed level immediately downstream of the dam, the reverse of the effect that might be expected with a general reduction in flows.

Changes to the river morphology may effect downstream uses, in particular navigation and abstraction for drinking, industry and irrigation. The river ecology may also be adversely effected.

3) Channel structures

- The susceptibility of channel structures to damage is strongly related to changes in channel morphology and changes in sediment regime.
- Increased suspended sediment will cause problems at intake structures in the form of siltation as well as pump and filtration operation.
- Abstraction structures may become clogged with sediment or left some distance from the water.

- Degradation of the river bed is likely to threaten the structural integrity of hydraulic structures (intakes, headworks, flood protection etc.) and bridges.
- The construction of new structures impacts on nearby structures by changing local flow conditions.

4) Sedimentation

- Irrigation schemes can fail if the sediment load of the water supply is higher than the capacity of the irrigation canals to transport sediment.
- Sediment excluders/extractors at the headworks can mitigate this effect to some extent.
- Sedimentation from within the scheme itself can also be a problem, for example, wind-blown soil filling canals.
- Canal desilting is an extremely costly element of irrigation maintenance and design measures should minimize sediment entry.
- Reservoir siltation shortens the active life of the reservoir and must be given careful consideration at the design stage.

- The increases in erosion due to the economic activity prompted by the reservoir and its access roads needs to be taken into account.
- Upstream erosion prevention, particularly within the project catchment is an important consideration of an EIA.

However, this may not be sufficient to significantly reduce reservoir sedimentation, especially in view of the time delay between soil conservation activities and a reduction in river sediment loads.

5) Estuary Erosion

- Changes to the morphology of river estuaries can result from increased erosion or sedimentation.
- Areas of mangrove may be threatened by changes to the estuary morphology and special studies may be required to determine any adverse impacts.
- Navigation and fishing may also be adversely affected.

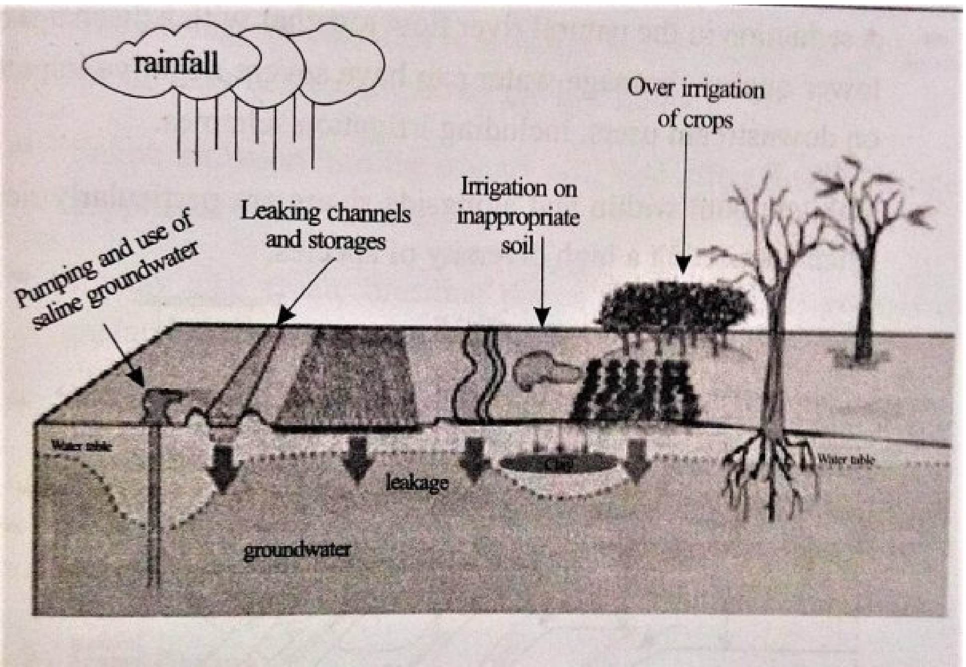


Fig. 2.2 Causes of irrigation salinity

2.4. AGRICULTURAL DRAINAGE AND DOWNSTREAM IMPACTS

2.4.1. Low Flow Regime

- Changes to the low flow regime may have significant negative impacts on downstream users
  - Whether they abstract water (irrigation schemes, drinking supplies) or use the river for transportation or hydro power
- Minimum demands from both existing and potential future users to be clearly identified and assessed in relation to current and future low flows.
- The quality of low flows is also important.
- Return flows are likely to have significant quantities of pollutants.
- Low flows need to be high enough to ensure sufficient dilution of pollutants discharged from irrigation schemes and other sources such as industry and urban areas.
- A reduction in the natural river flow together with a discharge of lower quality drainage water can have severe negative impacts on downstream users, including irrigation schemes.
- Habitats both within and alongside rivers are particularly rich, often supporting a high diversity of species.

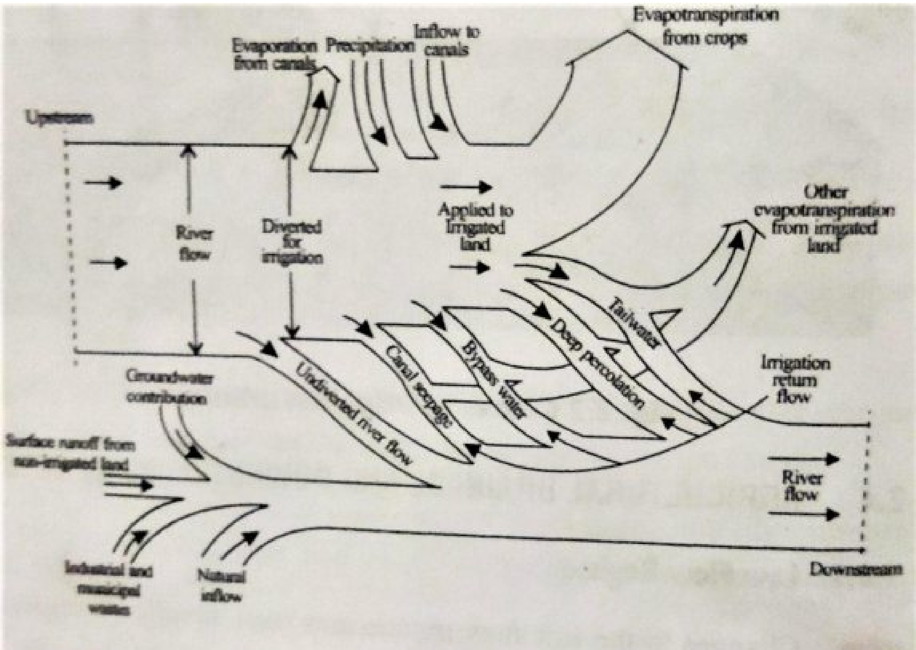


Fig. 2.3 Conceptual diagram of the irrigation return flow system for a given reach of a river system

- Large changes to low flows (+ 20%) will alter micro-habitats, of which wetlands are a special case.
- It is particularly important to identify any endangered species and determine the impact of any changes on their survival.
- Such species are often endangered because of their restrictive ecological requirements.

Example:

An example is the Senegal river downstream of the Manantali Dam where the extent of wetlands has been considerably reduced, fisheries have declined and recession irrigation has all but disappeared.

- The ecology of estuaries is sensitive to the salinity of the water, which may be determined by the low flows.
- Saline intrusion into the estuary will also affect drinking water supplies and fish catches.
- It may also create breeding places for anopheline vectors of malaria that breed in brackish water.

- The operation of dams offers excellent opportunities to mitigate the potential negative impacts of changes to low flows.
- Conceptual diagram of the irrigation return flow system for a given reach of a river system is shown in the figure. 2.3.

2.4.2. Flood Regime

Uncontrolled floods cause tremendous damage and flood control is therefore often an added social and environmental benefit of reservoirs built to supply irrigation water. However, flood protection works, although achieving their purpose locally, increase flooding downstream, which needs to be taken into account.

Radically altered flood regimes may also have negative impacts. Any disruption to flood recession agriculture needs to be studied as it often highly productive but may have low visibility due to the migratory nature of the farmers practicing it. Flood waters are important for fisheries both in rivers and particularly in estuaries.

- Floods trigger spawning and migration and carry nutrients to coastal waters.
- Controlled floods may result in a reduction of groundwater recharge via Blood plains and a loss of seasonal or permanent wetlands.
- Finally, changes to the river morphology may result because of changes to the sediment carrying capacity of the flood waters. This may he either a positive or negative impact.
- As with low flows, the operation of dams offers excellent opportunities to mitigate the potential negative impacts of changes to flood flows.
- The designation of flood plains may also be a useful that allows groundwater recharge and reduces peak discharges downstream. Measure
- This is one of the positive functions of many areas of wetland
- It is important that new irrigation infrastructure does not adversely effect the natural drainage pattern, thus causing localized flooding.

2.4.3. Operation of Dams

- The manner in which dams are operated has a significant impact on the river downstream.

- There is a range of measures that can be undertaken to reduce adverse environmental impacts caused by:
  - changing the hydrological regime that need not necessarily reduce the efficacy of the dam in terms of its main functions, namely:
    - Irrigation
    - Flood protection
    - Hydropower
- Multi-purpose reservoirs offer enormous scope for minimizing adverse impacts.
- In the case of modifying low flows, identifying downstream demands to:
  - Determine minimum compensatory flows, both for the natural and human environment.
  - It is the key requirement and such demands need to be allowed for at the design stage.
- The ability to mimic natural flooding may require modifications to traditional dam offtake facilities.
- In particular, passing flood flows early in the season to enable timely recession agriculture may have the added advantage of passing flows carrying high sediment loads.
- A number of disease hazards are associated with dams, some of which can be minimized, others eliminated by careful operation.
- They include malaria, schistosomiasis and river blindness; this is discussed more fully in the section Human health.
- Rooted aquatic weeds along the shore (or in shallow reservoirs) can be partially controlled by alternate desiccation and drowning.
- In some parts of the world local communities are willing to de-weed reservoirs and use the weeds as animal fodder.

2.4.4. Fall Of Water Table

- A possible advantage of reducing the water table level prior to the rainy season is that it may increase the potential for groundwater recharge

- Lowering the water table by the provision of drainage to irrigation schemes with high water tables brings benefits to agriculture.
- Lowering the groundwater table by only a few metres adversely affects existing users of ground water.
    - Whether it is required for drinking water for humans.
    - And animals or to sustain plant life (particularly wetlands), especially at dry times of the year.
- Springs are fed by groundwater and will finally dry up if the level falls.
- Similarly, low flows in rivers will be reduced. Any changing availability of groundwater for drinking water supply needs be assessed in terms of the economics of viable alternatives.
- Poor people may be disproportionately disadvantaged.
- They may also be forced to use sources of water that carry health risks, particularly guinea worm infection and schistosomiasis.
- In parts of Asia there are indications that lowering the ground level may favour the sand fly which may be vectors for diseases such as visceral leishmaniasis.

Saline intrusion along the coast is a problem associated with a falling groundwater level with severe environmental and economic consequences.

A continued reduction in the water table level (groundwater mining), apart from deleting an important resource, may lead to significant land subsidence with consequent damage to structures and difficulties in operating hydraulic structures for flood defense, drainage and irrigation.

Todd (1980) gives an example of a drop in ground level of over 3 m associated with a 60 m drop in groundwater level over a period of 50 years in the Central Valley, California. Vulnerable areas are those with compressible strata, such as clays and some fine-grained sediments.

Any structural change in the soil is often irreversible. The ground level can fall with a lowering of the water table if the soils are organic. Peats shrink and compact significantly on consequent lowering of the ground level by several metres.

Particular care is needed in the drainage of tropical coastal draining, with swamp regions as the FeSO4 soils can become severely acidic resulting in the formation of "cat-clays".

A number of negative consequences of a falling water table are irreversible and difficult to compensate for, eg salt water intrusion and land subsidence, and therefore groundwater abstraction needs controlling either by licensing, other legal interventions or economic disincentives.

Over-exploitation of groundwater, or groundwater mining, will have severe consequences, both environmental and economic, and should be given particular importance in any EIA.

2.4.5. Rise of Water Table

- In the long-term, one of the most frequent problems of irrigation schemes is the rise in the local water-table (water logging).
- Low irrigation efficiencies (as low as 20 to 30% in some areas) are one of the main causes of rise of the water table. The International Commission on Irrigation and Drainage (ICID) recommendation to increase field application efficiency to even 50% could significantly reduce the rise in the groundwater.
- The groundwater level rise can be spectacularly fast in flat areas where the water table has a low hydraulic gradient. The critical water table depth is between 1.5 and 2 m depending on:
    - Soil characteristics
    - The potential evapotranspiration rate
    - The root depth of the vegetation/crops
- Groundwater rising under capillary action will evaporate, leaving salts in the soil.
- The problem is of particular concern in arid and semi-arid areas with major salinity problems.
- A high water table also makes the soil difficult to work.

2.5. AGRICULTURE VERSUS URBAN IMPACTS

2.5.1. Introduction

Urbanization has been strengthened by the rapid growth in the world economy and in the proportion of gross world product and of workers in industrial and service enterprises.

Globally, agriculture has met the demands of this rapidly growing urban population, including food that is more energy, land, water and greenhouse gas emission-intensive. But hundreds of millions of urban dwellers suffer under-nutrition. So the key issues with regard to agriculture and urbanization are whether the growing and changing demands for agricultural products from growing urban populations can be sustained while at the same time underpinning agricultural prosperity and reducing rural and urban poverty. To this are added the need to reduce greenhouse gas emissions and to build resilience in agriculture and urban development to climate change impacts.

The paper gives particular attention to low- and middle-income nations since these have more than three-quarters of the world's urban population and most of its largest cities and these include nations where issues of food security are most pressing.

2.5.2. Urbanization-Food And Agriculture

- Urbanization brings major changes in demand for agricultural products, both from increases in urban populations and from changes in their diets and demands.
- This has brought and continues to bring major changes in how demands are met and with the farmers, companies, corporations, and local and national economies who benefit (and who lose out).
- It can also bring major challenges for urban and rural food security.
- It is worth considering likely changes at two different ends of the spectrum in terms of nations' economic success.

It would be expected that in nations with successful economies and rapid urbanization, there will be rising demands for meat, dairy products, vegetable oils and luxury foods, and this implies more energy-intensive production and, for many nations, more imports.

Urbanization is also associated with dietary shifts towards more processed and pre-prepared foods, in part, in response to long working hours and, for a proportion of the urban population, with reduced physical activity. Of course, food demand will also be influenced by how this economic growth changes the distribution of income.

How will this influence agriculture around or close to growing urban centres will also vary; it would be expected that a growing role of supermarkets (and transnational corporations) in food sales would bring changes in all aspects of the food chain.

- This would include favouring larger agricultural producers and major changes in the distribution and marketing of food.
- This also means a shift in employment within the food system, with fewer people working in agriculture and more working in transport, wholesaling, retailing, food processing and vending.

The high proportion of urban households with electricity in middle-income and some low-income nations also means far more households with refrigeration and this supports shifts in food demand.

2.5.3. The Implications of Urbanization for Food Production

1. Urbanization and the loss of agricultural land

Urban expansion inevitably covers some agricultural land while changes in land values and land markets around cities often result in land left vacant as the owners anticipate the gains they will make from selling it or using it for non-agricultural uses.

In most urban areas in low- and middle-income nations, the absence of any land-use plan or strategic planning framework to guide land-use change means that urban areas expand haphazardly. This expansion is determined by where different households, enterprises and public sector activities locate and build, legally or illegally. In most instances, there is little effective control over land-use conversions from agriculture to non-agricultural uses.

2. Urbanization - land intensive diets

- Dietary changes can increase pressures on agricultural systems, with increasing meat consumption the most important example of this.
- Diets differ between rural and urban areas, and meat consumption per capita is higher in urban areas.

- But a review of the relationship between urbanization and food prices suggests that this may be the result of higher urban incomes and not urbanization or urban living.

3. Urban Agriculture

Hundreds of millions of urban dwellers rely on urban agriculture for part of their food consumption or income as they sell high-value crops or non-food crops or raise livestock for sale, growing crops and or keeping livestock.

- The diversity among urban farmers-for instance, in Dar es Salaam, they included:
    - Professionals
    - Teachers
    - Government officials
    - Urban planners
    - Students
    - Casual laborers
    - The unemployed
    - Part-time workers
- Urban and peri-urban agriculture has a significant role in food and nutrition security in most low-income nations.
- In many cities it is more difficult for the urban poor to get access to the land needed for agriculture.

4. Urban Change, Food Demand And Rural-Urban Linkages

Perhaps surprisingly, the possible negative consequences of urbanization for agriculture are often stressed more than its positive consequences. Since urbanization is generally the result of a growth in non-food producers and their average incomes, it often provides growing demands for agricultural products and for higher value products that bring benefits to farmers.

Urbanization may affect food demand and supply needs to take into account the complexity of the linkages between rural and urban people and enterprises, and to recognize the capacity of food producers to adapt to changes in urban demand.

5. Urbanization and climate change

The multiple rural-urban linkages noted above mean that climate change impacts on agriculture will affect urban areas (for instance, influencing food availability and price), and climate change impacts on urban areas will affect agriculture (for instance, disruptions in urban demand for agricultural produce and disruptions to the goods and services provided by urban enterprises to agriculture and to rural households).

Many rural households would also suffer if remittances from family members working in urban areas were disrupted by climate change-related impacts.

Hundreds of millions of urban dwellers are at risk from the direct and indirect impacts of current and likely future climate change- for instance, from more severe or frequent storms, floods and heat waves, constraints on fresh water and food supplies, and higher risks from a range of waterborne, foodborne and vector borne diseases.

Conclusion

Urbanization is often considered as having negative impacts on agriculture-for instance, from the loss of agricultural land to urban expansion and an urban bias in public funding for infrastructure, services and subsidies. But the scale of urban poverty suggests little evidence of urban bias for much of the urban population-and clearly, urban demand for agricultural products has great importance for rural incomes.

Agricultural producers and rural consumers also rely on urban-based enterprises in a wide range of goods and services- including access to markets. So the key issue is whether the growing and changing demands for food (and other agricultural products) that an increasingly urbanized population and economy brings can help underpin agricultural and rural prosperity and sustainability within a global decline in agricultural land area per person and water constraints.

To this is now added the need to adapt to the impacts of climate change that have the potential to disrupt agriculture and urban demand, and the enterprises that provide products and consumer services to rural populations.

TWO MARK QUESTIONS AND ANSWERS

Unit II- Environmental Impacts

1. What are the indirect Environmental impacts of Irrigation development and watersheds?

a. Waterlogging

b. Salination

c. Ecological damage

d. Socioeconomic impacts

2. What are the direct Environmental impacts of Irrigation development and watersheds?

a. Reduction in downstream river flow,

b. Increased evaporation in the irrigated area,

c. Increased level in the water table as groundwater recharge in the area is increased and flow increased in the irrigated area.

d. Irrigation has immediate effects on the provision of moisture to the atmosphere, inducing atmospheric instabilities and increasing downwind rainfall, or in other cases modifies the atmospheric circulation.

