IWGI
INDIGENOUS WOMEN AND GIRLS INITIATIVE

FIMI
INTERNATIONAL INDIGENOUS WOMEN'S FORUM

AGROECOLOGY TRAINING MANUAL

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PURPOSE OF THE AGROECOLOGY TRAINING MANUAL

- It serves as a comprehensive guide to equip farmers, extension workers, and other stakeholders with the knowledge and skills necessary to adopt and implement agroecological practices.
- Democratize knowledge; make agroecological information accessible to a wide audience.
- Build capacity; strengthen the capacity of farmers and extension workers to implement agroecological practices.
- Standardize approaches; provide a common framework for agroecological training.
- Facilitate knowledge transfer; share best practices and lessons learned.
- Support policy development; inform policy makers about the potential of agroecology.

PREAMBLE

Agroecology represents a comprehensive approach to agriculture that emphasizes the integration of ecological principles into farming systems to create more sustainable, resilient, and equitable food systems. In response to increasing environmental challenges, such as soil degradation, climate change, and the loss of biodiversity, agroecology provides a comprehensive framework that empowers farmers to work in harmony with nature while enhancing food security, improving livelihoods, and promoting social justice.

This Agroecology Training Manual is designed to equip farmers, extension workers, and other stakeholders with the knowledge and tools necessary to adopt and implement agroecological practices. Through practical, firsthand guidance and a deep understanding of ecological processes, this manual aims to foster sustainable agricultural practices that contribute to healthier ecosystems, stronger communities, and vibrant economies.

Structured across eight core modules, the manual covers critical areas such as soil health, biodiversity, ecological pest management, animal health, and land governance. It highlights the importance of biodiversity, recycling, synergy, and economic diversification, among other principles, to build farming systems that are not only productive but also environmentally regenerative. The manual also promotes the co-creation of knowledge, encouraging the integration of traditional and scientific knowledge to address local challenges and opportunities.
By promoting fairness, connectivity, and participation, the manual supports a more equitable distribution of resources and fosters inclusive decision-making processes. These values are key to achieving the broader goals of agroecology, which include enhancing community well-being, ensuring the sustainable use of natural resources, and creating food systems that prioritize both human and environmental health.

This manual serves as a comprehensive guide to help farmers and stakeholders transition towards agroecological practices, ensuring that agriculture remains a viable and sustainable solution for future generations. Through this shared journey, we aim to cultivate ecosystems that are resilient, productive, and equitable for all.

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Module 1:
INTRODUCTION TO AGROECOLOGY
Agroecology Concept

Agroecology is an integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of food and agricultural systems. Agroecological approaches use natural processes to optimize the interactions between plants, animals, humans, and the environment while taking into consideration local and scientific knowledge and the social aspects that address for sustainable and fair food system.

BENEFITS OF AGROECOLOGY

01

Food and Nutrition Security

1. Promotes Biodiversification of plants and animals resulting to increased dietary diversity.
2. Promotes self-sufficiency through food and seed sovereignty which brings back as much control as possible to local farmers and other local food system actors.
3. Offers opportunities for livelihood diversification through the integration of livestock, beekeeping, and non-timber forest products, providing additional sources of income for ASAL communities.

02

Human health

1. Enhanced food safety; reduced health risks from pesticides and reduced use of chemical fertilizers.
2. Reduce the budget incurred on health provision because of reduced incidences of non-communicable diseases.

03

Environmental

1. Promotes nature-based solutions that enhance adaptation and mitigation against climate change.
2. Enhanced ecosystem services through biodiversity conservation, integrated soil fertility management.
3. Reduce hidden externality (environmental cost of production) substantially.

05

Social-cultural

1. Restoration, and preservation of indigenous knowledge and genetic resources.
2. Foster strong linkages between producers and consumers through a circular and solidarity economy.
3. Change power relationships by encouraging greater participation in decision-making on food systems.
4. Places a strong focus on the rights of women, youth, and Indigenous peoples

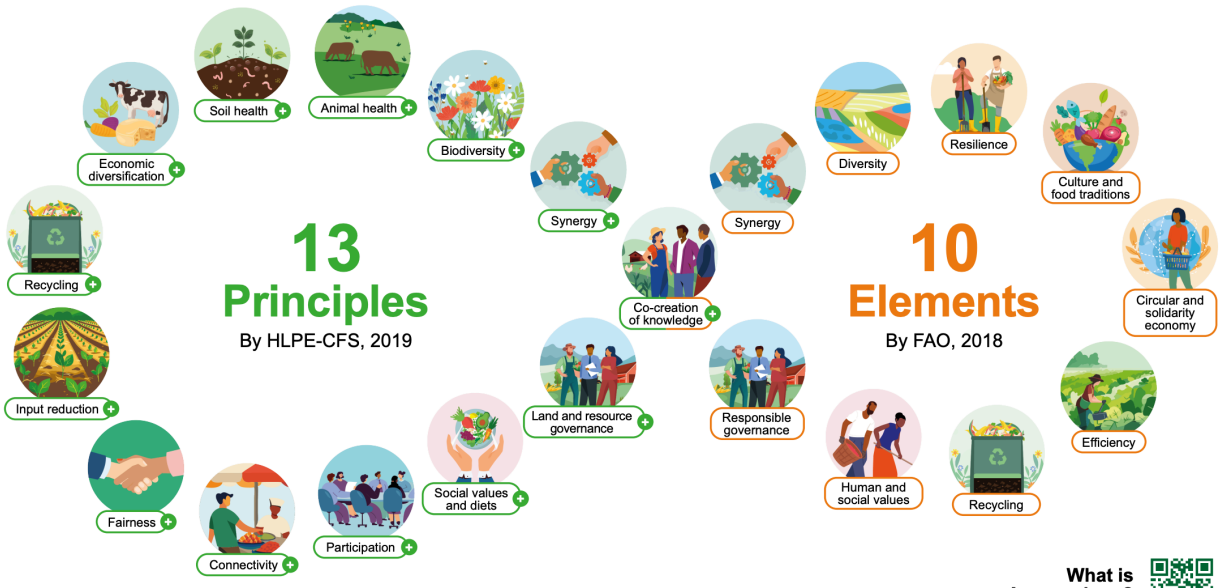
05

Economic

1. Production of agroecological inputs such as organic fertilizers and bio-pesticides will create green jobs for the youth and women.
2. Reduces cost of production by promoting producing more with fewer external inputs.
3. Increased productivity due to the use of agroecological inputs.

PRINCIPLES OF AGROECOLOGY

1. Biodiversity
2. Recycling
3. Animal health
4. Input reduction
5. Synergy
6. Soil Health
7. Economic diversification
8. Co-creation of knowledge
9. Fairness
10. Connectivity
11. Land and resource governance
12. Social Values and diets
13. Participation



What is Agroecology?

As you explore the infographic, you will come across the word «farmer» several times. This is often used to indicate other food producers (fisher-folks, herders...)

Module 2:
SOIL HEALTH AND RECYCLING

A) SOIL HEALTH

Secure and enhance soil health and functioning for improved plant health growth, particularly by managing organic matter and by enhancing soil.

B) RECYCLING

It means agricultural production with lower economic and environmental costs. Recycling delivers multiple benefits by closing cycles and reducing waste which translates into lower dependency on external resources, increasing the autonomy of producers, and reducing their vulnerability to market and climate shocks. Recycling organic materials and by-products offers great potential for agroecological innovations.
For example, agroforestry systems that include deep-rooting trees can capture nutrients lost beyond the roots of annual crops. Crop–livestock systems promote the recycling of organic materials by using manure for composting or directly as fertilizer, and crop residues and by-products as livestock feed.

