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AI 3019

SUSTAINABLE AGRICULTURE AND FOOD SECURITY

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UNIT IV

SUSTAINABLE FOOD PRODUCTION FOR FOOD SECURITY

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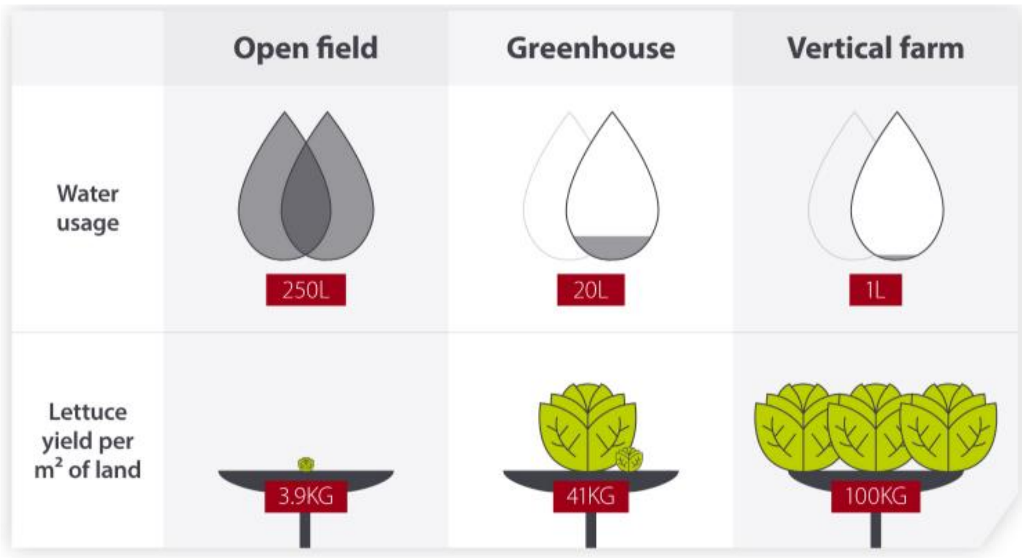
Inside a CEA facility, you'll see produce underneath LED growing lights with hydroponic (or aquaponic) systems providing water and nutrients. Heaters, ventilators, dehumidifiers, CO2 enrichment, humidifiers and coolers are used to regulate optimum growing climates.

These sheltered, controlled mini-ecosystems mean that plants can be grown all year round. They are safe from outside contamination (including E. coli) and make use of UV lights to remove bacteria.

When you can remove the challenges that come with traditional farming, the implications on output, long-term cost savings and environmental impact are enormous. There is significantly less need for heavy machinery, pesticides, herbicides or fertilisers, and you will use significantly less water (CEA allows us to produce crops with 70% to 95% less water than required for normal cultivation).



4.8 Genetic diversity

Genetic diversity in crop production refers to the variety of genetic material within and among plant species that are cultivated for food, fiber, and other agricultural purposes. This diversity is critical for improving the resilience, yield, and adaptability of crops to changing environments and challenges, such as pests, diseases, and climate change. Here's an overview of how genetic diversity plays a role in crop production:

1. Improved Disease Resistance

- Genetic diversity allows for the development of crops that are resistant to specific pests, diseases, or environmental stresses. When a crop is genetically uniform (monoculture), it can be more vulnerable to disease outbreaks, as a single pathogen or pest can wipe out the entire crop. Diverse genetic varieties, on the other hand, may have different levels of resistance to the same threat, reducing the risk of total crop loss.

2. Adaptation to Changing Environments

- Climate change presents a challenge for crop production by altering temperature, precipitation patterns, and the frequency of extreme weather events. Crop varieties with diverse genetic traits can help ensure that some crops can thrive under new conditions. For example, certain varieties of wheat may tolerate drought better than others, while others may perform well under cooler temperatures.

3. Increased Yield Potential

- Cross-breeding different varieties of crops with complementary traits can lead to improved yields. Genetic diversity can allow breeders to select traits such as faster growth, better disease resistance, or improved nutrient uptake. Through such breeding programs, the productivity of crops can be increased.

4. Resilience to Pests and Environmental Stresses

- Pests and diseases are constantly evolving, which makes it essential to have a broad genetic pool of crops to help ensure that some varieties remain resistant to these changing threats. Additionally, crops that are genetically diverse can better withstand various environmental stresses, including drought, heat, or soil salinity.

5. Conservation of Genetic Resources

- Genetic diversity is vital for conserving the broader gene pool of crops, which can be important for future breeding efforts. Crop wild relatives and traditional varieties that are genetically distinct from modern commercial crops often hold traits that are useful for enhancing crop performance or adapting to new conditions. This makes conserving genetic diversity a key part of sustainable agriculture.