3. List the adverse Environmental impacts of Irrigation development and watersheds?

a. Reduced river flow

b. Increased groundwater recharge, waterlogging, soil salinity

c. Reduced downstream river water quality

d. Lost land use opportunities

e. Affected downstream water users

f. Groundwater mining with wells, land subsidence

4. Define the Mechanized agriculture.

Mechanized agriculture is the process of using agricultural machinery to mechanize the work of agriculture, greatly increasing farm worker productivity.

5. Write the steps involved in the mechanization of agriculture.

a. The importance of machines and tools in sustainable agriculture

b. Holistic View of Sustainability

c. Moving on from subsistence farming

d. Intensification without degradation

e. Fitting the tools to the needs

f. Sustainable mechanization

6. What are the remedies of deposition in irrigation systems?

a. Drip irrigation is a technique that can be used in areas where the ground water level is high and in danger of suffering from a high salt content.

b. Where salinization is a problem to plants, enough water can be added to the irrigation process to leach salts away from plant roots.

c. When the danger of salinization is to the water table, it is necessary to add drainage to the irrigation system away from the table.

7. What is estuary erosion? Give an example.

Changes to the morphology of river estuaries can result from increased erosion or sedimentation.

Example:

Areas of mangrove may be threatened by changes to the estuary morphology and special studies may be required to determine any adverse impacts. Navigation and fishing may also be adversely affected.

8. What is the impact of Urbanization on food and agriculture?

- Urbanization brings major changes in demand for agricultural products, both from increases in urban populations and from changes in their diets and demands.
- This has brought and continues to bring major changes in how demands are met and with the farmers, companies, corporations, and local and national economies who benefit (and who lose out).
- It can also bring major challenges for urban and rural food security.

9. Write the implications of urbanization for food production.

a. Urbanization and the loss of agricultural land

b. Urbanization- land intensive diets

c. Urban agriculture

d. Urban change, food demand and rural-urban linkages

e. Urbanization and climate change

10. What is the impact of flood regime on irrigation?

Uncontrolled floods cause tremendous damage and flood control is therefore often an added social and environmental benefit of reservoirs built to supply irrigation water. However, flood protection works achieving their purpose locally, increase flooding downstream, which needs to be taken into account.

REVIEW QUESTIONS

1. What are the Main problems resulting in the non-sustainability of irrigation and drainage schemes? And give the appropriate mitigation measures.
2. Explain various adverse impacts of Irrigation development and watersheds with the help of case studies.
3. Discuss the role of mechanization in agricultural sustainability.
4. Elaborate the Erosion Problems and remedies of deposition in irrigation systems with suitable examples.
5. Explain the Agricultural drainage and downstream impacts with the help of a neat sketch.

UNIT III

CLIMATE CHANGE

Global warming and changing environment - Ecosystem changes Changing blue-green-grey water cycles – Water scarcity and water shortages - Desertification.

3.1. GLOBAL WARMING AND CHANGING ENVIRONMENT

Global warming is a long-term rise in the average temperature of the Earth's climate system, an aspect of climate change shown by temperature measurements and by multiple effects of the warming. Climate change can disrupt food availability, reduce access to food, and affect food quality.

Example:

Projected increases in temperatures, changes in precipitation patterns, changes in extreme weather events, and reductions in water availability may all result in reduced agricultural productivity.

- The gases that radiate heat also known as greenhouse gases absorb the energy radiated out by the Earth and reflect a part of it back to Earth.
- Of all the energy that the Earth receives from the Sun, a part of it around 26% is reflected back to space by the atmosphere and clouds.
- Some part of it is absorbed by the atmosphere, around 19%
- The greenhouse gases responsible for the greenhouse effect are
    - Water Vapour
    - Carbon Dioxide
    - Methane
    - Ozone

3.1.1. Causes And Effects Of Global Warming

1. Human Impacts

Atmospheric greenhouse gases trap some of the outgoing energy, retaining heat.

2. Natural Impacts

Change in sun's energy output Volcanoes Water Vapor Clouds

3. Greenhouse Gases

i. CO_2 , Methane. Nitrous oxide, Ozone and Fluorinated compounds.

ii. Since industrial revolution, atmospheric concentrations of carbon dioxide increased 30%, methane more than doubled nitrous oxide risen by 15%.

4. Effects

- Ice is melting worldwide, especially at the Earth's poles.
- This includes mountain glaciers, ice sheets covering Wo Antarctica and Greenland, and Arctic sea ice.
- In Montana's Glacier National Park the number of glaciers declined to fewer than 30 from more than 150 in 1910.
- Much of this melting ice contributes to sea-level rise. Global sea levels are rising 0.13 inches (3.2 millimeters) a year, and the rise is occurring at a faster rate in recent years.
- Rising temperatures are affecting wildlife and their habitats. Vanishing ice has challenged species such as the Adélie penguin in Antarctica, where some populations on the western peninsula have collapsed by 90 percent or more.
- As temperatures change, many species are on the move. Some butterflies, foxes, and alpine plants have migrated farther north or to higher, cooler areas.
- Precipitation (rain and snowfall) has increased across the globe, on average. Yet some regions are experiencing more severe drought, increasing the risk of wildfires, lost crops, and drinking water shortages.
- Some species including mosquitoes, ticks, jellyfish, and crop pests are thriving. Booming populations of bark beetles that feed on spruce and pine trees, for example, have devastated millions of forested acres in the U.S.

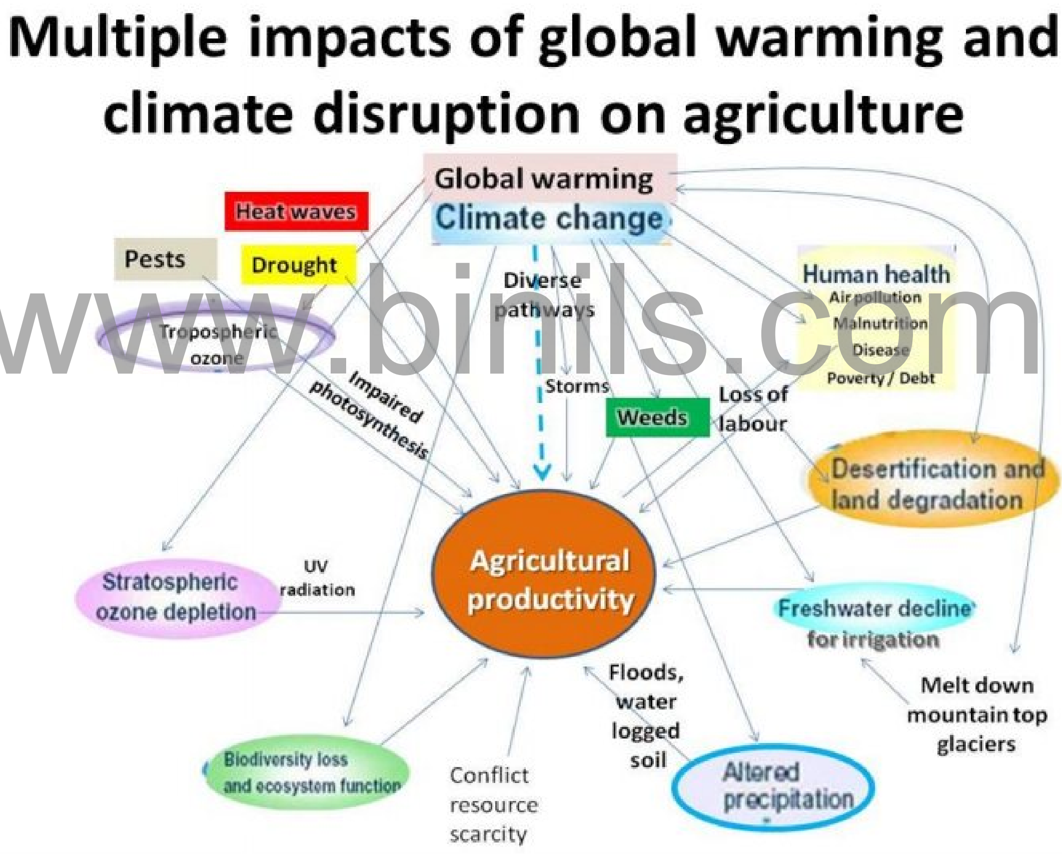
3.1.2. Global Warming Impacts On Agriculture

Global warming is projected to have significant impacts on conditions affecting agriculture, including temperature, precipitation and glacial runoff.

- These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals.

- Rising carbon dioxide levels would also have effects, both detrimental and beneficial, on crop yields.
- Assessment of the effects of global climate changes on agriculture might help to properly anticipate and adapt farming to maximize agricultural production.
- Agricultural productivity is sensitive to two broad classes of climate-induced effects.

    1. Direct effects from changes in temperature, precipitation or carbon dioxide concentrations.
    2. Indirect effects through changes in soil moisture and the distribution and frequency of infestation by pests and diseases.



3.1.3. Agriculture Impacts of Global Warming

1. Carbon sequestration in soils.
2. Agriculture as carbon cap and storage.
3. Local food systems and greenhouse gas emissions.
4. Industrial agriculture's huge carbon footprint.
5. Greenhouse gas emissions from fertilizer and pesticide use.

6. Land use changes and agriculture.

The vulnerability of production to climate change depends not only on the physiological response of the affected plant, but also on the ability of the affected socioeconomic systems of production to cope with changes in yield, as well as with changes in the frequency of droughts or floods.

- The adaptability of farmers in India is severely restricted by the heavy reliance on natural factors and the lack of complementary inputs and institutional support systems.
- The loss in net revenue at the farm level is estimated to range between 9% and 25% for a temperature rise of 2 °C to 3.5 °C.
- The scientists also estimated that a 2°C rise in mean temperature and a 7% increase in mean precipitation would reduce net revenues by 12.3% for the country as a whole.
- Agriculture in the coastal regions of Gujarat, Maharashtra, and Karnataka is found to be the most negatively affected.
- Small losses are also indicated for the major food-grain producing regions of Punjab, Haryana, and western Uttar Pradesh.
- On the other hand, West Bengal, Orissa, and Andhra Pradesh are predicted to benefit to a small extent from warming.

3.2. ECOSYSTEM CHANGES

The term "ecosystem services" denotes the economically valuable services generated by natural ecosystems as by-products of their normal functioning. The notion centers on natural ecosystems capacity to process matter their ability to alter the physical, chemical, or biological characteristics of the materials that pass through them.

3.2.1. Ecosystem Changes on Agriculture

- The fundamental source of energy in almost all ecosystems is radiant energy from the Sun.
- The energy of sunlight is used by the ecosystem's autotrophic, or self-sustaining, organisms.

- Consisting largely of green vegetation, these organisms are capable of photosynthesis i.e., they can use the energy of sunlight to convert carbon dioxide and water into simple, energy-rich carbohydrates.
- The autotrophs use the energy stored within the simple carbohydrates to produce the more complex organic compounds, such as proteins, lipids, and starches, that maintain the organisms' life processes.
- The autotrophic segment of the ecosystem is commonly referred to as the producer level.

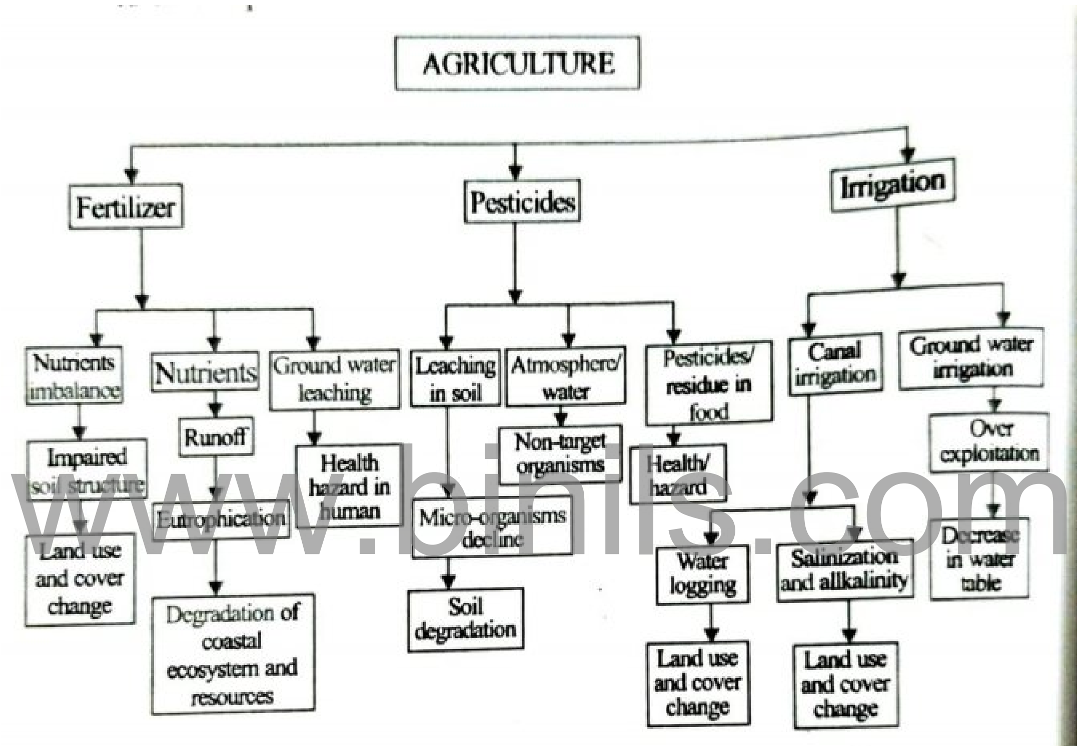


Fig. 3.2 Ecosystem Changes in Agriculture

- The natural environment provides essential inputs to agriculture, many of which are uncounted and unrecorded

The essence of plant agriculture is the capture of public environmental goods-sunlight, wind, and rain and their conversion into appropriable private goods such as crops. Daily organizes these services into the following categories:

1. Purification of air and water.
2. Mitigation of droughts and floods.
3. Generation and preservation of soils and renewal of their fertility.
4. Detoxification and decomposition of wastes

5. Pollination of crops and natural vegetation
6. Dispersal of seeds
7. Cycling and movement of nutrients
8. Control of the vast majority of potential agricultural pests
9. Maintenance of biodiversity
10. Stabilization of the climate
11. Moderation of weather extremes and their impacts
12. Provision of aesthetic beauty and intellectual stimulation that lift the human spirit.

3.2.2. Ecosystem Services Used By Agriculture

1. Pollination of Crops and Natural Vegetation

- About one-third by value of the crops, fruits, and vegetables produced in the world require pollination.
- Historically, "wild" populations of pollinators (bees, other insects, bats or birds) have carried out this function.
- Populations of many of these pollinators declined sharply, to the point that replacements have been needed.
- There is now an active market in the rental of bees, the most widely used insect pollinator.
- Beekeepers can increase their income by renting hives of bees to farmers at pollination periods apple growers and alfalfa growers make extensive use of these services.

2. Nutrient Cycling

- Natural ecosystems break down crop and animal wastes and release the nutrients in these to restore the fertility of farm lands.
- They maintain soil fertility and also avoid the runoff of wastes into water bodies, preserving their purity and value of humans and other animals.

3. Pest control

- Control of pests is one of the main problems facing farmers.
- A significant fraction of crops, of the order of one-quarter to one-half, may be lost to pests without extensive intervention by the farmer.
- Pests are just insects or animals that eat a crop designated for human consumption, and are naturally attracted to huge concentrations of their foodstuffs.
- Most pests have natural enemies that control their populations in natural ecosystems. In agricultural systems, however, these predators may have been eliminated.

Example:

The predators of many insect pests may be insects that are eliminated by the very insecticides aimed to kill the pests.

4. Carbon sequestration and stabilization of the climate

- Trees and other growing vegetation sequester carbon, as does soil.
- Decay of vegetable matter releases carbon, as does tilling soil. So farming practices can affect the carbon cycle both positively and negatively.
- This is now the focus of much political negotiation concerning the future of the Kyoto Protocol and the various flexibility mechanisms that have been proposed to lessen the costs of implementation to industrial countries.

5. Purification of Air and Water; Detoxification and Decomposition of wastes

- It is now increasingly recognized that wetlands can play a major role in removing a range of pollutants from stream water and so in preventing eutrophication by nitrates and phosphates.
- Retention or restoration of wetlands is therefore a mechanism through which farms may contribute to the resolution of some of the environmental problems they create.

6. Mitigation of droughts and floods

- We are increasingly recognizing that many floods are caused by human alterations to the landscape that have reduced the ability of natural ecosystems to buffer irregular rainfalls.

- Forests, wetlands, and floodplains have traditionally preformed this function, and the destruction of the former two and the canalization of rivers have destroyed natural flood control systems.
- Land management practices by farmers can to some degree restore these functions.

3.3. CHANGING BLUE-GREEN-GREY WATER CYCLES

Water is available from two coupled natural systems the green and blue water systems and one human source: grey water, broadly defined.

3.3.1. Water Cycles

1. Blue Water

"Blue water" is the amount of rainfall that enters lakes, rivers and groundwater.

- This is the main source of water that we use and manage for industrial, domestic and irrigation purposes.
- Only 30-35% of all water within the hydrological cycle is blue water.
- Saturated storage in streams, lakes, groundwater, wetlands, glaciers, and snowpack (blue reservoir).
- SW and GW fluxes in and out of a landscape hydrologic unit (blue fluxes).

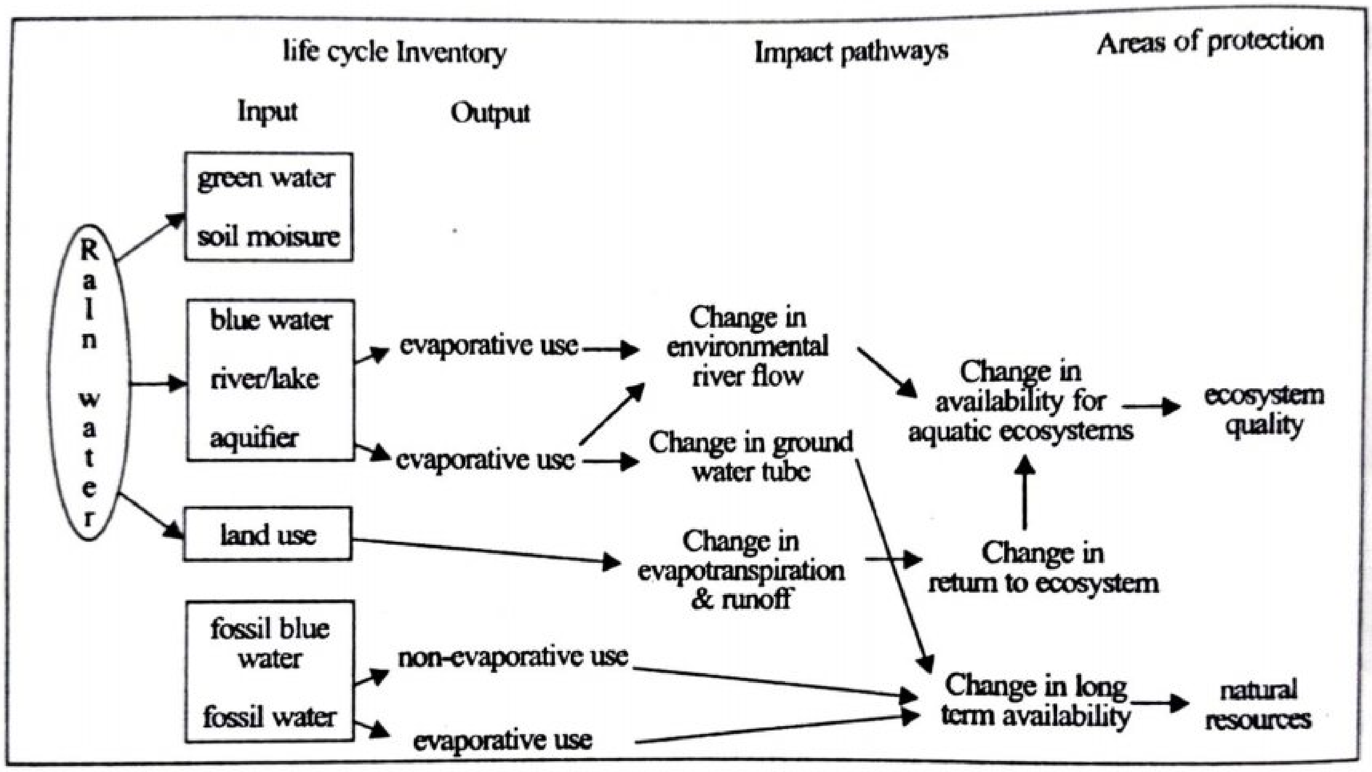


Fig. 3.3 Basic flow of blue, green and grey water cycle

2. Green Water

"Green water" is the amount of rainfall that is either intercepted by the vegetation, or enters the soil and is picked up by plants and evapotranspiration back into the atmosphere. Some 65% of all rain water is cycled through the green water cycle and is the water source for rained agriculture.