SOIL FERTILITY MAINTENANCE
1.COMPOSTING

Composting is a biological process during which naturally occurring microorganisms, bacteria, and insects break down organic materials such as leaves, grass clippings, and certain kitchen scraps into a soil-like product called compost. It is a form of recycling, a natural way of returning needed nutrients to the soil.

ADVANTAGES OF COMPOSTING

1. It promotes the growth of plants and roots
2. It improves the rate of nutrient diffusion
3. It improves soil porosity
4. It improves the water retention capacity
5. It increases resistance to erosion by wind and water
6. Compost attracts and feeds earthworms.
7. Compost improves the pH (acidity/alkalinity) of the soil.
8 .Compost reduces the water demand of plants and trees.
9. Compost helps control erosion.
10. Compost reduces plant stress in periods of drought or frost.
11. Compost can lengthen plant growth periods.
12. Compost improves the content of minerals and vitamins in foods grown in soils rich in compost.
13. Compost applied generously to the soil can completely replace petrochemical fertilizers.
14. Composting is the recycling system of nature.

Requirements / Materials: Rough materials (twigs), Dry materials, Animal manure/Droppings, Topsoil, green plants, Ash/eggshells, Water, Soil, and dry grass to cover.

Procedure

1. Begin building a compost pile by putting a bottom layer of rough materials such as maize stalks and hedge cuttings in the pit. This layer should be about 30 cm thick. Chop up any materials that are too long to improve the air circulation in the pile. Sprinkle some water on this layer.
2. Add a second layer of dry vegetation, hedge cuttings, or grass. This layer should be about 15 cm thick (6 inches). Sprinkle water on this layer
3. Put on a third layer of animal manure. The manure contains micro-organisms which are vital for decomposition.
4. Sprinkle some ash or dust on this layer. The ashes contain valuable minerals including potassium, phosphorus, calcium, and magnesium. The ashes also neutralize the acids produced during decomposition, especially by the animal manure.
5. The next layer should be green leaves from high-protein leguminous trees
6. Sprinkle on a little topsoil or old compost. The topsoil contains bacteria which are useful in the decomposition process. Add more layers in turn, starting with dry vegetative materials, then animal manure or slurry, followed by wood ash, green vegetation, and topsoil. Remember to sprinkle water on every layer. Build the pile up to 1.5 m (5 feet) high.

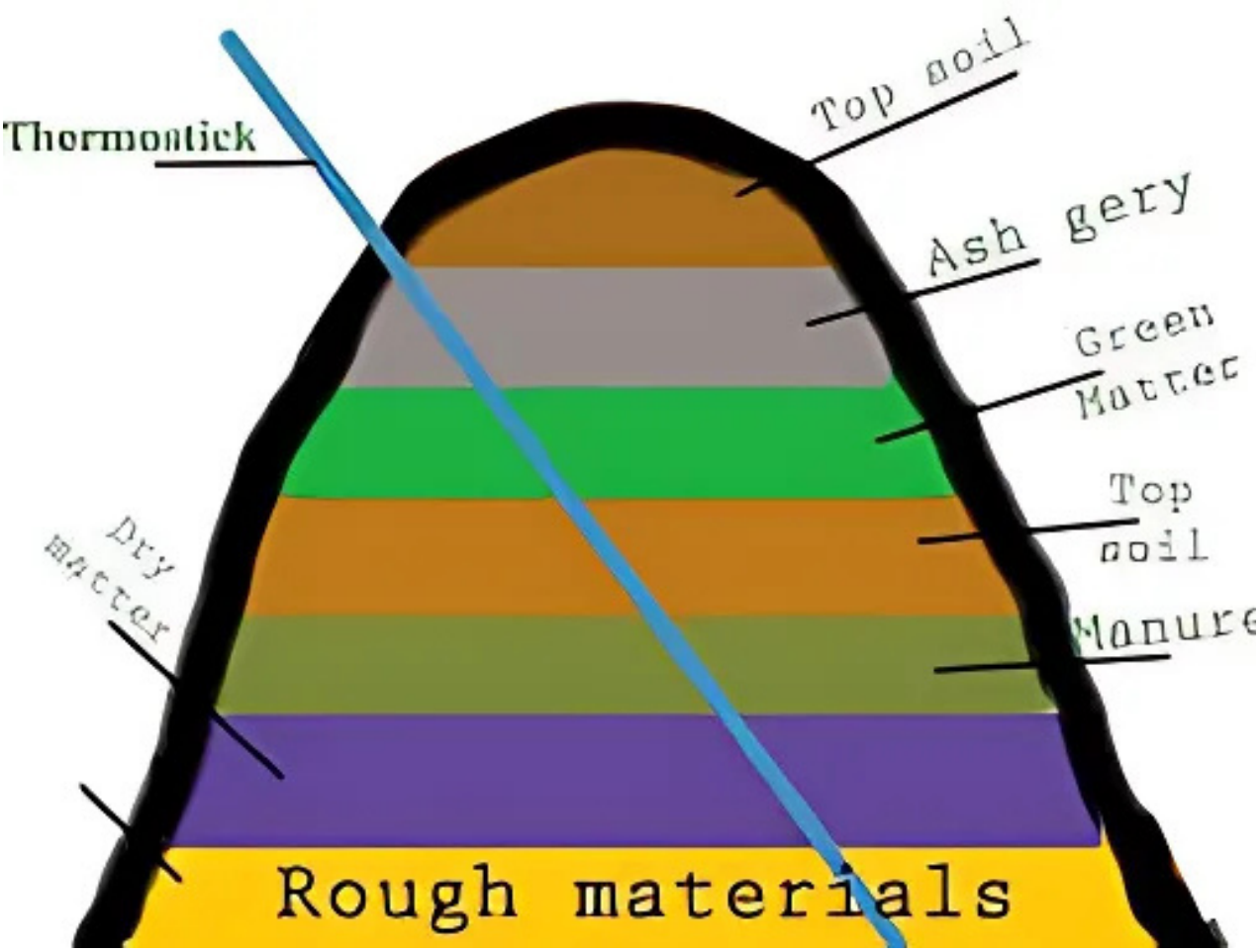
7. To complete the pile, cover it all over with a layer of topsoil about 10 cm (4 inches) thick. This layer prevents plant nutrients from escaping from the compost pile. Lastly, cover the whole with dry vegetation such as banana leaves to reduce moisture loss by evaporation.

8. Take a long, sharp, pointed stick and drive it in at an angle so that it passes through the pile from top to bottom. This stick will act as your “thermometer”

9. Pull the “thermometer stick” out from time to time to check the progress of the pile. You can also tell from the thermometer how dry or wet the pile is: it should be moist but not wet.

10. After 2-3 weeks, turn the pile over to mix the layers.

11. The compost will be ready after 4 weeks.



COMPOST MANURE

Farmyard manure

It refers to the decomposed mixture of dung and urine of farm animals along with litter and leftover material from roughages or fodder fed to the cattle. A well-decomposed farmyard manure improves the soil structure, increases soil capacity to hold water and nutrients, and increases the microbial activity of soil to improve its mineral supply.

Biochar

Is a carbonaceous porous substance derived from biomass. Biomass helps to increase crop yield while sustaining essential soil biodiversity. Provides nutrient-rich soil amendment that improves soil fertility and plant yield.

Bokashi is fermented manure used for soil amendment.

Ingredients for making Bokashi and their functions.

1. Manure

-Acts as inoculant for microbes
-Adds minerals

2. Soil

-Holds minerals
-Brings local microbes

3. Rice husks/Coffee husks

-Helps in soil texture/structure
-Holds moisture and improve aeration
-Husks is a source of silicon that aids in building soil structure, hence reduces soil erosion.