6. Reduced Dependency on Chemical Inputs

- Genetically diverse crops may require fewer chemical inputs like pesticides and fertilizers because they can naturally resist pests or thrive in diverse soil conditions. This can lead to more sustainable and eco-friendly farming practices.

7. Global Food Security

- Genetic diversity is essential for long-term global food security because it ensures that we have a wide range of options for breeding crops that can cope with both current and future challenges. Having diverse varieties of crops means that we are not overly dependent on a few high-yielding but genetically uniform varieties.

8. Challenges of Maintaining Genetic Diversity

- Despite its importance, genetic diversity is under threat due to modern agricultural practices, such as the widespread use of monocultures, commercial hybrid varieties, and the focus on a small number of high-yield crops. This makes the conservation and promotion of genetic diversity a challenge for sustainable agriculture.

Fig 4.8 Genetic diversity

<u>4.9 GMO's</u>

In 1996, Genetically Modified (GM) Crops were grown in 6 countries. In 2009, the number of countries using GM crops increased to 25. The year 2019 marks the 24th year of commercialization of biotech crops, and the number of countries using GM crops had increased to 29.

Some examples of GM-modified crops are listed below.

1. Genetically Modified Corn that are resistant to larval pests.

2. Genetically modified soybeans that are resistant to weed-killers like Roundup.
3. Genetically modified maize – used as animal feed, high-fructose corn syrup
4. Genetically modified cotton – This has been approved in India along with 9 other nations.
5. Genetically modified Canola – Used as cooking oil, emulsifier in packaged foods.

How Genetically Modified Crops are Made?

Genetic Modification is a technology that involves inserting DNA into the genome of an organism. To produce a GM plant, new DNA is transferred into cells of a plant. These cells are then grown in tissue culture where they transform into plants. The seeds produced by these plants will have new DNA. The most common way of inserting is using gene guns method. The other genetic engineering techniques are electroporation, microinjection and agrobacterium. There are 3 main types of genetic modifications which are listed below.

1. Transgenic – plants have genes inserted into them that are derived from other species.
2. Cisgenic – plants are made using genes of the same species or closely related.
3. Subgeneric – Alter genetic makeup of a plant without incorporating genes from other plants.

What is the Purpose of Genetically Modified Crops?

The multiple purposes behind genetically modified crops are listed below.

1. Higher yields
2. Enhanced nutritional value
3. Longer shelf life
4. Increase resistance to droughts
5. Increase resistance to insects, pests.
6. Increased resistance to herbicides.

Global GM crop cultivation

- The top five GM growing countries are
  - USA (top producer of biotech crops)
  - Brazil (second position)
  - Argentina
  - India
  - Canada
- These countries together account for approximately 90% area of the GM cultivation.
- Soybean, maize, cotton and canola with herbicide tolerance and insect resistance are the major GM crops grown around the world.

Impact of GM crops

- In the period of 23 years (1996-2018), about 17 million farmers, mostly from developing countries, adopted biotech crops, which in turn improved their socio-economic status.
- Apart from the economic benefits, usage of GM crops has also contributed to food security, sustainable development, and climate change mitigation. Those benefits are:
  - It increased crop productivity by 822 million tons;
  - Conserving biodiversity by saving 231 million hectares of land;
  - Adaptation of GM crops has provided a safer environment by saving 776 million kg of pesticides from being released into the environment;
  - GM crops have been helpful in reducing CO2 emissions by 23 billion kg, equivalent to taking 15.3 million cars off the road for one year (2018); and
  - Also, helping alleviate poverty through uplifting the economic situation of 16-17 million small farmers, and their families, totalling >65 million people (2018).

What are the Advantages of Genetically Modified Crops?

- The benefits experienced by the developed world by usage of GM crops are:
  - Higher crop yields
  - Reduced farm costs
  - Increased farm profit
  - Safer environment
  - More nutritious food
- The features of **first generation crops** such as insect resistance and herbicide tolerance have proven their ability to lower farm-level production costs.
- The features of **second-generation GM crops** include increased nutritional and/or industrial traits. These crops have more direct benefits to consumers.
- Examples of commercialized second generation crops include
  - Non-browning apples
  - Non-bruising and low acrylamide potatoes
  - Maize varieties with low phytic acid and increased essential amino acids
  - Healthier oils from soybean and canola
- Other GM crops in the research and/or regulatory pipeline include:
  - Rice enriched with iron, vitamin A and E, and lysine
  - Potatoes with higher starch content, and inulin
  - Insect resistant eggplant
  - Edible vaccines in maize, banana, and potatoes
  - Allergen-free nuts

What are the Disadvantages of Genetically Modified Crops?

As per reports, there are various disadvantages of genetically modified crops

1. Allergies, other anti-nutritional factors in foods
2. Resistance to antibiotics
3. Cancer

The above-mentioned disadvantages are not conclusive, and a lot more research is required to throw more light on the same.