- Soil moisture in unsaturated zone (green reservoir).
- Evapotranspiration (ET) flux to the atmosphere (green flux) from the partition of undifferentiated precipitation (P) influx. Land-atmosphere fluxes of the hydrologic cycle (P. ET): (green fluxes)

3. Grey Water

"Grey water" can be used to supplement your farm's water supply. In the home, it can be used for laundry and toilet flushing. Outside of the home, greywater can be used to water garden plants (but not vegetables), wash machinery and vehicles, and keep dust down around the house.

4. Waste Water

- Wastewater generated from domestic activities such as laundry, dishwashing, and bathing, which can be recycled for uses such as irrigation. Excludes sewage (also known as black water).
- Water stored in, or flowing through, human water infrastructure.

Critical Limits for Blue and Green Water Availability

Critical values for the availability of Blue and Green Water were determined by Rock Strom et al 2006 for a wide range of countries m^3 /capita/year..

They showed that countries with < 1000 m^3/capita/year of Blue and <1300 m^3/capita of Green water will have significant water challenges by 2050. In the three figures below, it is shown how much of the global population will have blue water shortages, green water shortages or both.

3.3.2. Partitioning Rainwater Into Blue And Green, White And Grey Water

This flowchart shows the % of rainfall that moves through the different hydrological systems and how much is then used for rained and irrigated agriculture.

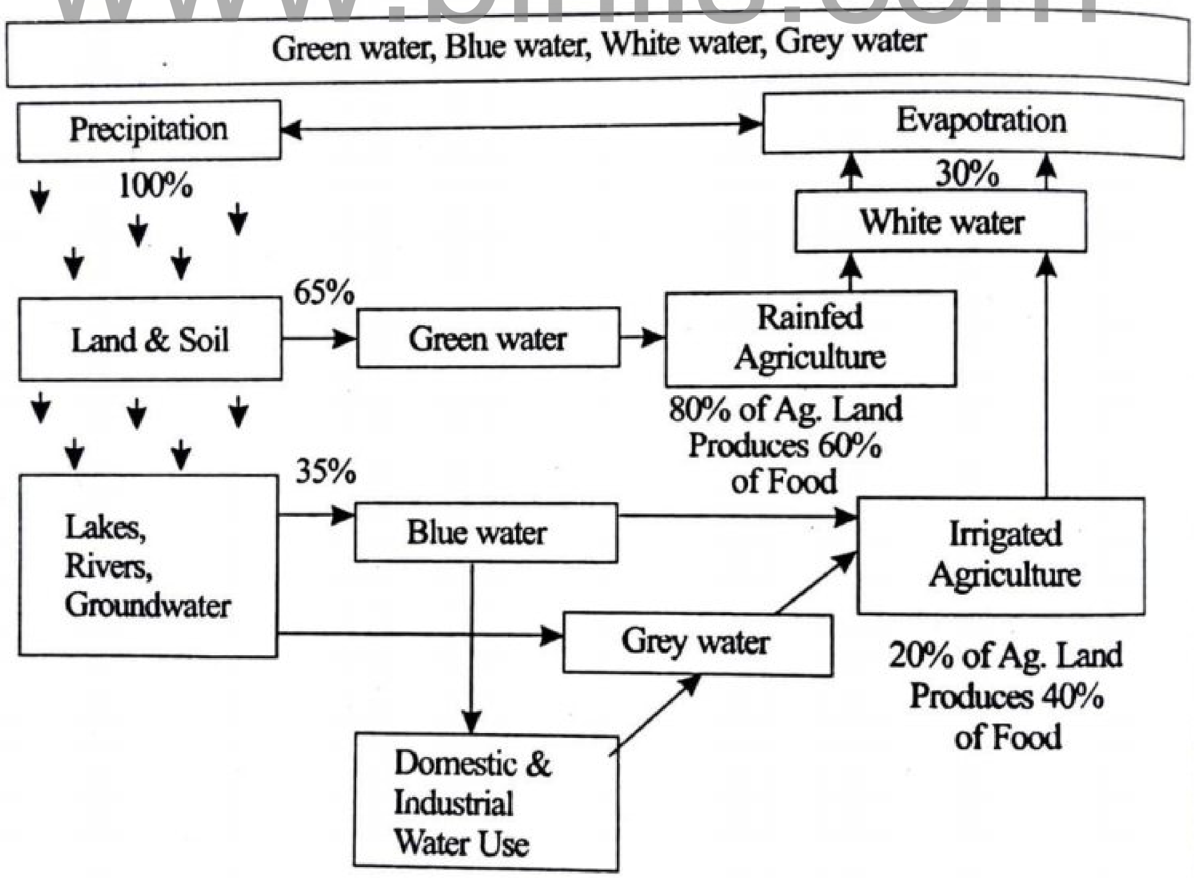


Fig. 3.4 Changing blue, green and grey water cycle changes

3.4. WATER SCARCITY AND WATER SHORTAGES

- Water scarcity has a huge impact on food production.
- Without water people do not have a means of watering their crops therefore, to provide food for the fast-growing population.

According to the International Water Management Institute, agriculture, which accounts for about 70% of global water withdrawals, is constantly competing with domestic, industrial and environmental uses for a scarce water supply.

3.4.1. Effective Methods Of Water Management

In attempts to fix this ever growing problem, many have tried to form more effective methods of water management.

1. Agriculture Uses Majority Of Available Freshwater

- The sad thing is that about 60% of this water gets wasted due to inefficient agriculture methods and leaky irrigation systems.
- Pesticides and fertilizers are washed away in rivers and lakes that further affect human and animal population

2. Effects On Environment

The resulting water overuse that is related to water scarcity, often located in areas of irrigation agriculture, harms the environment in several ways including increased salinity, nutrient pollution, and the loss of floodplains and wetlands.

3. Agriculture is Both a Victim And a Cause of Water Scarcity

Climate change will have significant impacts on:

- Agriculture by increasing water demand.
- Limiting crop productivity.
- Reducing water availability in areas where irrigation is most needed or has a comparative advantage.

The initiative will focus on a range of important thematic areas to address issues of water scarcity in agriculture, including the sustainable improvements of:

- Agricultural water productivity, cutting across all agricultural subsectors, from crop to livestock production.

- Aquaculture and agroforestry, based on introduction of best practices in soil and water management,
- Complementary afforestation, and sustainable grazing management.

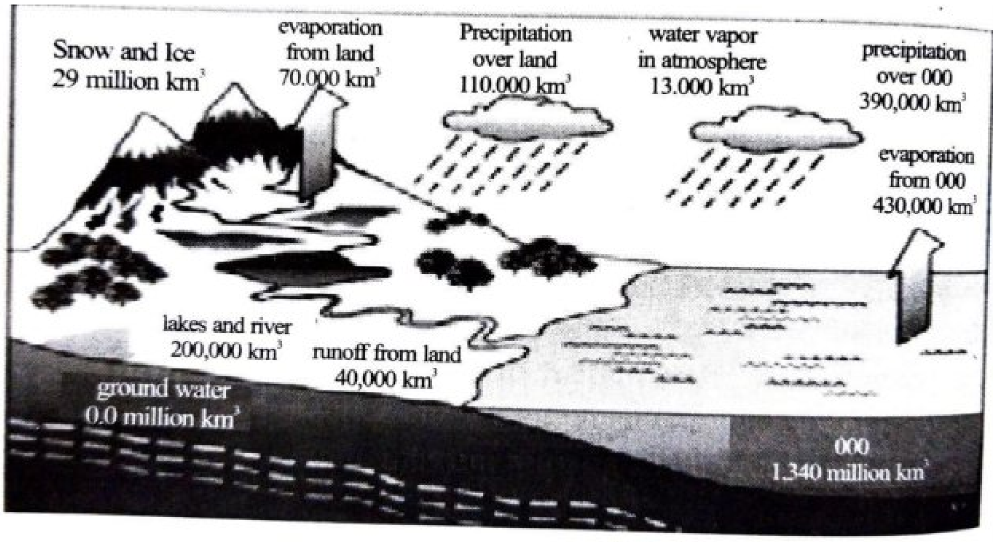


Fig. 3.5 Water scarcity on agriculture

- Modernization and development of multipurpose and climate proofing irrigation infrastructure are considered also as important action areas to improve the efficiency of water use in agriculture while adapting to climate change impacts.

- Integrated landscape approaches may play critical roles in regulating:
    - Rainfall
    - Other climate patterns.
    - Influencing water yields.
    - Sediment levels
    - Water quality
    - Increasing water availability for agricultural use.
- The reuse of treated wastewater for food production while ensuring food safety and prevention and controlling of water pollution from agricultural activities.

3.4.2. Solutions To Water Scarcity

1. Recharging aquifers/groundwater

According to a 2012 UN report on The World's Water, groundwater retraction has tripled in the past five decades because of industrial and agricultural uses. For this reason, governments and organizations can undertake measures to recharge aquifers or groundwater by undertaking projects aimed at infiltrating or injecting excess surface water into the underground aquifers. This may include aspects such as restoration of watersheds and wetlands and the practice of green infrastructure which aims at reducing impervious surfaces.

2. Water re-use and Effective Water Treatment Technologies

Water re-use strategies can help alleviate water scarcity in cities, schools, hospitals, and industries. The main strategies here include reuse and recycling and the use of zero-liquid discharge systems. Zero-liquid discharge system is whereby the water within a facility is constantly treated, used and reused again and again without being discharged into the sewer or other external water systems. Water re-use or greywater can hence save a lot of fresh water for human consumption in times of water shortage and water stress.

3. Desalination

Desalination is the treatment of saline waters. The treatment process aims at obtaining fresh drinking water from the salty ocean waters or groundwater with high salt concentrations that make them unsuitable for human consumption. Nations should invest in desalination technologies as a means of attaining a more reliable water resource system to meet the ever rising water demands.

4. Water Management

Water management by the use of regulations and policies can help reduce water scarcity. The regulations and policies can address the water-related problems including aspects such as water reuse, water resource management, water rights, industrial water use, wetland restoration, domestic water supplies, water pollution, and others.

5. Infrastructure Repair and Maintenance

One of the key ways of solving the problem of water scarcity can be through infrastructure repair and maintenance of water channels. Leaking pipes and sewage systems normally lead to water wastage and contamination respectively. If these infrastructures are left unattended to over time, the cumulative effects can create water shortages. Millions of liters of water are lost yearly in various regions of the world owing to leakages and sewer contamination, creating water shortages.

6. Water Conservation

Water conservation is one of the leading ways to grow out of water scarcity. It is an indirect approach to reducing water demands and is it usually critical in maintaining the supply-demand balance. During droughts and in densely populated regions, for instance, water conservation efforts ensure there is a supply-demand balance.

3.5. DESERTIFICATION

Progressive destruction or degradation of arid or semiarid lands to desert. Desertification leads to the conversion of range lands or irrigated croplands to desert. Desertification is characterized by de-vegetation, depletion of ground water, salination and soil erosion.

A desert is a landscape or region that receives almost no precipitation. Deserts are defined as areas with an average annual precipitation of less than 250 millimeters per year. It occupies about 17% of the earth's surface. Deserts are characterized by hot days & cold nights. The deserts of the world are mainly located in the South-western

United States, Mexico, North America, Asia (Thar, Gobi, Tibet) & west Asia. Deserts are characterized by scanty flora & fauna. Soils of deserts often have abundant nutrients but little or no organic matter.

- Around 80% of the agricultural land in the arid and semi-regions are converted into desert.
- Around 600 million people are threatened by desertification. Desertification on Agriculture is shown in figure 3.6.

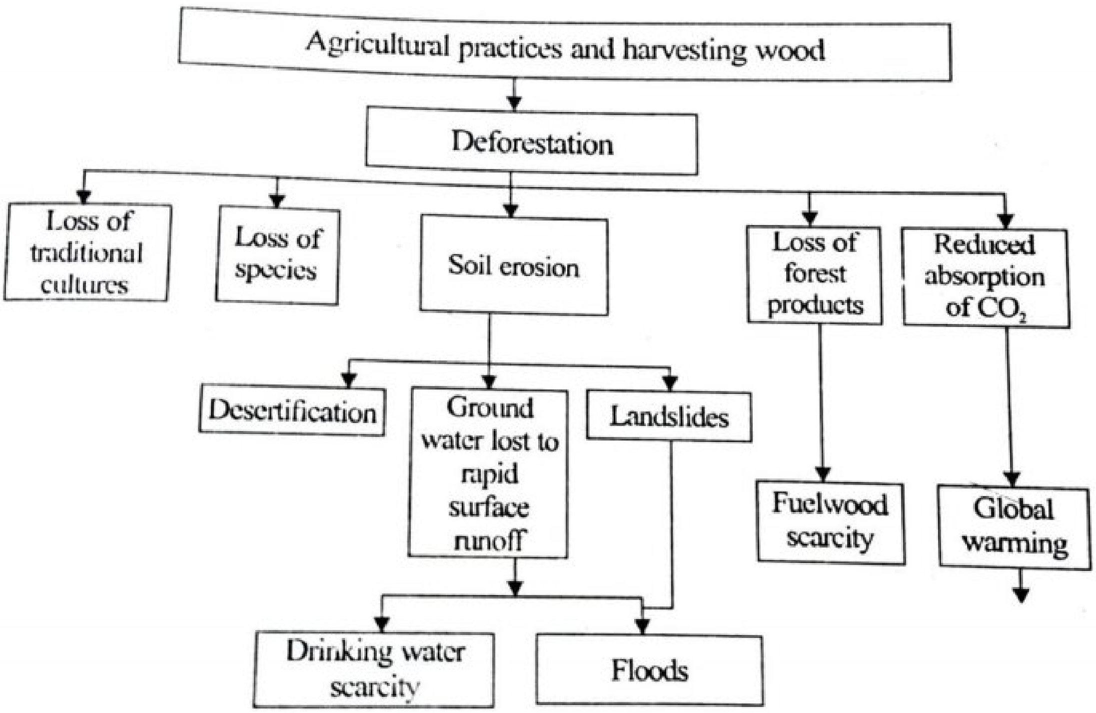


Fig. 3.6 Flow chart of desertification on agriculture

3.5.1. Causes Of Desertification

1. **Deforestation**

- ➢ The process of denuding and degrading a forest land initiates a desert.
- ➢ If there is no vegetation to hold back the rain water, soil cannot soak and groundwater level do not increase.
- ➢ This also increases, soil erosion, loss of fertility.

2. **Over Grazing**

- ➢ The increase in cattle population heavily grazes the grass land or forests and as a result denudes the land area.
- ➢ The denuded land becomes dry, loose and more prone to soil corrosion and leads to desert.

3. **Water Management**

Over utilization of ground water, particularly in the coastal regions, is resulting in saline water intrusion into aquifers which is unfit for irrigation.

4. Mining and Quarrying

These activities are also responsible for loss of vegetal cover and denudation of extensive land area leading to desertification.

5. Climate Change

Formation of deserts may also take place due to climate change. ie., failure of monsoon, frequent droughts.

6. Pollution

Excessive use of fertilizers and pesticides and disposal of toxic water into the land also leads to desertification.

3.5.2. Effects Of Desertification

1. Farming becomes next to Impossible

- If an area becomes a desert, then it's almost impossible to grow substantial crops there without special technologies.
- This can cost a lot of money to try and do, so many farmers will have to sell their land and leave the desert areas.

2. Hunger

- Without farms in these areas, the food that those farms produce will become much scarcer, and the people who live in those local areas will be a lot more likely to try and deal with hunger problems.
- Animals will also go hungry, which will cause even more of a food shortage.

3. Flooding

- Without the plant life in an area, flooding is a lot more eminent. Not all deserts are dry; those that are wet could experience a lot of flooding because there is nothing to stop the water from gathering and going all over the place.
- Flooding can also negatively affect the water supply, which we will discuss next.

4. Poor Water Quality

- If an area becomes a desert, the water quality is going to become a lot worse than it would have been otherwise.

- This is because the plant life plays a significant role in keeping the water clean and clear; without its presence, it becomes a lot more difficult for you to be able to do that.

5. Overpopulation

- When areas start to become desert, animals and people will go to other areas where they can actually thrive.
- This causes crowding and overpopulation, which will, in the long run, end up continuing the cycle of desertification that started this whole thing anyway.

6. Poverty

- All of the issues that we have talked about above (related to the problem of desertification) can lead to poverty if it is not kept in check.
- Without food and water, it becomes harder for people to thrive, and they take a lot of time to try and get the things that they need.

3.5.3. Solutions For Desertification

1. Policy Changes Related to How People can Farm

In countries where policy change will actually be enforced on those in the country, policy change related to how often people can farm and how much they can farm on certain areas could be put into place to help reduce the problems that are often associated with farming and desertification.

2. Policy Changes to other Types of Land Use

If people are using land to get natural resources or they are developing it for people to live on, then the policies that govern them should be the ones that will help the land to thrive instead of allowing them to harm the land further. The policy changes could be sweeping or they could be depending on the type of land use at hand.

3. Education

In developing countries, education is an incredibly important tool that needs to be utilized in order to help people to understand the best way to use the land that they are farming on. By educating them on sustainable practices, more land will be saved from becoming desert.

4. Technology Advances

In some cases, it's difficult to try and prevent desertification from happening. In those cases, there needs to be research and advancements in technology that push the limits of what we currently know. Advancements could help us find more ways to prevent the issue from becoming epidemic.