4. Wheat/Rice Ban

-Food for microbes
-Source of vitamin B-good for fermentation

5. Charcoal dust

-Home for microbes
-Retains humidity and nutrients
-Holds minerals
-Good for root development
-Aids oxygen availability.

6. Ash/Rock dust

-Good source of minerals
-Regulates PH
-Helps to hold moisture

7. Molasses

-Source of energy
-Food for microbes (yeast)
-Adds minerals.

8. Yeast

-Sets the right temperature for the microbes
-Aids in fermentation.

9. Water

-Medium for microbes to live in.

Procedure for making Bokashi.

1. Pour the sawdust, soil, manure, wheat bran, charcoal dust, and ash into a container or a shaded area on the ground. Water the layers with a solution of water, molasses, and yeast. Repeat this process until all materials are finished. Thoroughly mix the materials and continue to water. This allows for the air to get in.
2. Turn the mixture twice a day for three days and after three days, the mixture is turned once a day for ten days.
3. The bokashi manure will be ready for use after 15 days and should not be kept for more than 30 days.

PLANT TEAS/ FOLIAR MANURES

Materials needed: Drum, water, green vegetation

Procedure:

1. Chop the green plants into small pieces
2. Put them into a drum/container
3. Put some water
4. Cover with a polythene paper

Plant tea

After every 3 days, stir the mixture until 10-14 days when it will be ready.

How to use

1. Mix with water at a ratio of 1:2 (1litre of mixture diluted with 2 liters of water)
2. It is applied to boost the growth of the plant through the provision of nitrogen.

LIQUID MANURE

Liquid manure is applied as top dressing as the crop grows. It can be made from any livestock manure.

Materials: Drum animal manure, stick and sack

Procedure:

1. Put manure into a sack of 30-50 Kgs
2. Tie the sack with the pole and suspend it into a drum
3. Put water into the drum
4. Put it under a shade to reduce the rate of evaporation or cover with a polythene paper
5. Let the liquid manure stay for 3 days after which, shake it until 15 days are over.
6. After 15 days the liquid manure is ready.

How to use:

1. Mix with water at a ratio of 1:2
2. Apply around the base of the plant.
3. Avoid putting on leaves to avoid burning

Liquid manure

OTHER PRACTICES THAT ENHANCE SOIL FERTILITY

a) Polycultures: Cropping systems in which two or more crop species are planted within a certain spatial proximity, resulting in biological complementarities that improve nutrient use efficiency and pest regulation, thus enhancing crop yield stability.

b) Agroforestry systems: Trees grown together with annual crops, in addition to modifying the microclimate, maintain and improve soil fertility as some trees contribute to nitrogen fixation and nutrient uptake from deep soil horizons while their litter helps replenish soil nutrients, maintain organic matter, and support complex soil food webs.

c)Cover crops and mulching: The use of pure or mixed stands of grass-legumes, e.g., under fruit trees, can reduce erosion and provide nutrients to the soil, and enhance biological control of pests. Flattening cover crop mixtures on the soil surface in conservation farming is a strategy to reduce soil erosion and lower fluctuations in soil moisture and temperature, improve soil quality, and enhance weed suppression, resulting in better crop performance.

c)Green manures are fast-growing plants sown to cover bare soil. Their foliage smothers weed and their roots prevent soil erosion. When dug into the ground while still green, they return valuable nutrients to the soil and improve soil structure.

d)Crop-livestock mixtures: High biomass output and optimal nutrient recycling can be achieved through crop-animal integration. Animal production that integrates fodder shrubs planted at high densities, intercropped with improved, highly productive pastures and timber trees all combined in a system that can be directly grazed by livestock, enhances total productivity without need of external inputs.

MODULE 3: SYNERGY

Enhance positive ecological interaction, integration, and complementarity among the elements of agroecosystems (plants, animals, trees, soil and water

AGROFORESTRY

Is a land use management system in which trees or shrubs are grown around or among crops or pastureland.

Types of Agroforestry

1. **Agrisilvicultural systems;** it involves combination of crops and trees, such as home gardens.
2. **Silvopastoral systems;** it involves combination of forestry and grazing of domesticated animals on pastures, rangelands or on-farm.
3. **Agr-osylvopastoral systems;** it involves combination of trees, crops and domesticated animals.

Characteristics of trees for agroforestry

- Marketable; includes both the wood, nuts and fruits which would provide another source of income.
- Compatible with companion crops or forage; avoid trees that produce alello-chemicals that inhibit growth of crops.
- High quality; should be nitrogenous trees that can be able to fix nitrogen in the soil.
- Deep rooted; to avoid competition for moisture and nutrients
- Have rapidly decomposing foliage

Advantages of Agroforestry

1. Improvement of soil fertility; leaves, fruits and branches of trees that fall down and decompose, thereby increasing organic matter and recycling of nutrients.
2. Effects on soil moisture and microclimate; shading and windbreak effects of trees influence microclimate and help to conserve soil moisture by reducing water that evaporates into air.
3. Soil conservation; trees cushion the impact of raindrops on the soil and reduce amount of rain-splash. Their roots binds/stabilize the soil.
4. Improvement of biodiversity; agroforestry systems improve diversity and quantity of wildlife/animals by offering a greater variety of habitat.

Disadvantages of agroforestry

While agroforestry offers numerous benefits, it is important to acknowledge and consider the potential disadvantages and challenges associated with its implementation. Here are some of the disadvantages of agroforestry.

1. **Initial Investment and Establishment Costs:** Establishing an agroforestry system requires an upfront investment, including the costs of land preparation, purchasing tree seedlings, fencing, and other infrastructure. The initial investment can be a barrier for farmers with limited financial resources.
2. **Longer Time to Yield:** Unlike monoculture systems where crops can be harvested in a shorter time frame, agroforestry systems often require a longer time to reach full productivity. Trees take several years to mature and provide significant yields, which may impact short-term income generation.
3. **Complexity and Management Challenges:** Agroforestry systems are more complex than monoculture systems, requiring additional knowledge, skills, and management efforts. Proper management and maintenance of trees, crops, and sometimes livestock within the same system can be challenging and time-consuming, especially for farmers without access to training or technical support.
4. **Competition for Resources:** In some cases, trees and crops within an agroforestry system may compete for resources such as light, water, and nutrients. Poor planning or inadequate spacing between trees and crops can lead to reduced crop yields or hinder tree growth. Careful selection and proper management are essential to mitigate resource competition.
5. **Pest and Disease Management:** The presence of multiple plant species in agroforestry systems may increase the risk of pests and diseases. The spread and management of pests and diseases within the system can be more complex compared to monoculture systems. Integrated pest management strategies and regular monitoring are necessary to address potential pest and disease issues effectively.