GM Crops and the Environment

Environmental benefits

- Dramatic reduction in pesticide use. GM technology has reduced chemical pesticide use by 37 percent.
- Reduction in the release of greenhouse gas emissions from agriculture.

Fig 4.9 GMO's

4.10 Sustainable food security indicators and index

Sustainable food security is a concept that integrates the idea of access to nutritious food with environmental sustainability and economic stability. It involves ensuring that people have access to sufficient, safe, and nutritious food while promoting agricultural systems that are resilient and sustainable in the long term. To measure and monitor food security in a sustainable way, various indicators and indices have been developed. These are used to assess the progress of countries, regions, or communities toward achieving food security in the context of sustainability.

1. Indicators of Sustainable Food Security

Indicators of sustainable food security help measure various dimensions, including food availability, access, utilization, and stability, as well as environmental and economic factors. These include:

A. Availability of Food

Food Production Index: Measures the overall production of food in a country or region. A higher food production index indicates more food is available.

Agricultural Land Use Efficiency: Tracks the efficiency with which agricultural land is used to produce food, ensuring that land is used sustainably without degradation.

Crop Yield per Hectare: Measures how efficiently land produces food. Sustainable increases in crop yields help ensure long-term food security.

B. Access to Food

Income and Poverty Levels: The percentage of the population living below the poverty line affects access to food. High levels of poverty mean that many people may not have enough income to buy sufficient food.

Food Prices: Fluctuations in food prices can impact access, especially in low-income areas. Stable and affordable prices are key to sustainable access.

Social Safety Nets: Indicators of government policies, such as food assistance programs and subsidies, which help improve access to food for vulnerable populations.

C. Utilization of Food

Nutrition Status (e.g., Prevalence of Undernutrition): This measures the health and nutritional status of the population, including child malnutrition rates (e.g., stunting, wasting, and underweight).

Micronutrient Deficiencies: The proportion of people with deficiencies in key micronutrients (e.g., iron, vitamin A, iodine) indicates food utilization and dietary quality.

Water and Sanitation Access: Safe drinking water and sanitation infrastructure are critical for proper food utilization. Lack of access to clean water can hinder the body's ability to fully absorb nutrients.

D. Stability of Food Security

Food Price Volatility: Large fluctuations in food prices over time can undermine food security, especially for low-income households.

Climate Resilience: The ability of a region to cope with climate-related shocks (e.g., droughts, floods) directly impacts food stability.

Supply Chain Resilience: The robustness of food supply chains against disruptions (e.g., conflicts, pandemics, natural disasters) is another important indicator.

E. Environmental Sustainability

Biodiversity: The preservation of biodiversity within agricultural landscapes supports sustainable food production systems and maintains ecosystem services such as pollination and soil fertility.

Water Use Efficiency: Measures how efficiently water is used in agriculture. Overuse or mismanagement of water resources can lead to droughts, depletion of aquifers, and ecological damage.

Soil Health Indicators: Monitoring soil degradation, erosion, and organic matter content is essential for long-term agricultural sustainability.

Carbon Footprint: The greenhouse gas emissions associated with food production, transportation, and waste are key to ensuring that food security is achieved without furthering climate change.

2. Indices of Sustainable Food Security

Several indices have been developed to quantify and track progress on sustainable food security at the global, national, or regional level. These indices often combine multiple indicators into a single composite measure for easier monitoring and comparison.

A. Global Hunger Index (GHI)

The GHI is a tool designed to comprehensively measure and track hunger at global, regional, and national levels. It considers:

Proportion of the population that is undernourished.

Prevalence of stunting and wasting in children under 5.

Child mortality rates.

While it focuses on hunger, it also provides insight into sustainable food security by looking at the factors that contribute to long-term food availability and access.

B. Food Insecurity Experience Scale (FIES)

The FIES measures the experience of food insecurity through survey data on whether people have enough food or experience difficulty accessing it. It helps track not just availability but the economic and social dimensions of food insecurity.

It is used to understand how individuals and households cope with food insecurity and assess food security levels at the national and global levels.

C. Sustainable Development Goals (SDGs) Indicators

The SDGs, particularly Goal 2 (Zero Hunger), have specific indicators for tracking progress toward sustainable food security, such as:

Prevalence of undernourishment.

Proportion of children under 5 who are stunted or overweight.

Agricultural productivity and income of small-scale food producers.

Sustainable food production systems.

The SDG framework helps monitor progress on food security with an emphasis on sustainability and inclusivity.

D. Food Sustainability Index (FSI)

The FSI ranks countries based on their sustainability in food systems. It takes into account:

Nutritional quality of diets.

Environmental sustainability (e.g., carbon emissions, food waste).

Resilience and efficiency of food systems.

Health impacts of the food system.

This index emphasizes the link between food security and environmental and health sustainability.

Fig 4.10 Sustainable food security indicators and index