5. Putting Together Rehabilitation Efforts

There are some ways that we can go back and rehabilitate the land that we've already pushed into desertification; it just takes some investment of time and money. By putting these together, we can prevent the issue from becoming even more widespread in the areas that have already been affected.

6. Sustainable practices to prevent desertification from happening

There are plenty of sustainable practices that can be applied to those acts that may be causing desertification. By adding these to what we should be doing with land, we can ensure that we don't turn the entire world into a desert.

TWO MARK QUESTIONS AND ANSWERS

Unit III-Climate Change

1. What are the causes of global warming?

i. **Human Impacts** - Atmospheric greenhouse gases trap some of the outgoing energy, retaining heat.

ii. **Natural Impacts** - Change in sun's energy output Volcanoes Water Vapor Clouds

2. List the greenhouse gases responsible for the greenhouse effect.

i. Water Vapour

ii. Carbon Dioxide

iii. Methane

iv. Ozone

3. What are the Agriculture Impacts of Global Warming?

★ Carbon sequestration in soils

★ Agriculture as carbon cap and storage

★ Local food systems and greenhouse gas emissions

- ★ Industrial agriculture's huge carbon footprint
- ★ Greenhouse gas emissions from fertilizer and pesticide use
- ★ Land use changes and agriculture

4. Enlist the ecosystem services used by agriculture.

- ★ Pollination of crops and natural vegetation
- ★ Nutrient cycling
- ★ Pest control
- ★ Carbon sequestration and stabilization of the climate
- ★ Mitigation of droughts and floods.
- ★ Purification of air and water, detoxification and decomposition of wastes.

5. Define blue-green-grey water

"**Blue water**" is the amount of rainfall that enters lakes, rivers and groundwater. This is the main source of water that we use and manage for industrial, domestic and irrigation purposes. Only 30-35% of all water within the hydrological cycle is blue water.

"**Green water**" is the amount of rainfall that is either intercepted by the vegetation, or enters the soil and is picked up by plants and evapotranspiration back into the atmosphere. Some 65% of all rain water is cycled through the green water cycle and is the water source for rained agriculture.

"Grey water" can be used to supplement your farm's water supply. In the home, it can be used for laundry and toilet flushing. Outside of the home, grey water can be used to water garden plants (but not vegetables), wash machinery and vehicles, and keep dust down around the house.

6. What are Critical Limits for Blue and Green Water Availability?

The critical values for the availability of Blue and Green Water were determined by Rock Strom et al 2006 for a wide range of countries in m^3/capita/year.. They showed that countries with < 1000 m^3/ capita/year of Blue water and <1300 m3/capita of Green water will have significant water challenges by 2050.

7. Give the solutions to water scarcity

- ★ Recharging aquifers/groundwater

★ Water re-use and Effective Water Treatment Technologies

★ Desalination

★ Water Management

★ Infrastructure Repair and Maintenance

★ Water Conservation

8. What is desertification?

Progressive destruction or degradation of arid or semiarid lands to desert. Desertification leads to the conversion of range lands or irrigated croplands to desert. Desertification is characterized by de-vegetation, depletion of ground water, salination and soil erosion.

9. Write the harmful effects of desertification.

➢ Around 80% of the agricultural land in the arid and semi- regions are converted into deserts.

➢ Around 600 million people are threatened by desertification.

10. What are the effects of desertification?

a. Farming becomes next to impossible

b. Hunger

c. Flooding

d. Poor Water Quality

e. Poverty

f. Overpopulation

REVIEW QUESTIONS

1. Explain the various impacts of Global warming on agriculture, with the help of case studies
2. How ecosystem changes occur due to agriculture? Explain with the help of flow diagram
3. Discuss in detail about the ecosystem services used by agriculture.

4. Explain the changing of blue-green-grey water cycles with a neat sketch and how rainwater is partitioning into blue and green and grey water.

5. What is desertification? Write the causes, effects and solutions of desertification in related with agriculture.

UNIT IV

ECOLOGICAL DIVERSITY AND AGRICULTURE

Ecological diversity, wild life and agriculture - GM crops and their impacts on the environment - Insects and agriculture - Pollination crisis - Ecological farming principles - Forest fragmentation and agriculture - Agricultural biotechnology concerns.

4.1. ECOLOGICAL DIVERSITY IN AGRICULTURE

Agricultural biodiversity is a broad term that includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agricultural ecosystems, also named agro-ecosystems.

- Ecosystems are the basis of life and all human activities.
- Conservation of biological diversity is very important for the proper functioning of the ecosystem and for delivering ecosystem services.
- Maintaining high biodiversity in agro ecosystems makes agricultural production more sustainable and economically viable. Agricultural biodiversity ensures.

Example:

Pollination of crops, biological crop protection, maintenance of proper structure and fertility of soils, protection of soils against erosion, nutrient cycling, and control of water flow and distribution.

- The effects of the loss of biodiversity may not be immediately apparent, but they may increase the sensitivity of the ecosystems to various abiotic and biotic stresses.
- The combination of biodiversity conservation with profitable food production is one of the tasks of modern, sustainable agriculture that faces the necessity of reconciling the productive, environmental, and social goals.

As a further intensification of production and increase in the use of chemical pesticides, fertilizers, and water to increase yields are increasingly criticized, global agriculture is looking for other biological and agro-technical methods in order to meet the requirements of global food production.

- Agricultural biodiversity is the outcome of the interactions among genetic resources, the environment and the management systems and practices used by farmers.
- This is the result of both natural selection and human inventive developed over millennia.

4.1.1. Identification of Agricultural Bio-Diversity

The following dimensions of agricultural biodiversity can be a identified:

1. Genetic resources for food and agriculture

- Plant genetic resources, including crops, wild plants harvested and managed for food, trees on farms, pasture and rangeland species,
- Animal genetic resources, including domesticated animals, wild animals hunted for food, wild and farmed fish and other aquatic organisms, Microbial and fungal genetic resources.

These constitute the main units of production in agriculture, and include cultivated and domesticated species, managed wild plants and animals, species. as well as wild relatives of cultivated and domesticated

2. Components of biodiversity that support ecosystem services

These include a diverse range of organisms that contribute, at various scales to, inter alia, nutrient cycling, pest and disease regulation, pollination, pollution and sediment regulation, maintenance of the hydrological cycle, erosion control, and climate regulation and carbon sequestration.

3. Abiotic factors

Such as local climatic and chemical factors and the physical structure and functioning of ecosystems, which have a determining effect on agricultural biodiversity.

4. Socio-economic and cultural dimensions

Agricultural biodiversity is largely shaped and maintained by -human activities and management practices, and a large number of people depend on agricultural biodiversity for sustainable livelihoods. These dimensions include traditional and local knowledge of agricultural biodiversity, cultural factors and participatory processes, as well as tourism associated with agricultural landscapes.

4.1.2. Ecological Diversity in Wild Life

Wildlife habitat refers to two agricultural land use categories: woodlands and wetlands, and natural land for pasture. The category woodlands and wetlands is a combined variable and it is not possible to determine the relative contributions of the two components.

- Wildlife Diversity is the distinctive study related to various types. of species existing in the eco-system.
- It includes various aspects such as Genetic variation, Global diversity, Ecosystem diversity, maintaining genetically diverse and healthy livestock in fields like farm animal diversity.

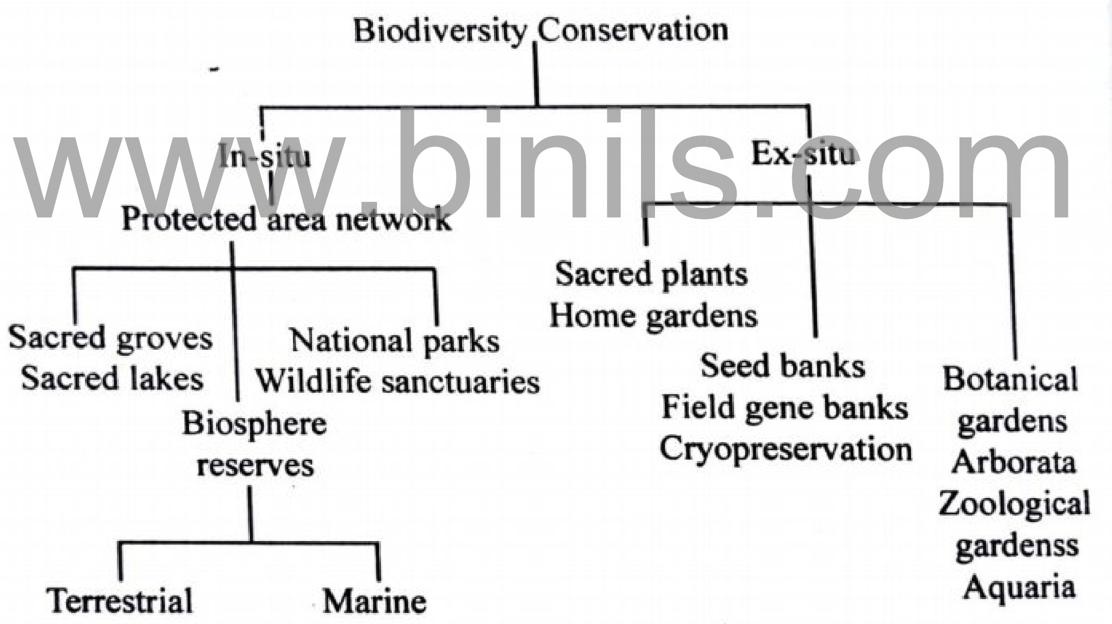


Fig. 4.1 Ecological diversity of wildlife

4.2. GM CROPS AND THEIR IMPACTS ON THE ENVIRONMENT

Genetically modified crops (GM crops) are plants used in agriculture, the DNA of which has been modified using genetic engineering methods. In most cases, the aim is to introduce a new trait to the plant which does not occur naturally in the species.

Examples:

1. In **food crops** include resistance to certain pests, diseases, environmental conditions, reduction of spoilage, resistance to chemical treatments (example: resistance to a herbicide), or improving the nutrient profile of the crop.
2. In **non-food crops** include production of pharmaceutical agents, biofuels, and other industrially useful goods, as well as for bioremediation.

4.2.1. Direct effects of genetically modified plants on the environment

Agriculture of any type: subsistence, organic or intensive - affects the environment, so it is expected that the use of new genetic techniques in agriculture will also affect the environment.

- Genetic engineering may accelerate the,
    - Damaging effects of agriculture.
    - Have the same impact as conventional agriculture,
    - Contribute to more sustainable agricultural practices The conservation of natural resources, including biodiversity.
- Horizontal gene flow refers to a gene transfer, usually through pollen, from cultivated species to their wild relatives (and vice- versa).
- This may happen with either conventional or genetically modified plants.

Moreover, gene flow from cultivated crops to wild relatives is expected to create hybrids with characteristics that are advantageous in agricultural environments, but that would not thrive in the wild. In the UK, for instance, no hybrid between a crop and a wild relative has ever become invasive.

4.2.2. Indirect effects of genetically modified plants on the environment

- Genetically modified crops may have indirect environmental effects as a result of changes in agricultural or environmental practices associated with the new varieties.
- Using genetically modified crops which are insect resistant because they carry the Bt gene has reduced insecticide use on maize, cotton, and soybean.
- The environmental benefits include less contamination of water supplies and less damage to non-target insects.

- The extensive use of herbicides and insect resistant crops could result in the emergence of resistant weeds and insects.
- This has often occurred as a consequence of conventional herbicide and insecticide spraying.
- Several weed species have developed resistance to specific herbicides, which are extensively used in combination with herbicide-resistant genetically modified crops.
- New genetically modified crops are being developed that can withstand environmental stresses such as drought, salinity, or the presence of aluminum in the environment.
- They may permit cultivation of soils that are presently of low productivity for agriculture.
- Scientists agree that these crops may be either beneficial or harmful for society, depending on the crop, the characteristic and the environment.

4.2.3. Advantages of Genetically Modified or GM Crops

It improves production and raise farmer's income. Indian farmers are still practicing traditional process of seeding and cultivation, which required scientific moves for raising their production. Hence, it is one of the moves to enhance the farm production.

- It reduces the use of pesticide and insecticide during farming that might be great moves for the betterment of the food supply.
- It can feed a rapidly increasing population because it shows dramatically increased yields.
- It can produce more in small area of land.

India introduced Bt cotton seeds in 2002. It has greatly reduced the use of toxic pesticides. Bt cotton produces a common soil bacterium, Bacillus Thuringiensis (Bt).

It is a natural pest repelling bacteria that is toxic to many worms and pests that can harm the crop but is not hazardous to humans. Bt is widely sprayed on crops by organic farmers as a pesticide.

As a result of the adoption of Bt cotton, India is now the largest cotton producer in the world.

4.2.4. Disadvantages of Genetically Modified or GM Crops

The production imposes high risks to the disruption of ecosystem and biodiversity because the "better" traits produced from engineering genes can result in the favoring of one organism. Hence, it can eventually disrupt the natural process of gene flow.

- It increases the cost of cultivation and more inclined towards marketization of farming that work on immoral profits.
- The transgenic crops endanger not only farmers but also the trade, and the environment as well.
- It is biologically altered. Hence, biotech foods may pose a human health risk.
- The excessive production of genetically modified foods will be rendered ineffective over time because the pests that these toxins used to deter might eventually develop resistance towards them.

4.3. INSECTS AND AGRICULTURE

Insects are essential to agriculture, some as pollinators and others as predators of other insect species that feed on crops or spread viruses and other diseases. Herbivorous insects are responsible for destroying up to 20% of the world's total crop production annually and up to 50% is lost to a combination of pests and diseases.

Farmers employ many different strategies to try and limit these losses. Currently, pesticides are one of the primary methods of controlling insect pests, particularly insect larvae. However, many insecticides are non-specific and affect pollinators and beneficial species as well as pests, particularly when applied as an aerial spray. Pesticides are progressively being restricted by European legislation due to concerns about negative impacts on biodiversity and non-sustainability.

4.3.1. Beneficial Insects and their Value to Agriculture

- Beneficial insects provide regulating ecosystem services to agriculture such as Pollination and the natural regulation of plant pests.
- It aims to enhance insect-derived ecosystem services from a conservation perspective (i.e. enhancing beneficial insects in agricultural landscapes that provide ecosystem services to crops.
- Human cultures and civilizations have been maintained in countless ways through these beneficial insects, they regulate the pest population of many harmful pest

species, produce natural products, and they also dispose the waste and recycle the organic nutrients.

Table 4.1: Natural insects and their uses

Predator/Parasitoid	**Group**	**Beneficial Insect or Invertebrate**	**Pest Attacked**	**Impact on Pest**
Predators	Beetles (Coleopter)	Lady Birds (Family Coccinellid), Red And Blue Beetles (Dicranolaius Bellulus), Green Carab Beetles (Calosoma Schayeri), Green Soldier Beetles (Chauliognathus Pulchellus)	Aphids, Mites, Thrips, Mealy Bugs Moth Eggs Including Heliothis Spp. And Larvae.	Able To Handle A Wide Range Of Prey And Are Immediately Effective. Some Species (E.G. Lady Birds) Both The Adult And Larvae Are Predatory
Predators	Predatory Larvae	Hoverfly Larvae (Family Syrphidae)	Aphids	Larvae Spear Aphids With Jaws And Suckout Internal Juices. Adult Hoverfly Are Not Predacious.
Predators	Mites (Acarina)	Predatory Mites Form Different Families.	Blue Oat Mite Lucerne	Predacious On Other Mite Species

		Example: Anystidae, Bdellidae, Erytharaeida, Parasitidae And Cunaxidae.	Flea Red-Legged Earth Mile.	And Lucerne Fleas (Sminthurus Viridis)
Predators	Lacewings	Green (Mallada Signatus) And Brown (Micromus Tasmaniae) Lacewings	Aphids, Moth Larvae And Eggs, Whitefly, Thrips, Mites And Mealy Bugs.	Larvae Insert Jaws Into Soft Bodies Insects And Eggs And Suck Out Contents. Larvae Of Both Brown And Green Lacewings Are Predatory. Adult Brown Lacewings Feed On Heliothis Eggs And Mites.
Predators	Spiders	Variety Of Species Including's Wolfspiders, Night's Taking Spiders, Orbweavers, Tangle Web Spiders, Flower Spiders, Jumping	Predators Or A Range Of Insect Pests.	Pest Species And Consumed.

		Spiders And Lynx Spiders.		
Parasitoids	Aphid Parasitoids	Trioxys Complanatus, Aphidius Ervi, Lysiphlebus Testaceipes, Aphidius Colemani.	Aphids	Wasp Inserts Egg Into Aphid. The Developing Larvae Eventually Killing The Aphid "Mummy" As The Adult Wasp Emerges.
Parasitoids	Caterpillar Parasitoids	Hymenoptera: Numerous Parasitic Wasps Including Banded Caterpillar Parasite (Ichneumon Promissorius), Two-Tonned Caterpillar Parasite (Heterpelma Scaposum) (Family Ichneumonidae), Microplitis Demolitor, Cotesia Spp. (Family Braconidae)	Heliothis And Other Moth Iarvae.	Female Lays Eggs In Hos Pupae As The Prisitoid Larvae Develop In The Host It Causes The Death Of The Pupa.

Parasitoids	Caterpillar Parasitoids	Sorghum Midge Parasites (Eupelmus Australiensis, Aprostocetus Diplosidis, Tetrastichus Spp)	Sorghum Midge.	Wasp Lays Eggs In Midge Larvae And Emerges At Pupal Stage.
Parasitoids	Caterpillar Parasitoids	Tachinid Flies	Heliothis, Looper, Armyworm, Grasshopper And Other Larvae.	Female Lays Egss In Host Pupae As The Parisitoid Larvae Develop In The Host It Causes The Death Of The Pupa.

4.4. POLLINATION CRISIS

- Pollinators such as the honey bee represent some of our most important species. Pollination allows plants to reproduce, provides the fruits, seeds and foliage that we eat, and much of the flora in our natural environment, gardens and parks.

For thousands of years, through the domestication of the honey bee, humans and the iconic Apis mellifera, L. (Western honey bee) have together produced:

- Flowering fields
- Abundant fruit and vegetable crops
- Honey and a variety of hive products

4.4.1. Types of Pollination

- Pollination is the transfer of pollen between plants enabling fertilization and sexual reproduction.
- There are two types of pollination.

- Abiotic
- Biotic

1. **Abiotic**

- Abiotic pollination takes place without the involvement of living organisms.

Example:

Where pollen is transported by wind.

2. **Biotic**

Biotic pollination is the result of the movement of pollen by living organisms.

Example:

Pollination will be carried out by different types of insects (Butterfly, Honeybee etc.)

- It is the most common form of pollination and accounts for an estimated 90% of pollination of all flowering plants.
- In exceptional cases, pollination may be achieved by hand.

4.4.2. Significance of Pollination

Pollination is critical for food production and human livelihoods, and directly links wild ecosystems with agricultural production systems.