Types of Agroforestry Trees

1. Avocado
2. Tree tomato
3. Pawpaw
4. Passion fruit
5. Strawberry
6. Gravelia
7. Podocarpus

Director IWGI, Ms. Monicah with Taac Berur Self Help Group at their tree nursery

Tree nursery with variety of tree seedlings

PRINCIPLES OF AGROFORESTRY

- **Biodiversity:** Agroforestry promotes biodiversity by integrating a variety of tree species, crops, and livestock within the same area. This diversity helps to support a wide range of plant and animal species, creating a more resilient and ecologically balanced system.
- **Tree-Crop-Livestock Interactions:** Agroforestry systems are designed to optimize the interactions and synergies between trees, crops, and livestock. For example, trees can provide shade and windbreaks for crops, improve soil fertility through nitrogen fixation, and provide fodder for livestock.
- **Multiple Outputs:** Agroforestry aims to produce multiple outputs from the same piece of land. These outputs can include food crops, timber, fruits, nuts, medicinal plants, and livestock products. By diversifying production, agroforestry systems can provide farmers with a more stable and sustainable income.
- **Soil Conservation and Improvement:** Trees in agroforestry systems play a crucial role in preventing soil erosion by reducing the impact of raindrops, improving water infiltration, and stabilizing the soil structure. Tree roots also help to enhance soil fertility by recycling nutrients and organic matter.
- **Climate Change Mitigation and Adaptation:** Agroforestry has the potential to mitigate climate change by sequestering carbon dioxide from the atmosphere through tree growth and reducing greenhouse gas emissions associated with conventional agricultural practices. Additionally, trees in agroforestry systems can provide shade and reduce temperature extremes, creating a more favorable microclimate for crops and livestock.
- **Water Management**: Agroforestry systems contribute to improved water management by reducing water runoff and enhancing water infiltration into the soil. Tree roots help to hold moisture in the soil and reduce the risk of droughts and floods.
- **Social and Economic Benefits**: Agroforestry can provide numerous social and economic benefits to farmers and communities. It can diversify income sources, create employment opportunities, enhance food security, and contribute to local economies through the production of marketable tree products.
- **Knowledge Sharing and Collaboration**: Agroforestry is based on the principle of knowledge sharing and collaboration between farmers, researchers, extension agents, and other stakeholders. By exchanging experiences and expertise, agroforestry practices can be continually improved and adapted to different ecological and socio-economic contexts.

These principles guide the design and implementation of agroforestry systems, allowing for the integration of trees into agricultural landscapes to achieve multiple benefits and promote sustainable land use.

Case studies of successful agroforestry practices in various regions.

Here are some of the case studies for successful agroforestry practices for various regions:

1. Taungya System in Thailand: The Taungya system is an agroforestry practice where crops are grown in the early stages of reforestation. In Thailand, the Royal Forest Department implemented the Taungya system in degraded forest areas. Local communities were involved in planting trees alongside food crops such as maize, rice, and vegetables. This approach helped restore forest cover, improve soil fertility, and provide additional income from agricultural produce.
2. Alley Cropping in Niger: In Niger, the implementation of alley cropping systems has had significant success. Farmers have planted rows of trees, such as Faidherbia albida, in between their crops. The trees fix nitrogen from the air, improve soil fertility, and provide shade to the crops. This has led to increased crop yields and improved food security for local communities, even in arid regions

Maintenance of agroforestry trees, pruning and thinning

Maintenance of agroforestry trees, including pruning and thinning, is essential to ensure their healthy growth, productivity, and long-term sustainability. Here are some considerations and techniques for maintaining agroforestry trees:

1. **Pruning Objectives:** Clearly define the objectives of pruning. Pruning can serve various purposes, such as shaping tree form, improving tree structure, controlling pests and diseases, increasing light penetration, promoting fruit production, or enhancing timber quality. Different pruning techniques may be employed depending on the specific objectives.
2. **Timing of Pruning:** Timing of pruning depends on the species, growth stage, and the desired outcome. In general, pruning is often conducted during the dormant season (winter or early spring) to minimize the impact on tree growth and minimize disease transmission. However, species with specific growth patterns or objectives may require pruning at different times of the year.
3. **Pruning Techniques:** Different pruning techniques are employed based on the pruning objectives and tree species characteristics. Common techniques include:- Crown Thinning: Removing selected branches or limbs within the crown to increase light penetration, improve air circulation, and reduce crown density.Crown Raising: Removing lower branches to provide clearance for under planting, agricultural activities, or access.-Crown Reduction: Pruning back the length of branches to reduce overall tree height or maintain a desired tree shape.Heading or Topping: Cutting back the leader or main branches to stimulate lateral branching and encourage bushier growth.Deadwood Removal: Removing dead, diseased, or damaged branches to prevent the spread of pests and diseases and improve tree health.Thinning of Fruit Trees: Removing excess fruiting wood to enhance fruit size, quality, and tree productivity.Training and Shaping: Pruning to guide tree growth and shape young trees, especially in orchards or hedge-like systems.
4. **Tools and Techniques:** Use appropriate tools, such as sharp pruning shears, loppers, pruning saws, or pole pruners, depending on the size of branches to be pruned. Ensure tools are clean and disinfected to prevent disease transmission. Make clean cuts just outside the branch collar to facilitate wound healing and minimize damage to the tree.
5. **Thinning:** Thinning refers to the removal of selected trees or branches to reduce tree density and competition. Thinning allows for better light penetration, nutrient availability, and overall tree health. Thinning may be necessary in overcrowded agroforestry systems to promote the growth and productivity of desired tree species or to provide better conditions for companion crops or livestock.

Role of agroforestry in climate change mitigation through carbon sequestration.

Agroforestry systems play a critical role in carbon sequestration by capturing and storing carbon dioxide (CO2) from the atmosphere. Here are some of the roles:

1. Trees in agroforestry systems can sequester significant amounts of carbon through photosynthesis, where they absorb CO2 and convert it into organic matter.
2. Agroforestry promotes the establishment of diverse tree species, which can sequester carbon at different rates and over various timeframes, increasing overall carbon storage potential. The above-ground biomass of trees in agroforestry systems, including trunks, branches, and leaves, acts as a long-term carbon sink.
3. Agroforestry also contributes to carbon sequestration in the soil through the accumulation of organic matter, such as fallen leaves, branches, and root systems. The diverse root systems of trees in agroforestry systems enhance soil structure and increase carbon storage in the form of soil organic carbon.
4. Agroforestry practices that incorporate perennial crops, such as fruit trees or timber species, can provide continuous carbon sequestration over extended periods.
5. Agroforestry systems help mitigate greenhouse gas emissions by reducing reliance on synthetic fertilizers and pesticides, thus minimizing associated carbon footprints.

Combining agroforestry with sustainable land management practices, such as conservation tillage or cover cropping, can enhance carbon sequestration in agricultural landscapes.

Methods and tools for agroforestry extension and education.

The following points highlighted are methods and tools for agroforestry extension and education

1. Demonstration Farms and Field Days:
    - Demonstration farms showcase established agroforestry systems, providing practical learning opportunities for farmers to observe successful models.
    - Field days allow farmers to visit demonstration sites, interact with experienced practitioners, and gain hands-on experience in agroforestry practices.
2. Training Workshops and Farmer Schools:
    - Conducting training workshops on agroforestry practices equips farmers with technical knowledge, skills, and best management practices.
    - Farmer schools provide ongoing education and support, promoting continuous learning and knowledge exchange among farmers.
3. Educational Materials and Publications:
    - Developing educational materials, such as brochures, manuals, and guidebooks, provides farmers with accessible and easy-to-understand information on agroforestry techniques.
    - Publications in local languages and formats increase the reach and effectiveness of educational resources.
4. Mobile Apps and Online Platforms:
    - Utilizing mobile applications and online platforms allows for widespread dissemination of agroforestry information to remote and digitally connected farming communities.
    - These tools can provide interactive learning experiences, decision support tools, and real-time updates.
5. Participatory Learning and Farmer Field Schools:
    - Adopting a participatory approach in farmer field schools engages farmers in the learning process, encouraging peer learning, and empowering them to make informed decisions.
    - Participatory learning fosters community ownership of agroforestry initiatives and increases adoption rates.
6. Audio-Visual Materials and Videos:
    - Creating audio-visual materials, such as videos and podcasts, facilitates visual learning and knowledge retention among farmers.
    - Videos can demonstrate agroforestry practices, benefits, and success stories, making it easier for farmers to understand complex concepts.
7. Local Agroforestry Champions and Knowledge Hubs:
    - Identifying and promoting local agroforestry champions who have successfully implemented agroforestry systems encourages peer learning and inspires others to adopt similar practices.
    - Establishing knowledge hubs or resource centers provides a central location for farmers to access information, share experiences, and receive expert guidance.