- The vast majority of flowering plant species only produce seeds if animal pollinators move pollen from the anthers to the stigmas of their flowers.
- Without this service, many interconnected species and processes functioning within an ecosystem would collapse.
- The losses of pollination services have been well documented in many specific instances.
- As managed pollinators such as honeybees face a suite of debilitating threats, the services provided by wild pollinators become even more essential.

4.4.3. Role of Pollinators in Agriculture

- 35% of food crop production worldwide depends on animal pollinators, including honey bees.

- Of the 115 crop species that provide 90 percent of food supplies for 146 countries, 71 are bee-pollinated.
- The total economic value of insect pollination worldwide amounted to $210 billion (€153bn) in 2005, which represented 9.5% of the total value of agricultural production used for human consumption.
- Through their pollination services and honey production, honey bees are estimated to be worth $5bn (£3bn) to New Zealand's economy,4 $15bn (€10.25bn) to the US,5 $19bn (E14bn) to the EU, over $69bn (£50bn) to East Asia6 and $1bn (60.75bn) to Canada.
- Insect pollination is thought to be the main reproductive mechanism in 78% of temperate flowering plants, and is essential to maintaining plant genetic diversity.
- Some crops, including blueberries and cherries, are 90-percent9 dependent on honey bee pollination; one crop, almonds, depends entirely on insect pollination at bloom time.
- California has 800,000 acres of almond groves, which demand the annual pollination of bees.
- California's almond pollination alone requires the services of 1.5 million bee hives.
- There are 620,000 beekeepers in the EU, producing 220,000 tons of honey every year.
- There are over 25,000 species of different bees in the world.

4.4.4. Pollination Crisis on Agriculture

- Agriculture provides habitat and forage for pollinating insects, and therefore contributes to the important ecosystem service of pollination
- The implementation of best management practices in agriculture can provide improved crop yields, and at the same time, improved conditions for pollinator species.

The diversity of pollinators and pollination systems is striking. Most of the 25,000 to 30,000 species of bees are effective pollinators, and together with moths, flies, wasps, beetles and butterflies, make up the majority of pollinating species.

- Vertebrate pollinators include bats, non-flying mammals (several species of monkey, rodents, lemur, tree squirrels, olingo and kinkajou) and birds (hummingbirds, sunbirds, honeycreepers and some parrot species).
- Healthy pollination services are best ensured by an abundance and diversity of pollinators.

The implementation of some best management practices can incur additional financial cost, but can also lead to positive results in yield, the conservation of nutrients, the protection of soil, and the safeguarding and promotion of biodiversity.

This is true, for example - of flowering cover crops, which can be sown after early summer harvests, and which can serve to provide Sage for pollinators. Grass buffer strips established for erosion control or water protection might also be planted with a flowering seed mix as additional food for bees and other pollinators.

4.5. ECOLOGICAL FARMING

- Ecological Farming combines modern science and innovation with respect for nature and biodiversity.
- It ensures healthy farming and healthy food.
- It protects the soil, the water and the climate.
- It does not contaminate the environment with chemical inputs or use genetically engineered crops.
- And it places people and farmers - consumers and producers, rather than the corporations who control our food now at its very heart.

It is a vision of sustainability, equity and food sovereignty in which safe and healthy food is grown to meet fundamental human needs, where control over food and farming rests with local communities, er than transnational corporations.

4.5.1. Benefits of Ecological Farming

1. Ecological farming involves the introduction of symbiotic species, where possible, to support the ecological sustainability of the farm. Associated benefits include a reduction in ecological debt and elimination of dead zones.
2. Ecological farming is a pioneering, practical development which aims to create globally sustainable land management systems, and encourages review of the

importance of maintaining biodiversity in food production and farming end products.

3. One foreseeable option is to develop specialized automata to scan and respond to soil and plant situations relative to intensive care for the soil and the plants. Accordingly, conversion to ecological farming may best utilize the information age, and become recognised as a primary user of robotics and expert systems.

4.5.2. Ecological Farming: The Seven Principles

1. Food sovereignty

- Ecological Farming supports a world where producers and consumers, not corporations, control the food chain.
- Food sovereignty is about the way food is produced, and by whom.

2. Benefitting farmers and rural communities

Ecological Farming contributes to rural development and fighting poverty and hunger, by enabling livelihoods in rural communities that are safe, healthy, and economically viable.

3. Smarter food production and yields

- To increase food availability globally.
- To improve livelihoods in poorer regions.
    - We must reduce the unsustainable use of what we grow at the moment.
    - We must reduce food waste, decrease meat consumption, and minimize the use of land for bioenergy.
    - We must also achieve higher yields where they are needed through ecological means.

4. Biodiversity

Farming is about nature's diversity from the seed to the plate, and across the entire agricultural landscape. It is about celebrating the flavour, nutrition, and culture of the food we eat, improving diets and health.

5. Sustainable soil health and cleaner water

It is possible to increase soil fertility without the use of chemicals. Ecological Farming also protects soils from erosion, pollution, and acidification. By increasing soil organic matter where necessary, we can enhance water retention, and prevent land degradation.

6. Ecological pest management

Ecological Farming enables farmers to control pests and weeds - without the use of expensive chemical pesticides that can harm our soil, water and ecosystems, and the health of farmers and consumers.

7. Resilient food systems

Ecological Farming creates resilience: it strengthens our agriculture, and effectively adapts our food system to changing climatic conditions and economic realities.

4.6. FOREST FRAGMENTATION AND AGRICULTURE

Forest fragmentation is the breaking of large, contiguous, forested areas into smaller pieces of forest; typically these pieces are separated by roads, agriculture, utility corridors, subdivisions, or other human development. It usually occurs incrementally, beginning with cleared patches here and there think Swiss cheese within an otherwise unbroken expanse of tree cover.

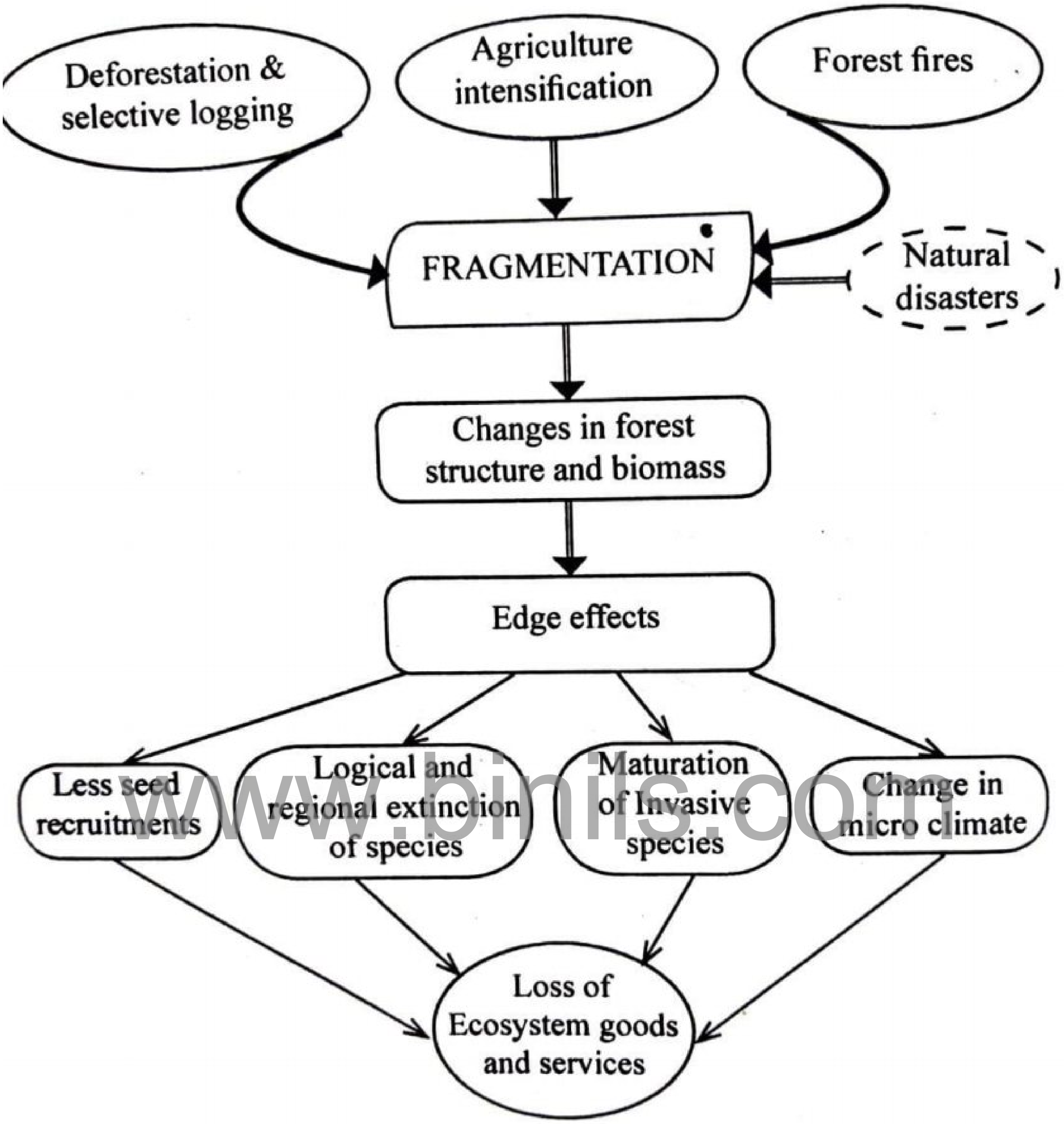


Fig. 4.2 Flow chart of Forest Fragmentation

Any large-scale canopy disturbance affects a forest, but it is important to distinguish between a forest fragmented by human infrastructure development and a forest of mixed ages and varied canopy closure that results from good forest management.

The former is typically much more damaging to forest health and habitat quality, usually with permanent negative effects, whereas the latter may cause only temporary change in the forest.

4.6.1. Forest Fragmentation in India

- Most of the biodiversity-rich forests, such as evergreen. subtropical broadleaf and temperate broadleaf forests, are relatively intact or have a low degree of fragmentation.
- But highly fragmented regions across the Indian landscape harbour a number of endemic species, some of them of medicinal importance, that need conservation.
- This study presents an approach to mapping fragmentation caused by socio-economic drivers, namely shifting cultivation, forest villages, infrastructural development, mining and encroachment.

4.6.2. Fragmentation Across Biodiversity Hotspots of The Indian Landscape

Fragmentation across biodiversity hotspots of the Indian landscape As the Indian subcontinent has three biodiversity hotspots according to Conservation International 25, we tried to assess the fragmentation status of these unique and important regions, namely the eastern Himalaya, the Western and the Andaman and Nicobar Islands (Figure 5). Of these biodiversity hotspots, the Andaman and Nicobar Islands have 82.43% of their total geographic area under forest, followed by the eastern Himalaya (68%) and the Western Ghats (43.6%).

A comparison of the fragmentation status in the biodiversity hotspots shows that the proportion of intact forest area is highest in the Andaman and Nicobar Islands, accounting for 78% of the forested area in the region.

This is due to the fact that the Andaman Islands are isolated from the mainland and has much less pressure due to the mainland Indian population and development. The eastern Himalaya has around 67% of intact forest area, followed by the Western Ghats, which has 58% of the area under intact forests.

The proportion of area under high fragmentation is highest in the eastern Himalaya and constitutes around 3% of the forested area. This is due to the prevalence of shifting cultivation in the region26. The Western Ghats has 1.66% of the forested area under high fragmentation, mainly due to extensive cash crop plantation and developmental activities27. In the Andaman and Nicobar Islands, 0.94% of the forests which fall within high fragmentation areas consists mainly of various natural creeks and water bodies that fragment the natural vegetation on the coast.

4.6.3. Effects of Forest Fragmentation

- The effects of fragmentation are well documented in all forested regions of the planet.
- By reducing forest health and degrading habitat, fragmentation leads to loss of biodiversity, increases in invasive plants, pests, and pathogens, and reduction in water quality.
- These wide-ranging effects all stem from two basic problems:
    - Fragmentation increases isolation between forest communities and it increases so-called edge effects.
    - When a forest becomes isolated, the movement of plants and animals is inhibited.
- This restricts breeding and gene flow and results in long-term population decline.
- Fragmentation is a threat to natural resilience, and connectivity of forest habitats may be a key component of forest adaptation and response to climate change.
    - Edge effects are even more complicated.
- They alter growing conditions within the interior of forests through drastic changes in temperature, moisture, light, and wind.
- Put simply, the environment of the adjacent non-forest land determines the environment of the forest fragment, particularly on its edges.
- This triggers a cascade of ill effects on the health, growth, and survivability of trees, flowers, ferns, and lichens and an array of secondary effects on the animals that depend on them.

Ecologists suggest that true interior forest conditions - you know, where it's hard to hear cars and lawnmowers and it remains cool, shady, and downright damp even during a three-week drought-only occur at least 200-300 feet inside the non-forest edge.

And so a circular forest island in a sea of non-forest would have to be more than 14 acres in size to include just one acre of such interior forest condition. Put differently, reports indicate that the negative habitat effects of each residential building pocket within a forest radiate outward, affecting up to 30 additional acres with increased disturbance, predation, and competition from edge-dwellers. This may not matter to generalist species like deer, raccoons, and blue jays, which may actually benefit from fragmentation, but it is hell on interior-dependent species like salamanders, goshawks, bats, and flying squirrels.

- The smaller the remnant the greater the influence of external factors and edge effects.
- A wise person once likened it to ice cubes: the smaller ones melt faster.

Moreover, as forest fragments become ever smaller, practicing. forestry in them becomes operationally impractical, economically nonviable, and culturally unacceptable.

The corresponding and important contributions that forestry makes to our economy and culture. The result is a rapid acceleration of farther fragmentation and then permanent loss.

4.7. AGRICULTURAL BIOTECHNOLOGY CONCERNS

- Agricultural biotechnology is a collection of scientific techniques used to improve plants, animals and microorganisms.
- Based on an understanding of DNA, scientists have developed solutions to increase agricultural productivity.
- Starting from the ability to identify genes that may confer advantages on certain crops, and the ability to work with such characteristics very precisely:
    - Biotechnology enhances breeders' ability to make improvements in crops and livestock.
    - Biotechnology enables improvements that are not possible with traditional crossing of related species alone.

4.7.1. Use of Agricultural Biotechnology

1. Genetic Engineering

- Scientists have learned how to move genes from one to another. This has been called Genetic Modification (GM), Genetic Engineering (GE) or Genetic Improvement (GI). Organism
- Regardless of the name, the process allows the transfer of useful characteristics (such as resistance to a disease) into a plant, animal or microorganism by inserting genes (DNA) from another organism.

- Virtually all crops improved with transferred DNA (often called GM crops or GMOs) to date have been developed to aid farmers to increase productivity by reducing crop damage from weeds diseases or insects.

2. Molecular Markers

- Traditional breeding involves selection of individual plants or animals based on visible or measurable traits.
- By examining the DNA of an organism, scientists can use molecular markers to select plants or animals that possess a desirable gene, even in the absence of a visible trait.
- Thus, breeding is more precise and efficient.

Example:

The International Institute of Tropical Agriculture has used molecular markers to obtain cowpea resistant to bruchid (a beetle), disease-resistant white yam and cassava resistant to Cassava Mosaic Disease, among others.

- Another use of molecular markers is to identify undesirable genes that can be eliminated in future generations.

3. Molecular Diagnostics

- Molecular diagnostics are methods to detect genes or gene products that are very precise and specific.
- Molecular diagnostics are used in agriculture to more accurately diagnose crop/livestock diseases.

4. Vaccines

- Biotechnology-derived vaccines are used in livestock and humans.
- They may be cheaper, better and/or safer than traditional vaccines.
- They are also stable at room temperature, and do not need refrigerated storage; this is an important advantage for smallholders in tropical countries.
- Some are new vaccines, which offer protection for the first time against some infectious illnesses.

Example:

In the Philippines, biotechnology has been used to develop an improved vaccine to protect cattle and water buffalo against hemorrhagic septicemia, a leading cause of death for both species.

5. Tissue Culture

- Tissue culture is the regeneration of plants in the laboratory from disease free plant parts.
- This technique allows for the reproduction of disease free planting material for crops.

Examples:

Crops produced using tissue culture include citrus, pineapples, avocados, mangoes, bananas, coffee and papaya.

Usage period of Biotechnology in Agriculture and Food Production

- The first food product of biotechnology (an enzyme used in cheese production and a yeast used for baking) appeared on the market in 1990. Since 1995, farmers have been growing GE crops.
- In 2003, 7 million farmers in 18 countries more than 85 percent of them resource-poor farmers in the developing world were planting biotech crops.
- Almost one third of the global biotech crop area was grown in developing countries.

Agricultural Biotechnology Economic and Social Impacts

- A safe and sufficient food supply, grown in an environmentally responsible fashion, is essential for humanity.
- Like any technology, agricultural biotechnology will have economic and social impacts.
- Since their introduction, crops improved using biotechnology have been used safely, with benefits such as the reduction of pesticide use.
- Agricultural biotechnology is only one factor among many influencing the health and welfare of farmers and other citizens in the developing world.

- As biotechnology continues to evolve, factual and open public discourse is vital to define the role it should play in society.

4.7.2. Environmental and Ecological Issues

1. Potential gene escape and superweeds

There is a belief among some opponents of genetic engineering technology that transgenic crops might crosspollinate with related weeds, possibly resulting in "superweeds" that become more difficult to control.

- One concern is that pollen transfer from glyphosate-resistant crops to related weeds can confer resistance to glyphosate.
- While the chance of this happening, although extremely small, is not inconceivable, resistance to a specific herbicide does not mean that the plant is resistant to other herbicides, so affected weeds could still be controlled with other products.

2. Impacts on "nontarget" Species

- Some environmentalists maintain that once transgenic crops have been released into the environment, they could have unforeseen and undesirable effects.

3. Insecticide Resistance

- Another concern related to the potential impact of agricultural biotechnology on the environment involves the question of whether insect pests could develop resistance to crop-protection features of transgenic crops.

4.7.3. Health-Related Issues

1. Allergens and Toxins

- People with food allergies have an unusual immune reaction when they are exposed to specific proteins, called allergens, in food.
- About 2 percent of people across all age groups have a food allergy of some sort.
- The majority of foods do not cause any allergy in the majority of people.
- Food-allergic people usually react only to one or a few allergens in one or two specific foods.
- A major safety concern raised with regard to genetic engineering technology is the risk of introducing allergens and toxins into otherwise safe foods.

2. Antibiotic resistance

- Antibiotic resistance genes are used to identify and trace a trait of interest that has been introduced into plant cells.
- This technique ensures that a gene transfer during the course of genetic modification was successful.
- Use of these markers has raised concerns that new antibiotic resistant strains of bacteria will emerge.

4.7.4. Social Issues

1. Labeling

- Some consumer groups argue that foods derived from genetically engineered crops should carry a special label.
- In the USA, these foods currently must be labeled only if they are nutritionally different from a conventional food.

2. "Terminator" technology

- Most farmers in the USA and elsewhere, buy fresh seeds each season, particularly of such crops as corn, green peppers, and tomatoes.
- Anyone growing hybrid varieties must buy new seeds annually, because seeds from last year's hybrids grown on the farm will not produce plants identical to the parent.

TWO MARK QUESTIONS AND ANSWERS

1. What is meant by agricultural biodiversity?

Agricultural biodiversity is a broad term that includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agricultural ecosystems, also named Agro-ecosystems.

2. List the dimensions of agricultural biodiversity.

a. Genetic resources for food and agriculture

b. Components of biodiversity that support ecosystem services

c. Abiotic factors

d. Socio-economic and cultural dimensions

3. Write the Advantages of Genetically Modified Crops.

- It improves production and raise farmer's income. Indian farmers are still practicing traditional process of seeding and cultivation, which required scientific moves for raising their production. Hence, it is one of the moves to enhance the farm production.
- It reduces the use of pesticide and insecticide during farming that might be great moves for the betterment of the food supply.
- It can feed a rapidly increasing population because it shows dramatically increased yields.
- It can produce more in a small area of land.

4. What are the direct effects of genetically modified plants on the environment?

- Agriculture of any type-subsistence, organic or intensive - affects the environment, so it is expected that the use of new genetic techniques in agriculture will also affect the environment.

- Genetic engineering may accelerate the damaging effects of agriculture, have the same impact as conventional agriculture, or contribute to more sustainable agricultural practices and the conservation of natural resources, including biodiversity.
- Horizontal gene flow refers to a gene transfer, usually through pollen, from cultivated species to their wild relatives (and vice-versa). This may happen with either conventional or genetically modified plants.
- Gene flow from cultivated crops to wild relatives is expected to create hybrids with characteristics that are advantageous in agricultural environments, but that would not thrive in the wild. In the UK, for instance, no hybrid between a crop and a wild relative has ever become invasive.

5. Write the indirect effects of genetically modified plants on the environment.

- Using genetically modified crops which are insect resistant because they carry the Bt gene has reduced insecticide use on maize, cotton, and soybean. The environmental benefits include less contamination of water supplies and less damage to non-target insects.

- The extensive use of herbicides and insect resistant crops could result in the emergence of resistant weeds and insects. This has often occurred as a consequence of conventional herbicide and insecticide spraying. Several weed species have developed resistance to specific herbicides, which are extensively used in combination with herbicide-resistant genetically modified crops.

6. What are the disadvantages of Genetically Modified or GM Crops?

- The production imposes high risks to the disruption of ecosystem and biodiversity because the "better" traits produced from engineering, genes can result in the favouring of one organism. Hence, it can eventually disrupt the natural process of gene flow.
- It increases the cost of inclined towards marketization of farming that work on immoral profits.
- The transgenic crops endanger not only farmers but also the trade, and the environment as well. It is biologically altered. Hence, biotech foods may pose a human health risk.

7. What is the value of Beneficial insects in agriculture?

Beneficial insects provide regulated ecosystem services to agriculture such as Pollination and the natural regulation of plant pests. It aims to enhance insect-derived ecosystem services from a conservation perspective (i.e. enhancing beneficial insects in agricultural landscapes that provide ecosystem services to crops.

Human cultures and civilizations have been maintained in countless ways through these beneficial insects, they regulate the pest population of many harmful pest species, produce natural products, and they also dispose the waste and recycle the organic nutrients

8. Define Ecological Farming.

- Ecological Farming combines modern science and innovation with respect for nature and biodiversity.
- It ensures healthy farming and healthy food.
- It protects the soil, the water and the climate.

- It does not contaminate the environment with chemical inputs or use genetically engineered crops. And it places people and farmers consumers and producers, rather than the corporations who control our food now - at its very heart.

9. Write the benefits of Ecological Farming.

- Ecological farming involves the introduction of symbiotic species, where possible, to support the ecological sustainability of the farm. Associated benefits include a reduction in ecological debt and elimination of dead zones.
- Ecological farming is a pioneering, practical development which aims to create globally sustainable land management systems, and encourages review of the importance of maintaining biodiversity in food production and farming end products.

10. What is meant by Forest fragmentation?

Forest fragmentation is the breaking of large, contiguous, forested areas into smaller pieces of forest; typically these pieces are separated by roads, agriculture, utility corridors, subdivisions, or other human development.

REVIEW QUESTIONS

1. Explain various dimensions identified in agricultural biodiversity.
2. Discuss in detail about genetically modified crops (GM crops) and their impacts on the environment.
3. Mention the natural insects and their use in agriculture, depict the impact of pests with suitable examples.
4. Describe the Pollination Crisis, types and explain the role of Pollinators in Agriculture.
5. a. Review the Forest Fragmentation in India and furnish the effects of Forest Fragmentation.

   b. Specify the uses of biotechnology in various issues.

UNIT V

EMERGING ISSUES

Global environmental governance - alternate culture systems Mega farms and vertical farms - Virtual water trade and its impacts on local environment - Agricultural environment policies and its impacts - Sustainable agriculture.

5.1. GLOBAL ENVIRONMENTAL GOVERNANCE

5.1.1. Introduction

Global Environmental Governance (GEG) is the sum of organizations, policy instruments, financing mechanisms, rules, procedures and norms that regulate the processes of global environmental protection.

- The effectiveness of global environmental governance will ultimately depend on implementation on global and domestic levels.
- National implementation is the ultimate key, both to the efficacy of the GEG system and to meaningful environmental improvements.

- Since environmental issues entered the international agenda in the early 1970's, global environmental politics and policies have been developing rapidly (figure. 5.1).
    - The first global conference on the environment, held in Stockholm in 1972, set in motion three decades of discussion, negotiation and ratification of a whole series of international environmental agreements.
    - The Stockholm Conference spawned the United Nations Environment Program.
    - The Earth Summit, held in Rio 20 years later, brought with it the Conventions on Biological Diversity, Climate Change and Desertification and created another UN political institution, the Commission on Sustainable Development.

The desire to host a prestigious international institution led to the decisions to locate the small and underfunded secretariats of many of these agreements in many geographically diverse homes-from Montreal to Bonn to Rome and some places in between.

- Major institutions, such as the World Bank as well as the World Trade Organization, claim sustainable development as their overarching goal.
- A similar growth of interest is also seen within non – UN international and regional institutions in terms of environmental and sustainable development concerns.
- Multiple sources of funding for international environmental action are now available.

These not only include the operational budgets of the various organizations, but also specialized funding mechanisms created either as part of specific treaties or in general.

Example:

the Global Environment Facility (GEF), created in 1991 has financed US$4.8 billion in projects and generated co-financing of US$15.6 billion.

5.1.2. Challenges of GEG

1. **Explosion of Multilateral Environmental Agreements (MEAs) and fragmentation of GEG**

- There are too many organizations engaged in environmental governance in too many different places, often with duplicate mandates.
- Fragmentation can lead to conflicting agendas, geographical dispersion and inconsistency in rules and norms, as the different secretariats have limited opportunity to interact and cooperate

2. L**ack of cooperation and coordination among international organizations**

- The concern here is about the absence of any meaningful coordination mechanisms for GEG.
- Theoretically, such coordination is part of UNEP's natural mandate.
- UNEP has never been given the resources or the political capital to fulfill this mandate.
- UNEP's ability to "coordinate" other UN agencies is further hampered by the sheer number of agencies and programs in the UN that have some stake in environmental protection.

3. Lack of implementation, enforcement and effectiveness in GEG

The GEG system has turned into a "negotiating system" that seems to be in a perpetual state of negotiation and is obsessed with continuing negotiations rather than thinking about the implementation of existing agreements.

4. Inefficient use of resources

The concern that is usually raised here is that the system as a whole seems to have significant (even if insufficient) resources, but the duplication and lack of coordination within the system can mean that resources are not always used most efficiently.

Example:

In 2000, the World Bank had an active portfolio of over US$S billion in environmental projects.

- The UNDP's portfolio was over US$1.2 billion in the same year.
- The GEF has funded over US$4.5 billion of projects since its inception.

- National governments, civil society and the private sector in aggregate also expend significant financial resources on environmental projects.
- In spite of this impressive pool of money, particular elements of the system remain chronically under-funded.
- Geographic fragmentation and duplication of activities can result in higher operational costs and inefficient use of resources.
- With greater coherence in the system of governance and financing, a great deal more could be achieved with the existing resources.

5. GEG outside the environmental arena

- An increasing number of important decisions affecting environmental governance now take place outside the environmental arena, in areas such as trade, investment and international development.
- While institutions like the WTO, UNDP and the World Bank have begun to pay much more attention to the environment and sustainable development than in the past, they still remain largely outside the discussions on global environmental governance

6. There is inertia within the system a desire to maintain the status quo

- The UN has engaged in many self-reform initiatives, actors in the system have an incentive to maintain the status quo.
- Neither national delegates nor international environmental bureaucrats seem motivated to allow meaningful change in the terms of the GEG system.
- A system in which, despite all its faults, they feel comfortable and have learned to use their individual and institutional advantage.
- The proposals that do emerge, such as those originating from the IEG Working Group, tend to advocate a soft approach and incremental change.

7. Developing country concerns

- Developing countries have legitimate concerns about the state of the international system.
- They are already distrustful of the international system in general and are especially concerned about the rapid growth of environmental instruments and its possible impacts on their economic growth.
- Developing countries are not necessarily beholden to the status quo.
    - They fear that any change will necessarily make things even worse from their perspective.

8. Lack of political will and the balance of national interests versus global environmental problems

- National economic and security interests can often run counter to environmental concerns.
- Not all nations wish to have a strong system of GEG.
- Even when the logic of a stronger global environmental system is apparent.
    - It tends to be overwhelmed by the fact that actors within the system are primarily charged with safeguarding their narrower national and institutional interests.

5.1.3. Goals of GEG

1. Leadership

- The GEG system should grasp the attention and visible support of high-profile political leaders.
- The key institutions within the system should be managed by leaders of the
    - Highest professional caliber
    - International repute
- All working together towards the best interests of the GEG system as a whole.

2. Knowledge

- Science should be the authoritative basis of sound environmental policy.
- The GEG system should be seen as a knowledge-based and knowledge-producing system.

3. Coherence

GEG should operate as a coherent "system" with reasonable coordination, regular communication and a shared sense of direction among its various elements.

4. Performance

The institutions that make up the GEG system should be well- managed.

- They should have the resources they need.
- Should use these resources efficiently.
- They should be effective in implementation.
- The ultimate purpose of the GEG system is to improve the global environmental condition.

5. Main streaming

The GEG system should seek to incorporate environmental concerns and actions within other areas of international policy and action, and particularly so in the context of sustainable development

5.1.4. Evidence of Environmental Degradation

The Millennium Ecosystem Assessment and the work of the Inter-governmental Panel on Climate Change have shown that ecosystem decline and global warming continue, representing real dangers to our planet.

➢ This state of affairs is well documented in the Millennium Ecosystem Assessment (2006).

Example:

Despite the feverish discussions about global climate change, carbon emissions continue to rise; global atmospheric CO, levels that were around 300 parts per million (ppm) in the early 1900's have now reached approximately 380 ppm.

➢ The Millennium Ecosystem Assessment also found that approximately 60 percent of the ecosystems that it examined were either being degraded or used unsustainably.

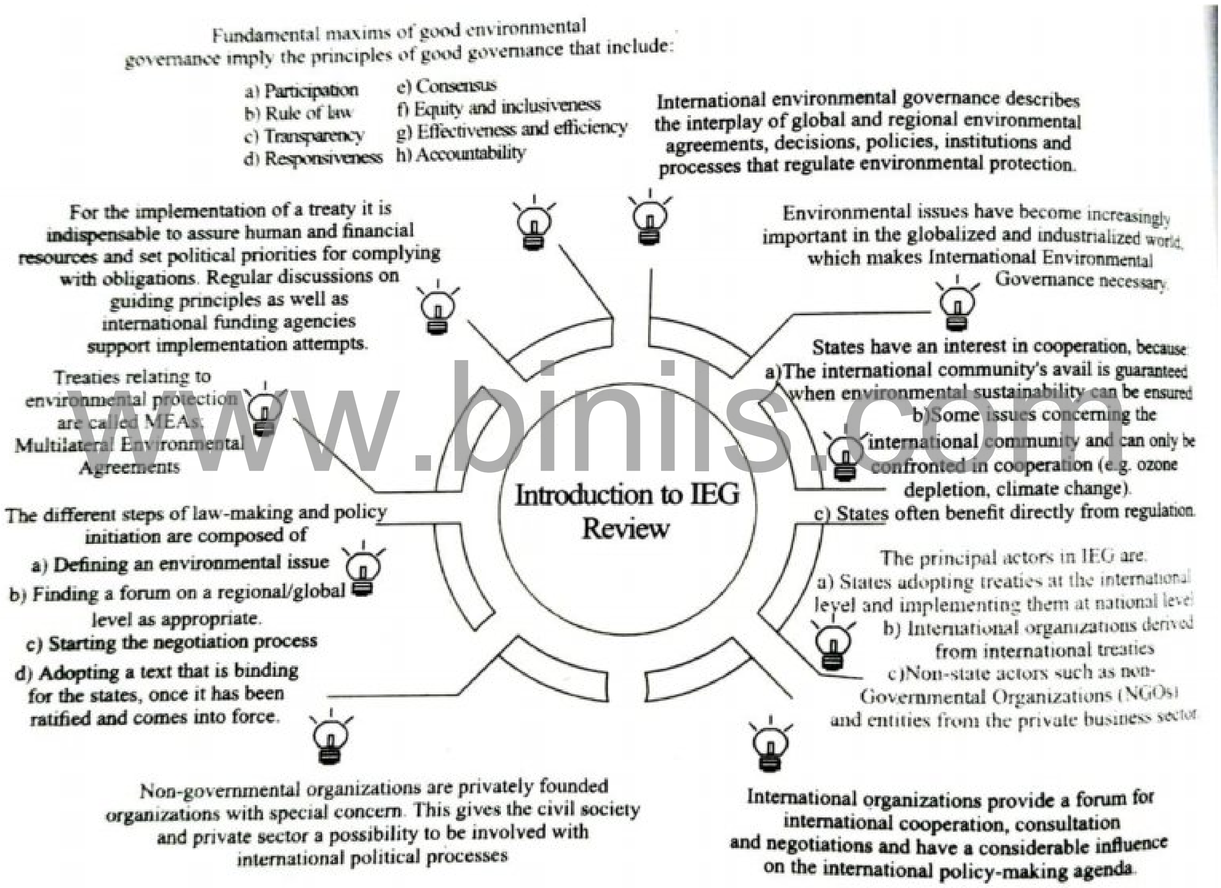


Fig. 5.1 International Environmental Governance

➢ Since 1980, 35 per cent of the world's mangroves have been lost and 20 per cent of the world's precious coral reefs have been destroyed.

➢ A decade after the signing of the Biodiversity Convention.

- The species extinction rate is still 1,000 times higher than what would be occurring naturally, without human impact.

- Despite the dozens of global and regional fisheries treaties.
    - An estimated 90 percent of the total weight of large predators in the oceans such as:
    - Tuna
    - Sharks
    - Swordfish
- These are disappeared over the last few decades
- Estimates suggest that we may still be losing as much as 150.000 square kilometers of forest each year

5.2. ALTERNATE CULTURE SYSTEMS

5.2.1. Definition

The term 'Alternative agriculture 'as it applies to the area of agriculture can be defined as "A systematic approach to farming intended to reduce agricultural pollution, enhance sustainability, and improve efficiency and profitability.

5.2.2. Process of Alternate Culture Systems

- Overall, alternative agriculture emphasizes management practices that take advantage of natural processes (such as nutrient cycles, nitrogen fixation, and pest-predator relationships)
- Improve the match between cropping patterns and agronomic practices on the one hand and the productive potential and physical characteristics of the land on the other.
- Make selective use of commercial fertilizer and pesticides to ensure efficiency and conservation of soil, water energy, and biological resources.

Examples:

It include use of crop rotation, animal and green manures, soil and water conserving tillage systems, such as no-fil planting methods, integrated pest management, and use of genetically improved crops and animals

Consonant with sustainable agriculture, alternative agriculture focuses on those farming practices that go beyond traditional or conventional agriculture, though it does not exclude conventional practices that are consistent with the overall system'.

5.2.3. Benefits of Alternative Agriculture

- Permaculture can help farmers produce more food using fewer resources through Agroecology - a farming approach that mimics natural ecosystems.
- Small-scale farmers produce food for 70% of the global population. Yet, they are some of the world's poorest and most food insecure people.
- Agroecology, a farming approach that mimics natural ecosystems, is an alternative method that can produce more food using fewer resources.
- In contrast, conventional farming is characterized by mono-cropping, green revolution technologies, and synthetic fertilizer
- There are numerous permaculture projects globally. However, they are largely disparate, small-scale projects.
- Permaculture programs are more multi-functional than typical agricultural development programs.
- This is important given the growing call for "triple-win solutions for agriculture, health, and environmental sustainability.
- Despite the potential of permaculture and Agroecology. mainstream agriculture continues to focus on conventional techniques.

5.3. MEGA FARMS AND VERTICAL FARMS

5.3.1. Mega Farming

- Demand for cheaper food and lower production costs is turning green fields into industrial sheds to process vast amounts of meat and poultry.

Intensive Animal Farming

"Intensive animal farming or industrial livestock production, is known as factory/mega/intensive farming, is a productive approach towards farm animals in order to maximize production output, while minimizing production costs".

Intensive Farming

- Intensive farming refers to animal husbandry, the keeping of livestock such as cattle, poultry, and fishat higher stocking densities than is usually the case with other forms of animal agriculture a practice typical in industrial farming by agribusinesses (figure. 5.2).

- The main products of this industry are meat, milk and eggs for human consumption.
- There are issues regarding whether factory farming is sustainable or ethical.
- Confinement at high stocking density is one part of a systematic effort to produce the highest output at the lowest cost by relying on economies of scale, modern machinery, biotechnology, and global trade.
- There are differences in the way factory farming techniques are practiced around the world.
- There is a continuing debate over the benefits, risks and ethical questions of factory farming.
- The issues include the efficiency of food production, animal welfare, health risks and the environmental impact (eg Agricultural pollution and climate change)

Modern animal production

- Factory farms hold large numbers of animals, typically cows, pigs, turkeys, or chickens, often indoors, typically at high densities.

- The aim of the operation is to produce large quantities of meat, eggs, or milk at the lowest possible cost. Food is supplied in place.

The methods employed to maintain health and improve production may include some combination of disinfectants. antimicrobial agents, anthelmintics, hormones and vaccines; protein. mineral and vitamin supplements, frequent health inspections, biosecurity; climate-controlled facilities and other measures.

- Physical restraints, e.g. fences or creeps, are used to control movement or actions regarded as undesirable.
- Breeding programs are used to produce animals more suited to the confined conditions and able to provide a consistent food product.
- Intensive production of livestock and poultry is widespread in developed nations
    - From 2002-2003, FAO estimates of industrial production as a percentage of global production were 7 percent of beef and veal, 0.8 percent for sheep and goat meat. 42 percent for pork, and 67 percent for poultry meat.