8. Community Workshops and Extension Events:
    - Organizing community workshops and extension events allows extension workers to engage directly with farmers, answer questions, and address concerns.
    - Community gatherings foster a sense of collective responsibility for sustainable agroforestry practices.
9. Games and Simulations:
    - Developing educational games and simulations on agroforestry can make learning more engaging and enjoyable for farmers, encouraging active participation and knowledge retention.
    - Gamification can reinforce agroforestry concepts in a playful and interactive manner.
10. On-Farm Trials and Experimentation:
    - Encouraging farmers to conduct on-farm trials and experimentation enables them to test agroforestry techniques and adapt them to their specific conditions.
    - Learning from hands-on experience enhances farmers' confidence in adopting and adapting agroforestry practices

Agroforestry design and planning:

1. **Site Assessment:** Conduct a comprehensive site assessment to understand the agro-climatic conditions, soil characteristics, topography, water availability, and potential environmental constraints. This information guides the selection of suitable tree species, crops, and livestock for the specific site.
2. **Objectives and Goals:** Clearly define the objectives and goals of the agroforestry system. Determine the desired outputs, such as timber production, fruit yield, erosion control, biodiversity conservation, or climate resilience, to guide the design and planning process.
3. Tree-Crop-Livestock Interactions: Identify potential synergies and interactions between trees, crops, and livestock components. For example, shade-providing trees can benefit certain crops, while integrating livestock can provide natural fertilization for the system.
4. **Species Selection:** Select tree species based on their suitability to the site conditions, market demand for products, and ecological functions. Consider the compatibility of tree species with selected crops and livestock for a harmonious coexistence.
5. **Spatial Arrangement and Density:** Plan the spatial arrangement of trees, crops, and livestock to optimize resource use and productivity. Consider factors such as tree spacing, intercropping patterns, and rotational grazing schemes for livestock.
6. **Succession and Timing:** Consider the succession of tree species and crops over time. Plan for staggered planting or crop rotations to ensure continuous yield and productivity while maintaining the balance of the agroforestry system.

7.**Ecosystem Services:** Integrate tree species that provide specific ecosystem services, such as nitrogen fixation, soil improvement, windbreaks, or pollination support for crops. This enhances the ecological functions of the agroforestry system.

8.**Livelihood and Socioeconomic Considerations:** Assess the socio-economic context of the community and farmers involved in the agroforestry project. Ensure that the system aligns with their livelihood needs and preferences.

9.**Water Management:** Incorporate water management strategies, such as rainwater harvesting, contour planting, or mulching, to optimize water use efficiency and reduce soil erosion.

MODULE 4: BIODIVERSITY AND ECONOMIC DIVERSIFICATION

a)Biodiversity

It means agricultural systems which are biodiversity diverse for sustain food production and other ecosystem services like pollination, control of pest and diseases, and soil health.

Diversification is key to agroecological transitions to ensure food security and nutrition while conserving, protecting, and enhancing natural resources. Increasing biodiversity contributes to a range of production, socio-economic, nutrition, and environmental benefits. By planning and managing diversity, agroecological approaches enhance the provisioning of ecosystem services, including pollination and soil health, upon which agricultural production depends. Diversification can increase productivity and resource-use efficiency by optimizing biomass and water harvesting. Agroecological diversification also strengthens ecological and socio-economic resilience, including by creating new market opportunities. For example, in a diversified rice paddy system where the interactions of rice, weeds, insects, fish, and ducks promote key processes (nutrient cycling, pest control, etc.), allowing the rice system to function without need of external inputs.

b)Economic diversification

Diversify on-farm incomes by ensuring small scale farmers have greater financial independence and value addition opportunities while enabling them to respond to demand from consumers

NURSERY ESTABLISHMENT

Nursery – A protected environment /seedbed for the production of planting materials before establishing them in the main field.

Nurseries are established where;

- Seeds are too small to be sown directly in the main field
- Seedlings are delicate when young hence require extra care
- Management is eased by watering, weeding etc.

Site Selection

- Near water source
- Close to planting area
- In a secured area
- Lightly shaded and sheltered area

Types of Nursery Beds

1. Raised bed – Suitable in rainy areas
2. Sunken bed – Suitable in dry areas
3. Movable beds (Flats)

Crop production

Nursery Beds

These are seedbeds which are raised about 15cm from the ground level and measurement of 1.5m by 6m for the standard raised bed.

Preparation

- Select site and clear grasses and weeds
- Measure 1metre wide and any length – should be east to west oriented to facilitate light penetration, minimize effects of heat and to welcome light rays
- Loosen the soil 1 feet deep and add one wheelbarrow of manure and 4 spades of sand for every 3metres and mix well
- Rake the bed into a uniform size
- Make drills or furrows across the bed at 10 – 15cm apart
- Spread seeds thinly and cover with a thin layer of soil
- Beds should be firmed by palm after sowing to ensure close contact between soil and seeds
- Water after firming
- Mulch after first watering

Farmers making a nursery bed for planting.

CROPPING / PLANTING SYSTEMS

These include: -

- Mixed Cropping
- Crop rotation
- Companion planting

1.MIXED CROPPING

This is planting different crops on the same piece of land

Advantages

- High yield per area
- Diseases and pest outbreak: Spread is lower than in mono-cropping
- If one crop fails you can harvest the other one
- It reduces soil erosion because the land is not left bare
- Maximum land use i.e. provision of variety of food.

Mixed farming practices

2.COMPANION PLANTING

This system offers a considerable degree of preventive protection, which occurs naturally for the following reasons:

- Some plants produce aromatic smell, which confuse pests from discovering their food. Plants like onions; Mexican marigold act as repellants therefore reduces the spread and prevalence of pests.
- Biological pest control will occur because pest-to-pest control will take place i.e. pest that affects beans will attack pests that affect maize and vice versa.

Examples:

- Mixture of maize and beans reduces infestation from armyworm.
- Tomatoes planted in rows between cabbages reduce damage by the diamond black moth.
- Potatoes planted in conjunction with onions, beans, and Soya beans reduce damage caused by potato tuber moth.
- Some plants release (exude) chemicals from the roots, which stimulate growth of their companions or perhaps protect it from soil pest.

- Cabbage and Tobacco
- Cucumber and beans/peas
- Cucumber and maize
- Spinach and strawberries
- Sukumawiki and onions
- Turnips and peas
- Potatoes and maize
- Tomatoes and Cabbages

Plants for Companion Cropping

Onions, beans, maize, Mexican marigold, nasturtium, tobacco, stinging nestle, hot pepper, cowpea, potatoes, cabbages, kales, sesbania sesban, caliandra, desmodium, etc.
This is planting of crops which are beneficial to each other e.g. maize and beans, kales and onions, etc.
Maize helps the beans with shade and acts as windbreaks, while beans benefit maize with nitrogen fixation. Kales (sukumawiki) helps the onions by covering them while onions act as repellants thus, they control pests and diseases.

Companion cropping

Advantages:

- The crops supplement one another with nutrients
- They help in the control of pests and diseases since some plants acts as repellants e.g. onions.

3. CROP ROTATION

This is changing of crops seasonally. The farm is always divided into plots and crops are rotated after every harvest.

Crop rotation pattern

The most important consideration in rotation planting is the supply of plant nutrients.

- **Heavy feeder (leafy plants):**

These are crops that take a lot of nutrients from the soil e.g. maize, cabbages, onions, *sukumawiki*, spinach, etc.

- **Moderate feeder**

These are mainly fruit trees and other crops which produce fruits e.g. tomatoes, cucumber, and pepper.

- **Light feeder (root crops)**

These are crops which do not need a lot of compost or manure e.g. carrots, sweet potatoes, cassava, beet roots, etc.

- **Leguminous crops**

These are crops which are good at nitrogen fixation. They fix nitrogen in the soil through their root nodules and improve soil fertility e.g. beans, peas, *dolichos lablab* (*njahi*), cowpeas (*thoroko*), etc

Field / Plot No	*1st year*	*2nd year*	*3rd year*	*4th year*
1	Heavy Feeder e.g. Maize	Legumes Beans	Moderate feeder or fruit crops e.g. tomatoes	Light feeder or root crop e.g. cassava
2	Legumes	Fruit crop	Root crop	Leafy crop
3	Fruit crop	Root crop	Leafy crop	Legumes crops
4	Root crops	Leafy crops	Legumes crops	Fruit crops

Crop rotation guide

KITCHEN GARDENING

A Kitchen Garden is where herbs and vegetables are grown around the house for household use. This is an opportunity for every rural family to make a kitchen garden. The cone kitchen garden is a type of garden that resembles a cone. It consists of arranging soil in a conical shape above the ground to create more space for crop growing. Cone kitchen garden allows for mixed cropping, conserves water, and minimizes space since different species of crops are grown on different layers.

Old circular containers have different circumferences in a manner that they can be concentric.

Site identification: Choose a site that receives sufficient direct sunlight throughout the day and is well-drained.

Examples of Kitchen Gardens

1. Cone garden
2. Sack garden
3. Tyre garden

Benefits of Kitchen Gardening

1. To grow healthy, fresh vegetables yourself
2. To save the cost of buying vegetables and herbs
3. Wasteland around the house can be made productive
4. Waste resources such as sweepings, kitchen scraps and dirt water can be recycled into the garden.

Materials needed for Cone Garden;

1. Dam liner
2. Mixture of soil and manure
3. Gravel/stone
4. Water

Procedure:

- Mark the middle point of the garden site, and arrange the containers/polythene in layers, "one inside and above the other" until you make a height of around 5 feet. Use wooden pegs to mark the radius of each. container/polythene. A 2.3-foot radius is recommended for the outermost circle.
- The Second circle should have a smaller radius than the outer, and the same for all inner circles.
- Keep filling in the soil in that process until you reach the maximum.
- After you fill the soil, water it sufficiently and give it at least 12 hours to settle down before you transplant. If there is space due to the settling down, make sure you refill before transplanting.
- Plant vegetables that are in high demand in your house or your neighborhood.
- Regarding the soil, mix soil with manure in a ratio of one to one. Use manure from any source, just ensure that your manure is well-decomposed.

Cone gardens

MODULE 5: CO-CREATION OF KNOWLEDGE AND SOCIAL VALUES AND DIETS

a. Co-creation of knowledge

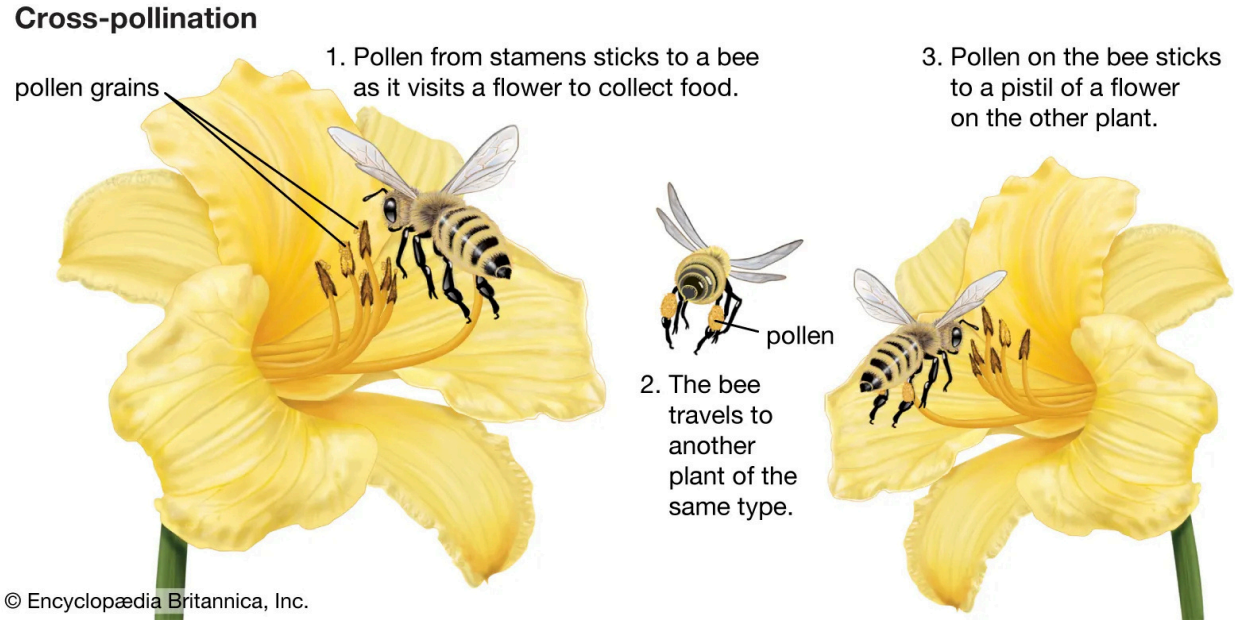
Enhance co-creation and horizontal sharing of knowledge, including local and scientific innovation, especially through farmer-to-farmer exchange.

b. Social values and diets

Protecting and improving rural livelihoods, equity, and social well-being is essential for sustainable food and agricultural systems. Agroecology places a strong emphasis on human and social values, such as dignity, equity, inclusion, and justice all contributing to the improved livelihoods dimension of the SDGs. It puts the aspirations and needs of those who produce, distribute, and consume food at the heart of food systems. Agroecological approaches empower people and communities to overcome poverty, hunger and malnutrition while promoting human rights, such as the right to food, and stewardship of the environment so that future generations can also live in prosperity. Agroecology seeks to address gender inequalities by creating opportunities for women. Globally, women make up almost half of the agricultural workforce. They also play a vital role in household food security, dietary diversity, and health, as well as in the conservation and sustainable use of biological diversity. Despite this, women remain economically marginalized and vulnerable to violations of their rights, while their contributions often remain unrecognized. It also creates employment for youth. As a bottom-up, grassroots paradigm for sustainable rural development, agroecology empowers people to become their own agents of change.

OPEN-POLLINATED SEEDS

Agroecology also promotes the use of open-pollinated seeds. Open pollination means the flowers are fertilized by bees, moths, birds, bats, and even the wind or rain. The seed that forms produces the same plant the following year. Some open pollinated plants are self-pollinators. This means the structure of the flower allows fertilization before it opens. Seed savers must start with open pollinated seeds because hybrid seeds have been crossed already and do not have pure genes. Pure seeds will produce true-to-type offspring, keeping variety strong and consistent. To attain seed purity, it is wise to grow most crops for seeds at a good distance from other varieties and other crops of the same family to avoid cross-pollination.



Farmers are also trained on how to established community seed banks. They save the open pollinated seeds in the seedbanks for planting next season.

Farmers showcasing their indigenous seeds during seed fair

MODULE 6: INPUT REDUCTION

By using existing resources effectively, enhancing biological processes results in optimizing the use fertilizers and minimize the use of pesticides reducing cost production and negative impacts to the environment.

ECOLOGICAL PEST MANAGEMENT (EPM) AND NATURAL REMEDIES

a) ECOLOGICAL PEST MANAGEMENT.