- Industrial production was estimated to account for 39 percent of the sum of global production of these meats and 50 percent of total egg production
- In the U.S., according to its National Pork Producers Council, 80 million of its 95 million pigs slaughtered each year are reared in industrial settings

5.3.2. Vertical farming

Vertical farming is a system of food production in controlled. door environments. This allows factory style precision agriculture This approach can reduce the environmental impact and the influence of environmental variability associated with future climate change on food production.

1. Important features of vertical farming

- Controlled Environment Agriculture (CEA), more commonly known as Vertical Farming, is the process of growing food or other agricultural products within factory-style situations, without the typical natural resources associated with plant production, such as soil and sunlight.
    - These resources are instead provided via the use of innovative lighting and nutrient delivery technologies.

- Vertical farming is most commonly associated with urban farm production systems, as these can easily be integrated into urban landscapes, reducing the length of supply chains.
    - This style of production may also have the potential to benefit general agricultural production outside of urban situations.
    - Using controlled environments, crops can be cultivated which may otherwise be unsuited to UK climates reducing reliance on overseas supply chains.
- Food production systems also face numerous future challenges with regard to feeding growing populations.
    - Vertical Farming allows for faster, more controlled production, irrespective of season.
    - One acre of vertical farming can provide the product equivalent to between 10-20 acres of convention production.
- This system offers a model to enable greater future food security

- As production through such controlled systems is not vulnerable to a variety of factors such as climate or pests and pathogens.
    - A vertical farm can take advantage of low value land otherwise unavailable for food production.
- Vertical Farming is thus regarded as a realistic future farming system, which may offer the stable model needed for future food production, to provide for the 3 billion increase in population predicted by 2050.

2. Current systems

There are three main systems utilised for CEA:

- Hydroponics
- Aeroponics
- Aquaponics

- All three are systems for the growth of vegetation using no soil, but instead nutrient rich water solutions, which plant roots access directly.

i. Hydroponics

- In hydroponic systems, the nutrient solution is pumped around reservoirs which the plant roots grow directly.
- This increases the degree of aeration of the roots, which can have favorable effects in terms of plant health and growth potential.

ii. Aeroponics

- In aeroponic systems, the plant roots grow free and a water and nutrient solution is sprayed directly onto them.

iii. Aquaponics

- Aquaponics is a combination of aquaculture and hydroponics
- Linking these systems means that the plants can use the fish waste as a fertilizer
- Meanwhile, the hydroponic system filters the water before returning it to the fish.
    - This can be an effective production system when emp fish pairings requiring similar environmental condition are chosen.

- It reduces the cost burden for fertilizer and produces an additional crop in the form of fish.

3. Environmental Impact

- Reducing the environmental impact of modern farming is important to achieve sustainability.
- Vertical Farming systems can offer a raft of potential opportunities to reduce environmental impact.
  - This approach offers a system with no loss of nutrients to the environment.
  - Vastly reduced land requirement (10-20 times),
  - Better control of waste, less production loss to pests and diseases (~40% less).
  - Year round crop production, increased daylight hours or growing time per day, no variation in productivity due to weather variation, and no adverse effects of extreme weather events.
  - Most vertical farms also use 70-80% less water than conventional growing.
- Globally, around 70% of the fresh water available for hum use is used for agriculture, which is a major environmental and human health issue.
- In the UK, this figure is much lower (-10%); but this is likely increase as a consequence of climate change.
- A CE system can present a scenario where, in principal, all production factors can be regulated.
- The precise nature of this approach means that the use of expensive materials such as fertilizer can be targeted and limited to only what is necessary.
- This system therefore avoids costly and damaging losses to the environment.
- As a simple consequence of regulating all the inputs to plants, the potential for inadvertent contamination is also reduced.

- In typical field environments, heavy metals or pathogens can contaminate soils, both inadvertently through the application of soil treatments and fertilizer, or via natural
- High levels of control therefore reduce the interaction between crops and pests or pathogens, increasing food security and safety.
- In extreme instances, should bio-security measures fail and disease outbreaks occur, then production can be resumed in the short term, whereas in typical agriculture the same effect is likely to mean a lost year.

Using Life Cycle Analysis (LCA) it has been possible to assess the carbon footprint of food grown through CEA. This analysis shows that at the moment more carbon is emitted as a result of CEA production than conventional techniques.

- This effect may be offset by the application of renewable energy sources.
- The use of renewable energy could reduce the carbon footprint enough to equal or exceed conventional production.

In addition, intensifying production in controlled situations such as this, which require a relatively small footprint in land terms, allows more land to be set aside for natural processes and ecosystem service provision. It has even been suggested that the land freed from agricultural production because of this approach, could be returned to hardwood forestry, which could actively mitigate against the effects of climate change.

4. Energy efficiency

The principal limiting factor in a CE system is the amount of energy required to grow produce, and thus the economic cost of production. This fact has drawn criticism from several areas with regard viability, and to whether CEA has merit in terms of reducing environmental impact and delivering food security solutions

However, modern renewable energy technologies may hold great potential in terms of converting sunlight and wind power im usable energy for internal heating and lighting.

- Low energy lighting systems, such as those utilizing LED bulbs may limit the level to which energy is required.

A study that modelled energy requirements indicated that solar panels could produce sufficient energy to meet the lighting and water pumping requirements, suggesting a good degree of feasibility in production terms with the application of renewable energy technologies

- This is likely to only be the case in areas with plentiful sunlight
- Vertical farms have yet to be built taking advantage of developments in energy efficient architectural design. (1 Passivhaus).
- By growing selected crops, a vertical farmer knows exactly
    - What the internal environment is that they require
    - A building can be designed to maintain that environment with the maximum use of energy efficient technologies such as:
        - Heat recovery
        - Passive ventilation
        - Advanced materials
- Food production in controlled environments allows systems to be developed which can capitalize on all opportunities to recapture and re-use resources.
- This can come in both the recycling of building energy, or the recovery of energy from the non-used plant products, such as roots.

Vertical Farms have basic requirements for heat, energy, Co, and nutrients and as such, represent an excellent opportunity for co- location with other systems. Any operation or process that generates a surplus of these resources is an opportunity to improve the economic potential of both that business and a vertical farm.

Examples:

It could be on-farm anaerobic digestion, renewable energy production, CHP plants, server farms or industrial food processing plants.

- This mutually beneficial economic model potentially allows value to be reclaimed from what would otherwise be wasted resources, and which would require further energy to generate a new

5.4. VIRTUAL WATER TRADE AND ITS IMPACTS ON LOCAL ENVIRONMENT

5.4.1. Virtual water

- Producing goods and services generally requires water.

- The water used in the production process of an agricultural or industrial product is called the 'virtual water' contained in the product. For producing 1 kg of grain we need, for instance 1000-2000 kg of water, equivalent to 1-2 m^3.
- Producing livestock products generally require even more water per kilogram of product.
- For producing 1 kg of cheese we need, for instance 5000-5500 kg of water and for 1 kg of beef we need in average 16000 kg of water.
- If one country exports a water-intensive product to another country, it exports water in virtual form. In this way some countries support other countries in their water needs.
- Trade of real water between water-rich and water, poor regions is generally impossible due to the large distances and associated costs, but trade in water-intensive products (virtual water trade) is realistic.
- For water-scarce countries, it could therefore be attractive to achieve water security by importing water-intensive products instead of producing all water-demanding products domestically.
- Water-rich countries could profit from their abundance of water resources by producing water-intensive products for export

The concept of 'virtual water has been introduced by Torty Allan in the early nineties. It took nearly a decade to get global recognition of the importance of the concept for achieving regional and global water security.

The first international meeting on the subject was held in December 2002 in Delft, the Netherlands. A special session is devoted 10 the issue of virtual water trade at the Third World Water Forum in Japan, March 2003.

1. Definition of 'virtual water'.

Virtual water is the water 'embodied in a product, not in the real sense, but in a virtual sense. It refers to the water needed for the production of the product.

Virtual water has also been called 'embedded water or exogenous water', the latter referring to the fact that import of virtual water into a country means using water that is exogenous to the importing country.

- Exogenous water is thus to be added to a country's "indigenous water'.

- If it comes to a more precise quantitative definition, principally two different approaches have been proposed and applied so far.

Approaches

i. In one approach, the virtual water content is defined as the volume of water that was in reality used to produce the product.

- This will depend on the production conditions, including place and time of production and water use efficiency.
- Producing one kilogram of grain in an arid country. for instance, can require two or three times more water than producing the same amount in a humid country.

ii. In the second approach, one takes a user rather than a producer perspective, and defines the virtual water content of a product as the amount of water that would have been required to produce the product at the place where the product is needed

- This definition is particularly relevant if one poses the question: how much water do we save if we import a product instead of producing it ourselves?
- In the second approach to the definition of 'virtual water' a difficulty arises if a product is imported to a place where the product cannot be produced, for instance due to the climate conditions.

2. The practical value of the virtual water concept

- The virtual water concept has basically two major types of practical use.
- Virtual water trade as an instrument to achieve water security and efficient water use Net import of virtual water in a water- scarce nation can relieve the pressure on the nation's own water
- Virtual water can be seen as an alternative source of water.
- Using this additional source can be an instrument to achieve regional water security.

The economic argument behind the virtual water trade is that according to international trade theory, nations should export products in which they possess a relative or comparative advantage in production, while they should import products in which they possess a comparative disadvantage.

Virtual water trade between nations can be an instrument to increase 'global water use efficiency. From an economic point of view, it makes sense to produce the water-intensive products demanded in this world in those places where water is more abundantly available.

3. Quantifying the virtual water content of products

Assessing the virtual water content of a product is not an easy task, because there are many factors influencing the amount of water used in a production process.

4. Factors of Virtual water

The following factors should at least be considered and preferably provided together with the estimates

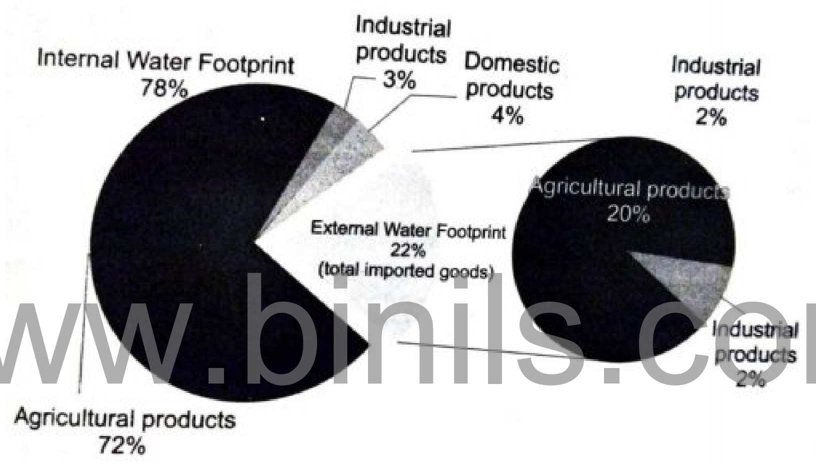


Fig. 5.5 Global water footprint

- The place and period (e.g. which year, which season) of production.
- The point of measurement. In case of irrigated crop production, the question is for instance, whether one measures water use at the point of water withdrawal or at the field level.
- The production method and associated efficiency of water use A relevant question is whether water wasted is included in the estimate.
- The method of attributing water inputs into intermediate products to the virtual water content of the final product.
- Considering the various studies available, little convergence exists with respect to the general approach taken.

5.4.2. Impacts on local environment

1. **Insufficient consideration of the consequences of proposed water saving policies to farm households**

According to Dennis Wichelns of the International Water Management Institute: "Although one goal of the virtual water analysis is to describe opportunities for improving water security, there is almost no mention of the potential impacts of the prescriptions arising from that analysis on farm households in industrialized or developing countries.

It is essential to consider more carefully the inherent flaws in the virtual water and water footprint perspectives, particularly when seeking guidance regarding policy decisions."

2. **Regional water scarcity should be taken into account when interpreting water footprint**

The application and interpretation of water footprints may sometimes be used to promote industrial activities that lead to facile criticism of certain products.

Example:

The 140 litres required for coffee production for one cup might be of no harm to water resources if its cultivation occurs mainly in humid areas, but could be damaging in more arid regions.

Other factors such as hydrology, climate, geology, topography, population and demographics should also be taken into account. Nevertheless, high water footprint calculations do suggest that environmental concern may be appropriate.

The use of the term footprint can also confuse people familiar with the notion of a carbon footprint, because the water footprint concept includes sums of water quantities without necessarily evaluating related impacts. This is in contrast to the carbon footprint, where carbon s are not simply summarized but normalized by CO, emissions, emissions a which are globally identical, to account for the environmental harm.

The difference is due to the somewhat more complex nature of water, while involved in the global hydrological cycle, it is expressed in conditions both local and regional through various forms like river basins, watersheds, on down to groundwater (figure. 5.5).

3. **Sustainable water use**

Sustainable water use involves the rigorous assessment of all sources of clean water to establish the current and future rates of use, the impacts of that use both downstream and in the wider area where the water may be used and the impact of contaminated water streams on the environment and economic well being of the area. It also involves the implementation of social policies such as water pricing in order to manage water demand.

In some localities, water may also have spiritual relevance and le the use of such water may need to take account of such interests. For example, the Maori believe that water is the source and foundation all life and have many spiritual associations with water and places Sociated with water.

On a national and global scale, water sustainability requires strategic and long term planning to ensure appropriate sources of clean Water are identified and the environmental and economic impact of ach choices are understood and accepted.

The re-use and reclamation of water is also part of sustainability, including downstream impacts on both surface waters and ground waters.

5.5. AGRICULTURAL ENVIRONMENT POLICIES AND ITS IMPACTS

5.5.1. Agricultural Environment Policies

- Agricultural policies, including price and income supports, were not originally developed to affect environmental quality in any way. They included no explicit conservation objectives.
- Agricultural policies influence farming practices mainly by changing the relative costs and returns of using resources in agriculture, or by imposing direct restrictions on output and input use.
- In particular, agricultural policy influence farming activities through changes in:
    - The relative prices of inputs and outputs.
    - Direct and indicate restrictions on the use of inputs and outputs.
    - Incentives (or disincentives) for adopting new practices.
    - Impediments to resource movement.
    - Agricultural and rural infrastructure.

- The main objectives of agricultural policy are to support farm incomes and ensure a stable and reasonably priced supply of food.
- These objectives are achieved through a complicated system of farm programs that insulate the farm sector from the market economy by artificially supporting the prices of certain commodities, and controlling their supply.
- Each mechanism employed to support commodity prices, farm incomes and control the supply goals have had secondary, and unintentional, effects on environmental quality.
- As well as price supports, agricultural policies may include trade barriers, subsidies for inputs and direct payments to farmers.
- It is increasingly recognized that price supports provided to farmers have encouraged them to expand their production, making intensive use of potentially polluting inputs such as chemical fertilizers and pesticides.
- The effects of agricultural policies on the environment also involve some uncertainties.
- To make things more complex, many policies are administered on a commodity basis.
    - Whereas the environmental effects of agriculture are resource-specific.
- There can be a considerable time lag between a change in a policy and its environmental impact.
- The effects of changes in policies and production practices on the environment are often gradual and cumulative.
- It may take some time before they become noticeable and measurable.

5.5.2. Integration of Agricultural and Environmental Policies

1. Goals and Principles

- Integration means to make whole, or to bring different parts together.
- Policy integration requires that policy instruments designed to achieve a particular objective in one sector should first be assessed in terms of their effects on other sectors.

- Conflicts and inconsistencies are common in agricultural policy programs. They arise because the policies have different goals.

Example:

An environmental policy to control non-point source pollution in agriculture must consider the effects on farm incomes and water quality.

- Agricultural policies designed to raise farm incomes must be assessed in terms of their effect on the environment.
- An integrated approach requires that we consider simultaneously the potential impact of environmental policy on agricultural production, incomes and prices.
- Integrating agricultural and environmental policies requires a clear understanding of the fundamental concepts underlying sustainable development.
- Sustainability is about being fair to the future, or inter generational welfare. More specifically, the central goal is to maintain a certain environmental stock, or its equivalent, for current and future generations. For the individual farmer, inter generational welfare means the transfer of his stewardship of environmental and other assets to others.

i. Goals

To achieve sustainability, the public decision processes must incorporate the shadow prices of environmental quantity and quality. Shadow prices reflect the social opportunity costs of using the resources, whether they are traded in markets or allocated in some other manner.

- Conservation of the natural resource base has emerged as a goal of environmental policy.
- This is critical, because agricultural production relies heavily on the quality and quantity of the natural resource base.
- Agriculture produces a wide array of positive environmental services, and affects the quality of environmental resources used by the public.

These broad goals give us a general policy direction, we need more specific principles to develop programs for integrating agricultural and environmental policies.

ii. Principles

The following principles to achieve integrated agricultural and environmental policies have been formulated by OECD(1993).

- View rural countryside assets as a source of agricultural products and environmental services.
- Promote comprehensive resource use efficiency by directly or indirectly, including environmental shadow prices.
- Alter agricultural commodity program provisions that cause distortions in inputs, or crop and livestock outputs, which result in environmental degradation.
- Encourage farmers to recognize that it is in their and society's best interests to maintain and enhance their asset base.
- Promote pollution prevention rather than waste management. Target specific environmental objectives rather than use broad agricultural and environmental initiatives.
- Apply the principle "The polluter pays".
- Create an administrative framework which can promote integration.

As mentioned above, the basic principle for integrating agricultural and environmental policies is: "The polluter pays". This principle states that the polluter should be held responsible for any environmental damage he causes, and bear the expenses of preventing pollution. OECD adopted this principle in 1972, to encourage the rational use of scarce environmental resources.

iii. Instruments of Policy Integration

Integrating agricultural and environmental policies has three dimensions (OECD 1989).

a. First, there is institutional integration â€" the development of administrative structures designed to ensure greater co-operation among the ministries and various agencies responsible for agriculture and the environment.

b. Second, there is the need for integrative procedures, including the development of agreed objectives.

- The need to integrate agricultural and environmental policies has now become formally recognized by most countries.

- This has led to the revision of procedures for policy formulation.

c. Third, there is a whole set of integrative instruments. These are sometimes subdivided into three broad categories:

- Regulatory instruments
- Economic instruments
- Moral

- The traditional instruments of Agri-environmental policy is regulatory or administrative.
- They try to influence the environmental performance of polluters directly, by regulating the processes or products used, or by abandoning or limiting the use of potential pollutants through licensing, standards and zoning.
- Instruments of Agri-environmental policy are labeled economic if they affect probable costs and benefits of alternatives, in this way influencing the decisions taken.
- Economic instruments are based on the polluter-pays-principle.
- Subsidies are economic instruments only if they influence the cost-benefit ratio of certain activities in the direction of a reduced impact on the environment.
- The moral suasion approach is used to bring about a voluntary change in behavior.
- Basically, this involves greater awareness of environmental issues, and a greater sense of responsibility in individual decision-making.
- This approach often uses the threat of possible regulations in order to bring about voluntary change, supported by economic incentives and disincentives.

I do not want to go deeper into a theoretical discussion of environmental instruments. Instead, I should like to focus on the question: what kind of instruments for environmental protection can be applied to the agricultural sector?

- Agri-environmental policy generally refers to a group of programs that encourage farmers to adopt environmentally sound production practices.

- Policy instruments or tools range from a coercive approach, such as regulations or environmental taxes, to a voluntary approach such as technical assistance and subsidies.

2. Regulatory approach

- The regulatory approach is the most important set of policy instruments.
- Regulatory action may restrict the availability of environmentally hazardous agricultural inputs, or prohibit the use of environmentally damaging production practices.
- It can be applied uniformly to all farmers, or may target specific farming operations or particularly vulnerable production areas.
- The most common adverse effect of environmental regulations is a change in the distribution of incomes within the farming sector.
- Other effects include an increase in the cost of agricultural production, with the possibility of higher consumer prices and decreased trade competitiveness.
- The regulatory approach has only been employed if the perceived environmental costs are high.
- The political and administrative structure of many countries, prevents the strict enforcement of regulations.

Only the most blatant offenses are penalized. Because of these limitations, it is usual to use voluntary programs to achieve the desired state of the environment and the economy, and social well-being.

If all externalities of agricultural policies could be internalized and all changes in relative prices anticipated, near-perfect incentive systems could be designed.

However, it is impossible to anticipate changes in input costs. Nor is it possible to account for all externalities, or all the local effects of a national incentive-based system. Moreover, often the information costs associated with such schemes are prohibitive.

In many cases, regulations backed by appropriate sanctions can be targeted more precisely than economic incentives. In particular, they do not require a knowledge of the nature of damage functions, and are not sensitive to price variations.

3. Economic incentive approach

- There is now widespread interest in the use of economic instruments to complement regulatory instruments for environmental management.
- These include taxes on farm inputs which are sources of pollution, on farm emissions, or taxing farmers for their failure to meet required levels of environmental quality.
- An approach being tried in several countries is the use of input taxes to reduce the use of agricultural chemicals.

Fertilizer charges as high as 100% are needed to reduce pollution significantly. However, taxes of only 10-20% may have a favorable effect. Kim and Kim (2001) showed that a tax of 100% on the nitrogen in chemical fertilizer leads to a reduction of 14.6% in fertilizer use and a fall of 0.3% in rice yield and 3.1% in farm income. Generally, taxes raised in this way are used to finance pollution control and finance research into improving input use.

- A subsidy program might pay farmers who use environmentally friendly production practices such as sound nutrient management or Integrated Pest Management (IPM).

- When the issue is not one of pollution, but rather one of or enhancing the environment, incentive schemes are particularly effective.
- The administrative costs of incentive-based approaches are often significantly lower than regulatory schemes.
- Most governments have a strong preference for this approach.

4. Cross-compliance

- Cross-compliance means that a farm operation must meet certain requirements in order for the farmer to be eligible for assistance under government support schemes.
- Farmers claiming support under one program have to meet the rules for that program and certain obligations of other programs.
- This makes a link "across programs", giving rise to the term "cross-compliance".
- Cross-compliance is a marvelous way of ensuring that participants. in commodity programs to keep to minimum standards of environmental conservation. It has

increased the consistency between farm commodity programs and environmental objectives, yielding significant environmental gains.

Example:

Participants in some programs have been obliged to use fertilizer and pesticides in stipulated ways.

Various forms of cross-compliance and their consequences for the agricultural sector and the environment have not yet been fully examined. However, the requirements may be made in a variety of ways:

- One or several conditions which apply across the board must be fulfilled.
- A choice can be made from several sets of conditions, as a kind of a package system.
- An even more flexible opinion is the points system, whereby several options are combined to achieve the required number of points.
- Point systems or package systems are a more flexible approach, as they enable farmers to select the options that fit in with the actual situation on their farms.
- This is important, because certain options may be feasible in some areas but not in others.

5. Advisory approach

Voluntary or direct advisory approaches to farmers are widely used in most OECD countries to achieve agricultural objectives (OECD 1993). To be successful, they must take into account all the economic conditions faced by farmers. Problems have been encountered if advisory methods alone are used, to try and persuade farmers to adopt environmentally friendly farming practices.

- In most countries, advisory approaches are supplemented by:
    - Regulations and economic incentives.
    - In addition, education and technical assistance, help farmers to adopt environmentally benign practices.
- Assistance may include providing data on soil quality. disseminating information about new sustainable practices, and helping farmers prepare conservation plans.

- Providing the public with information may increase the use of conservation practices by farmers.
- Training, education and demonstration projects spread information and make farmers aware of the environmental effects of alternative farming practices. Such programs are completely voluntary.
- Their effectiveness largely depends on whether a given practice provides enough benefits to farmers to offset the cost of adoption.
- The relative efficiency of a voluntary program increase if
    - There is no rivalry between different government services.
    - Government services are less expensive than those provided by the private sector.
    - Enforcement costs are compared to those regulations and restrictions.

5.5.3. Environmental Impacts of Agriculture

The environmental impact of agriculture is the effect that different farming practices have on the ecosystems around them, and how those effects can be traced back to those practices.

- The environmental impact of agriculture varies based on the wide variety of agricultural practices employed around the world.
- The environmental impact depends on the production practices of the system used by farmers.
- The connection between emissions into the environment and the farming system is indirect, as it also depends on other climate variables such as rainfall and temperature.
- There are two types of indicators of environmental impact:
    - Means-Based
    - **Effect-Based**

Means-Based

"Means-based", which is based on the farmer's production methods..

Example:

A means-based indicator would be the quality of groundwater, that is affected by the amount of nitrogen applied to the soil.

Effect-Based

"Effect-based", which is the impact that farming methods have on the farming system or on emissions to the environment. An indicator reflecting the loss of nitrate to groundwater would be effect-based.

The means-based evaluation looks at farmers' practices of agriculture, and the effect-based evaluation considers the actual effects of the agricultural system.

Example:

Means-based analysis might look at pesticides and fertilization methods that farmers are using, and effect-based analysis would consider how much CO, is being emitted or what the Nitrogen content of the soil is.

The environmental impact of agriculture involves a variety of factors from the soil, to water, the air, animal and soil variety, people. plants, and the food itself.

- Some of the environmental issues that are related to agriculture are:

  - Climate change
  - Deforestation
  - Genetic engineering
  - Irrigation
  - Pollutants
  - Soil degradation
  - Waste
  - Issues by region

1. Climate change

- Climate change and agriculture are interrelated processes, both of which take place on a worldwide scale.
- Global warming is projected to have significant impacts on conditions affecting agriculture, including temperature, precipitation and glacial run-off.

- These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals.
- Rising carbon dioxide levels would also have effects, both detrimental and beneficial, on crop yields.
- Assessment of the effects of global climate changes on agriculture might help to properly anticipate and adapt farming to maximize agricultural production.

Although the net impact of climate change on agricultural production is uncertain it is likely that it will shift the suitable growing zones for individual crops.

- Adjustment to this geographical shift will involve considerable economic costs and social impacts.
- At the same time, agriculture has been shown:
    - To produce significant effects on climate change," primarily through the production and release of greenhouse gases such as carbon dioxide, methane, and nitrous oxide.

In addition, agriculture that practices tillage, fertilization, and pesticide application also releases ammonia, nitrate, phosphorus, and many other pesticides that affect air, water, and soil quality, as well as biodiversity.

Agriculture also alters the Earth's land cover, which can change its ability to absorb or reflect heat and light, thus contributing to radiative forcing. Land use change such as deforestation and desertification, together with use of fossil fuels, are the major anthropogenic sources of carbon dioxide; agriculture itself is the major contributor to increasing methane and nitrous oxide concentrations in earth's atmosphere.

2. Deforestation

- Deforestation is clearing the Earth's forests on a large scale worldwide and resulting in many land damages.
- One of the causes of deforestation is to clear land for pasture or crops.
- According to British environmentalist Norman Myers, 5% of deforestation is due to cattle ranching, 19% due to over-heavy logging, 22% due to the growing sector of palm oil plantations, and 54% due to slash-and-burn farming.
- Deforestation causes the loss of habitat for millions of species, and is also a driver of climate change.

- *Trees act as a carbon sink: that is, they absorb carbon dioxide, an unwanted greenhouse gas, out of the atmosphere.
- Removing trees releases carbon dioxide into the atmosphere and leaves behind fewer trees to absorb the increasing amount of carbon dioxide in the air
- In this way, deforestation exacerbates climate change.

When trees are removed from forests, the soils tend to dry out because there is no longer shade, and there are not enough trees to assist in the water cycle by returning water vapor back to the environment.

- With no trees, landscapes that were once forests can potentially become barren deserts.
- The removal of trees also causes extreme fluctuations in temperature.

In 2000 the United Nations Food and Agriculture Organization (FAO) found that "the role of population dynamics in a local setting may vary from decisive to negligible," and that deforestation can result from "a combination of population pressure and stagnating economic, social and technological conditions."

3. Genetic engineering

Genetically engineered crops are herbicide-tolerant, and their overuse has created herbicide resistant "super weeds", which may ultimately increase the use of herbicides. Seed contamination is another problem of genetic engineering; it can occur from wind or bee pollination that is blown from genetically-engineered crops to normal crops.

About 50% of corn and soybean samples and more than 80% of canola samples were found to be contaminated by Monsanto's (genetic Engineering company) genes.[citation needed].

- This accidental contamination can cause organic farmers to lose a lot of money because they needed to recall their products.
- There are various cases of this such as in the corn and alfalfa industry.

4. Irrigation

Irrigation lead to a number of problems:

- Among some of these problems is the depletion of underground aquifers through over drafting

- Soil can be over-irrigated because of poor distribution uniformity or management wastes water, chemicals, and may lead to water pollution.
- Over-irrigation can cause deep drainage from rising water tables that can lead to problems of irrigation salinity requiring water table control by some form of subsurface land drainage.
- If the soil is under irrigated:
    - It gives poor soil salinity control which leads to increased soil salinity with consequent buildup of toxic salts on soil surface in areas with high evaporation.
- This requires either leaching to remove these salts and a method of drainage to carry the salts away.
- Irrigation with saline or high-sodium water may damage soil structure owing to the formation of alkaline soil.

5. Pollutants

- Synthetic pesticides such as 'Malathion', 'Rogor', 'Kelthane' and 'confidor' are the most widespread method of controlling pests in agriculture.
- Pesticides can leach through the soil and enter the groundwater, as well as linger in food products and result in death in humans and non-targeted wildlife.
- A wide range of agricultural chemicals are used and some become pollutants through use, misuse, or ignorance.
- The erosion of topsoil, which can contain chemicals such as herbicides and pesticides, can be carried away from farms to other places.
- Pesticides can be found in streams and ground water.
- Atrazine is a herbicide used to control weeds that grow among crops.
- This herbicide can disrupt endocrine production which can cause reproductive problems in mammals, amphibians and fish that have been exposed.
- Pollutants from agriculture have a huge effect on water quality.
- Agricultural Nonpoint Source (NPS) solution impacts lakes, rivers, wetlands, estuaries, and groundwater.

- Agricultural NPS can be caused by poorly managed animal feeding operations, overgrazing, plowing, fertilizer, and improper, excessive, or badly timed use of Pesticides.
- Pollutants from farming include sediments, nutrients, pathogens, pesticides, metals, and salts.
- Animal agriculture can also cause pollutants to enter the environment.
- Bacteria and pathogens in manure can make their way into and groundwater if grazing, storing manure in lagoons and applying manure to fields is not properly managed.
- Listed below are additional and specific problems that may arise the release of pollutants from agriculture.
    - Pesticide drift
        - Soil contamination
        - Air pollution spray drift
- Pesticides, especially those based on organochloride
- Pesticide residue in foods
- Pesticide toxicity to bees
    - List of crop plants pollinated by bees
    - Pollination management
- Bioremediation

6. Soil degradation

- Soil degradation is the decline in soil quality that can be a result of many factors, especially for agriculture.
- Soils hold the majority of the world's biodiversity, and healthy soils are essential for food production and an adequate water supply.

Common attributes of soil degradation can be salting, waterlogging, compaction, pesticide contamination, decline in soil structure quality, loss of fertility, changes in soil acidity, alkalinity, salinity, and erosion.

- Soil erosion is the wearing away of topsoil by water, wind, or farming activities.

- Topsoil is very fertile, which makes it valuable to farmers growing crops.
- Soil degradation also has a huge impact on biological degradation, which affects the microbial community of the soil and can alter nutrient cycling, pest and disease control, and chemical transformation properties of the soil.
    - Soil contamination
    - Sedimentation

7. Waste

- Plasticulture is the use of plastic mulch in agriculture.
- Farmers use plastic sheets as mulch to cover 50-70% of the soil and allows them to use drip irrigation systems to have better control over soil nutrients and moisture.
- Rain is not required in this system, and farms that use plasticulture are built to encourage the fastest runoff of rain.
- The use of pesticides with plasticulture allows pesticides to be transported easier in the surface runoff towards wetlands or tidal creeks
- The runoff from pesticides and chemicals in the plastic can cause serious deformations and death in shellfish as the runoff carries the chemicals towards the oceans.
- In addition to the increased runoff that results from plasticulture, there is also the problem of the increased amount of waste from the plastic mulch itself.
- The use of plastic mulch for vegetables, strawberries, and other row and orchard crops exceeds 110 million pounds annually in the United States.

Most plastic ends up in the landfill, although there are other disposal options such as disking mulches into the soil, on-site burying. on-site storage, reuse, recycling, and incineration.

The incineration and recycling options are complicated by the variety of the types of plastics that are used and by the geographic dispersal of the plastics.

Plastics also contain stabilizers and dyes as well as heavy metals, which limits amount of products that can be recycled. Research is continually being conducted on creating biodegradable or photodegradable mulches

While there has been a minor with this, there is also the problem of how long the plastic takes to degrade, as many biodegradable products take a long time to break down.

8. Issues by region

- The environmental impact of agriculture can vary depending on the region as well as the type of agriculture production method that is being used.
- Listed below are some specific environmental issues in a various different regions around the world.
  - Hedgerow removal from the United Kingdom.
  - Soil salinization, especially in Australia.
  - Phosphate mining in Nauru
  - Methane emissions from livestock in New Zealand.
  - Environmentalists attribute the hypoxic zone in the Gulf of Mexico as being encouraged by nitrogen fertilization of the algae bloom.

5.6. SUSTAINABLE AGRICULTURE

Sustainable agriculture is the idea that agriculture should occur in a way such that we can continue to produce what is necessary without infringing on the ability for future generations to do the same.

- The exponential population increase in recent decades has increased the practice of agricultural land conversion to meet demand for food which in turn has increased the effects on the environment.
- The global population is still increasing and will eventually stabilize, as some critics doubt that food production, due to lower yields from global warming, can support the global population.
- Agriculture can have negative effects on biodiversity as well.
- Organic farming is a multifaceted sustainable agriculture set of practices that can have a lower impact on the environment on the small scale.
- In most cases organic farming results in lower yields in terms of production per unit area.

Therefore, widespread adoption of organic agriculture will require additional land to be cleared and water resources extracted to meet the same level of production.

A European meta-analysis found that organic farms tended to have higher soil organic matter content and lower nutrient losses (nitrogen leaching, nitrous oxide emissions and ammonia emissions) per unit of field area but higher ammonia emissions, nitrogen leaching and nitrous oxide emissions per product unit.

- It is believed by many that conventional farming systems cause less rich biodiversity than organic systems.
- Organic farming has shown to have on average 30% higher species richness than conventional farming.
- In organic systems on average also have 50% more organisms.
- This data has some issues because there were several results that showed a negative effect on these things when in an organic farming system.
- The opposition to organic agriculture believes that these negatives are an issue with the organic farming system.
- What began as a small scale, environmentally conscious has now become just as industrialized as conventional agriculture.
- This industrialization can lead to the issues shown above such as climate change, and deforestation.

5.6.1. Conservation Tillage

- Conservation tillage is an alternative tillage method of farming which is more sustainable for the soil and the surrounding ecosystem.
- This is done by allowing the residue of the previous harvest crops to remain in the soil before tilling for the next crop.
- Conservation tillage has shown to improve many things such as soil moisture retention, and reduce erosion.
- Some disadvantages are the fact that more expensive equipment is needed for this process, more pesticides will need to be used, and the positive effects take a long time to be visible.

The barriers of instantiating a conservation tillage policy are that farmers are reluctant to change their methods, and would protest a more expensive, and time consuming method of tillage than the conventional one they are used to.

- Other specific methods include: permaculture; and biodynamic agriculture, which incorporates a spiritual element.
    - Category: Sustainable agriculture
    - Biological pest control

TWO MARKS QUESTIONS AND ANSWERS

1. **Define Global environmental governance.**

Global Environmental Governance (GEG) is the sum of organizations, policy instruments, financing mechanisms, rules, procedures and norms that regulate the processes of global environmental protection.

2. **Enlist the goals of Global environmental governance (GEG).**

    a. Leadership

    b. Knowledge

    c. Coherence

    d. Performance

    e. Main streaming

3. **Write the definition of Alternate Culture Systems.**

The term 'Alternative agriculture as it applies to the area of agriculture can be defined as "A systematic approach to farming intended to reduce agricultural pollution, enhance sustainability, and improve efficiency and profitability.

4. **Mention any two Benefits of alternative agriculture.**

    i. Permaculture can help farmers produce more food using fewer resources through Agroecology - a farming approach that mimics natural ecosystems

    ii. Small-scale farmers produce food for 70% of the global population. Yet, they are some of the world's poorest and most food insecure people.

5. **What is Mega farming?**

"Intensive animal farming or industrial livestock production, is known as factory/mega/intensive farming, is a productive approach towards farm animals in order to maximize production output, while minimizing production costs".

6. **What is vertical farming?**

Vertical farming is a system of food production in controlled, indoor environments. This allows factory style precision agriculture. This approach can reduce the environmental impact and the influence of environmental variability associated with future climate change on food production.

7. **Write the definition of 'virtual water'.**

Virtual water is the water embodied in a product, not in the real sense, but in a virtual sense. It refers to the water needed for the production of the product.

Virtual water has also been called 'embedded water' or 'exogenous water', the latter referring to the fact that import of virtual water into a country means using water that is exogenous to the importing country.

8. **Define the Sustainable agriculture.**

Sustainable agriculture is the idea that agriculture should occur in a way such that we can continue to produce what is necessary without infringing on the ability for future generations to do the same.

9. **What are the Environmental impacts of Agriculture?**

a. Climate change

b. Deforestation

c. Genetic engineering

d. Irrigation

e. Pollutants

f. Soil degradation

g. Waste

h. Issues by region

10. **How the Climate change and agriculture are interrelated?**

Climate change and agriculture are interrelated processes, both of which take place on a worldwide scale. Global warming is projected to have significant impacts on conditions affecting agriculture, including temperature, precipitation and glacial runoff.

These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals. Rising carbon dioxide levels would also have effects, both detrimental and beneficial, on crop yields.

REVIEW QUESTIONS

1. Assess the Challenges, Goals of Global environmental governance and deduce the Evidence of Environmental Degradation.
2. What is Alternate Culture System? Explain the Process and Benefits of alternative agriculture.
3. Explain the Virtual water trade and its impacts on the local environment.
4. Explore the pros and problems of Mega farms and vertical farms in the production of food.
5. Integrate the Agricultural and Environmental Policies and explain its environmental impacts.