Ecological Pest Management, also known as Ecological Pest Control or Ecological Pest Management (EPM), is an approach to pest management that emphasizes the use of ecological principles and practices to promote natural pest control and minimize the use of synthetic pesticides. It is based on the understanding that pests are part of complex ecological systems and that their populations can be regulated through the manipulation of their natural enemies and the enhancement of biodiversity.

Terms used in EPM.

1. Biological Control: The use of natural enemies, such as predators, parasitoids, and pathogens, to suppress pest populations and maintain their balance.

2. Natural Enemies: Organisms that prey upon, parasitize, or otherwise control pest populations. They can include predators, parasitoids, entomopathogens, and competitors.

3. Beneficial Insects: Insects that provide ecosystem services by contributing to natural pest control. They include predators, parasitoids, and pollinators.

4. Habitat Management: Manipulating or creating habitats that support the presence and abundance of natural enemies, such as flowering plants for nectar and pollen sources.

5. Conservation Biological Control: Practices aimed at preserving and enhancing the populations of natural enemies by providing suitable habitats, food sources, and other resources.

6. Crop Diversity: Planting a variety of different crops or crop varieties to disrupt pest life cycles, reduce pest build-up, and enhance natural enemy populations.

7. Trap Crops: Plants that are attractive to pests and are strategically placed to lure pests away from the main crop, reducing pest damage.
8. Cultural Practices: Farming practices that promote plant health, resilience, and resistance to pests, such as crop rotation, intercropping, and maintaining optimal soil fertility.
9. Thresholds: Pre-determined pest population levels at which action needs to be taken to prevent significant economic or ecological damage.
10. Monitoring: Regular observation and assessment of pest populations, natural enemy populations, and crop conditions to guide decision-making in pest management.
11. Pheromones: Chemical substances emitted by pests to communicate with each other for mating or other behaviors. Synthetic pheromones can be used in monitoring or pest control, such as for mating disruption.
12. Cultural Control: Techniques that modify the crop environment to make it less favorable for pests, such as adjusting irrigation, planting dates, or using physical barriers.
13. Least-Toxic Pesticides: Pesticides that have low toxicity to humans, non-target organisms, and the environment. They are used as a last resort when other pest management strategies are insufficient.
14. Integrated Pest Management (IPM): A holistic approach that integrates various pest management techniques, including ecological methods, to minimize the use of pesticides and reduce the impact of pests.
15. Ecosystem Services: The benefits provided by ecosystems, including natural pest control, pollination, soil fertility, and nutrient cycling. EPM aims to protect and enhance these services

IMPORTANCE OF EPM.

1. Sustainability: EPM promotes long-term sustainability in agriculture by minimizing the reliance on synthetic pesticides, which can have negative effects on human health, non-target organisms, and the environment. It focuses on ecological principles and practices that maintain the balance between pests, natural enemies, and the surrounding ecosystem.
2. Reduced Chemical Inputs: By emphasizing biological control, habitat management, and cultural practices, EPM reduces the need for chemical pesticides. This helps minimize the negative impacts associated with pesticide use, such as pesticide resistance, environmental contamination, and harm to beneficial organisms.
3. Preservation of Natural Enemies: EPM recognizes the value of natural enemies, such as predators and parasitoids, in regulating pest populations. By conserving and enhancing populations of these beneficial organisms, EPM reduces the reliance on chemical control methods, promotes ecological balance, and maintains natural pest control services.

4. Protection of Biodiversity: EPM focuses on creating diverse and resilient ecosystems that support a wide range of organisms. By promoting biodiversity, including beneficial insects, plants, and microorganisms, EPM enhances ecosystem services and helps maintain a healthy and balanced environment.
5. Economic Benefits: EPM can lead to economic benefits for farmers. By reducing pesticide use, farmers can lower input costs, preserve the effectiveness of pesticides for when they are truly needed, and avoid yield losses associated with pesticide resistance. EPM also promotes crop health and productivity through cultural practices and natural pest control, leading to improved crop yields and profitability.
6. Human Health and Safety: By minimizing the use of synthetic pesticides, EPM reduces the potential risks to human health and safety associated with exposure to harmful chemicals. It also helps protect farmworkers, nearby communities, and consumers who may be exposed to pesticide residues on food.
7. Resilience to Climate Change: EPM promotes practices that enhance ecosystem resilience, including soil health, water conservation, and biodiversity. These practices can help agriculture adapt to the impacts of climate change, such as extreme weather events, pests shifting their ranges, and changes in crop productivity.
8. Public Perception and Consumer Demand: There is a growing consumer demand for sustainably produced food and a preference for products that minimize environmental impact. EPM aligns with these expectations, enhancing the reputation and marketability of agricultural products.

PRINCIPLES OF EPM

1. Prevention: EPM focuses on preventing pest problems before they occur. This includes implementing practices that promote plant health and resilience, such as maintaining balanced soil fertility, using proper irrigation and drainage, and selecting resistant crop varieties. Prevention also involves implementing good agricultural practices, such as proper sanitation, crop rotation, and weed management, to minimize conditions favorable to pests.
2. Monitoring and Thresholds: Regular monitoring of pest populations, crop health, and environmental conditions is essential in EPM. This allows for early detection of pests and the establishment of action thresholds. Action thresholds are predetermined levels of pest populations or damage that trigger the implementation
3. Monitoring of control measures. Monitoring helps ensure timely and targeted interventions, avoiding unnecessary pesticide applications and minimizing pest damage.
4. Cultural Practices: Cultural practices in EPM aim to create unfavorable conditions for pests while promoting plant health. This includes practices such as crop rotation, intercropping, trap cropping, and planting diverse cover crops. These practices disrupt pest life cycles, reduce pest build-up, and enhance natural enemy populations.

5. Biological Control: EPM emphasizes the use of natural enemies to regulate pest populations. Biological control involves conserving and enhancing populations of beneficial organisms, such as predators, parasitoids, and pathogens that naturally suppress pests. This can be achieved through habitat management, providing nesting sites and food sources for natural enemies, and avoiding the use of broad-spectrum pesticides that harm beneficial organisms.
6. Habitat Management: Creating and maintaining diverse habitats that support beneficial organisms is a key principle of EPM. This includes planting hedgerows, flowering plants, or cover crops that provide nectar, pollen, and shelter for natural enemies. Enhancing biodiversity and providing suitable habitats can promote the establishment and persistence of beneficial organisms, improving pest control services.
7. Least-Toxic Pesticides: While minimizing pesticide use is a goal of EPM, in some cases, pesticide applications may be necessary. The principle of using the least-toxic pesticides involves selecting pesticides with low toxicity to humans, non-target organisms, and the environment. Pesticides should be applied judiciously, targeting specific pests, and considering their potential impact on natural enemies and other beneficial organisms.
8. Integrated Approach: EPM promotes an integrated approach to pest management, combining multiple strategies to achieve effective and sustainable control. This includes integrating cultural practices, biological control, monitoring, and, when necessary, targeted pesticide applications. By integrating multiple approaches, EPM aims to synergistically enhance pest control and minimize reliance on any single method.

BIOLOGICAL METHODS USED IN PEST MANAGEMENT

1. Biological Control: Biological control involves introducing or conserving natural enemies of pests to suppress their populations. These natural enemies can be predators, parasitoids, or pathogens. They prey upon or parasitize pests, leading to their decline. Examples include ladybugs for aphid control and parasitic wasps for caterpillar control.
2. Conservation of Natural Enemies: Creating a favorable habitat and conditions for beneficial organisms encourages their presence and activity. This can include planting flowering plants to attract beneficial insects, providing nesting sites for birds, or preserving natural areas that support beneficial wildlife.
3. Microbial Insecticides: Microbial insecticides use naturally occurring pathogens, such as bacteria, viruses, or fungi, to infect and kill specific pests. These pathogens are formulated and applied as products to target pest populations while minimizing harm to beneficial organisms and the environment.
4. Microbial Pest Control Agents: Beneficial microorganisms, such as Bacillus thuringiensis (Bt), are used to control pests. But produces toxins that specifically target certain insect pests, providing an effective and selective means of control.
5. Sterile Insect Technique (SIT): SIT involves mass rearing and releasing sterile male insects to mate with wild female pests. As the sterile males do not produce offspring, the pest population's reproductive cycle is disrupted, leading to a reduction in population over time.

6. Pheromone-based Pest Monitoring and Control: Pheromones are chemical substances released by insects to communicate with each other. Synthetic pheromones can be used to monitor pest populations by attracting them to traps for identification and population assessment. Pheromones can also be used for mating disruption, confusing pests and reducing their ability to find mates.
7. Bio pesticides: Bio pesticides are derived from natural materials, such as plants, bacteria, or fungi, and are used to control pests. They can be selective, targeting specific pests while minimizing harm to beneficial organisms and the environment. Bio pesticides are an alternative to synthetic chemical pesticides.
8. Genetic Control: Genetic control involves using genetic manipulation techniques to develop pest-resistant crop varieties or pest-specific control strategies. This includes genetically modified organisms (GMOs) that are engineered to express traits that deter pests or enhance resistance to pest attacks.
9. Integrated Pest Management (IPM): Biological methods are often integrated with other pest management techniques, such as cultural practices, monitoring, and targeted chemical control, within an IPM framework. This holistic approach combines different strategies to manage pests effectively while minimizing environmental impact.

EPM - Integration of available pest management techniques to reduce pest population and maintain them below the levels where they can cause economic decline.

Aim: EPM systems lowers pest control costs rather than to protect the environment.
“It’s time to get back to basics”
Some pests and diseases control measures are: -

1. Start with disease free seeds, cuttings or propagation materials
2. Grow disease resistant materials i.e. indigenous crops
3. Quarantine incoming plant materials
4. Monitor and suppress insects and mite’s population as soon as noticed
5. Keep the environment clean use good spacing
6. Avoid plant stress i.e. water, PH, nutrients and environment especially in greenhouse
7. Keep unauthorized personnel to a minimum
8. Use organic pesticides and natural remedies as the last resort
9. Ensure permanent soil fertility by deep digging, mulching, composting
10. Use recommended ways of cultivation to keep away predators i.e. sheltering with trees, use of attractants, crop diversity, crop rotation, mixed cropping and intercropping

Pest: Any organism that hinders the proper growth of a crop and causes reduced production (insects, nematodes, other animals, fungi, weeds, and virus)

b) NATURAL PESTS AND DISEASES MANAGEMENT

There are many pests and diseases threatening crop production. These may spread fast if they are not controlled. These problems can be controlled biologically, culturally or by use of effective plant extracts (EPE)
Farmers should check for pests and diseases on their crops by use of the physical signs that are evident.

1. Diseases

- Area affected e.g. stem, leaf, root, fruit etc.
- Color of the affected part
- Smell from the diseased are e.g. rotting smell

Some signs may arise from mineral deficiency, inappropriate climate, seed condition at planting or pests

1. Pests

Nature of the pest identifies e.g. size, color, no. of legs and body hardness (hard or soft)

- Population density e.g. few, all over etc.
- Crop affected and part affected by the pest
- Name of the pest identified if possible

- NB: Not all insects in the farm are pests. Some of them are beneficial to the farmer e.g. ladybird larvae, wasps, spiders and centipedes. Some pests attack the crop at specified period of growth e.g. at germination, fruiting, flowering or storage i.e. pre-harvest and post-harvest pests.

- Ladybird prey on black and green flies and especially on aphids
- Ladybird larvae feeds mainly on aphids and other bugs
- Lacewing (green eats a wide range of pests (almost all pests)
- Wasps larvae kill other insects as they develop on their bodies where eggs are laid
- Spiders are predators to insects
- Centipedes feeds on slugs, slug eggs and soil dwelling insects for they are ground based predators

Crop rotation, timely planting and harvesting periods trap crops use and resistant crop varieties use also go a long way in preventing damage from pests.

HOW TO PREPARE NATURAL REMEDIES

Some pest's repellants include: onions, Mexican marigold, garlic, hot pepper and wood ash.

Some pest killers include pyrethrum, tobacco, hot pepper, onions /garlic.

(i) Garlic and Chilies

Preparation

- Crush one garlic bulb
- Mix with one teaspoonful of powdered chili / pepper
- Add a little soft soap and stir well
- Spray for caterpillars in fruit trees

(ii) Onions / Garlic

It's useful to grow the crops in between the others especially carrots and tomatoes against flies. The pest gets confused because of the smell and gets unable to recognize the host plant.

(iii) Chilies / Hot pepper

Procedure

- Chop 100gms of fruits and put it in a litre of water
- Allow it to stand in water for 2-3 days or boil it for 20 min
- Add an equal amount of water containing soap to dilute
- Spray against all insects

(iv) Chilies, garlic and onions

Preparation

- Chop or grind one garlic bulb and one onion
- Add one tablespoonful of hot pepper
- Mix with one liter of water and let it stand for one hour
- Add one tablespoonful of liquid soap
- Spray to control insects in general

(v) Chilies, Mexican Marigold and Onions

Preparation

- Chop four chilies, four onions and a handful of Mexican marigold leaves
- Cover with soapy water for 24 hours
- Sieve and add two liters of water
- Spray against red spider mites

(vi) Chilies, Garlic, Mexican Marigold and Onions

- Take three large cloves of garlic, add two handfuls of marigold leaves, two large onions, 2 large peppers
- Add water and boil it for 30 min and let it cool
- Dilute with 4 times the quantity of water and stir occasionally
- Spray against all insects

(vii) Mexican Marigold

It controls aphids, ants, caterpillars, maggots, mosquitoes, termites and nematodes.
It also helps in controlling such diseases as blight, mildew, coffee berry disease.

Procedure

- Harvest a lot of Mexican marigold especially when it is flowering
- Place it in a drum, half a drum or a debe and cover it with water
- Let it stand in the water for 5-10 days and stir occasionally
- Cover the stuff with polythene paper
- Sieve/ strain the solution
- Dilute with soapy water and spray to the affected crops

(Viii) Pawpaw leaves

Take 1 kg of green and fresh leaves, - crush and boil in 4 liters of water for 20 minutes. Spray to control scale insects and aphids.

(ix) Wood ash

Get maize combs, burn them, and dry the ash. This should be applied around the plants especially the transplanted vegetable seedlings, to control cutworms in fields where cutworms are a problem.

Reasons to go organic

1. Healthy Consumers: Avoids genetically modified foods /GMO.
2. Chemical free: No harmful chemical residues.
3. Great taste. Food is naturally tastier:
4. Naturally healthy. Naturally full of health nutrients.
5. Environmentally friendly. Does not pollute or degrade the environment.
6. Healthy farmers. Does not cause diseases to farmers through chemical sprays.
7. Patent free seeds. Encourages biodiversity and conservation of indigenous seeds:
8. Harmony with Mother Nature. Promotes soil health, plant health and animal health.
9. Respects traditional wisdom.... Organic farming recognizes local farmers indigenous knowledge:

Sustainable food security.... Organic farming is in line with sustainable farming practices.

MODULE 7: ANIMAL HEALTH

The negative impact of industrial livestock farming on animal health and welfare, but also on human health, ecosystems, and the environment is indisputable and no longer needs to be demonstrated.

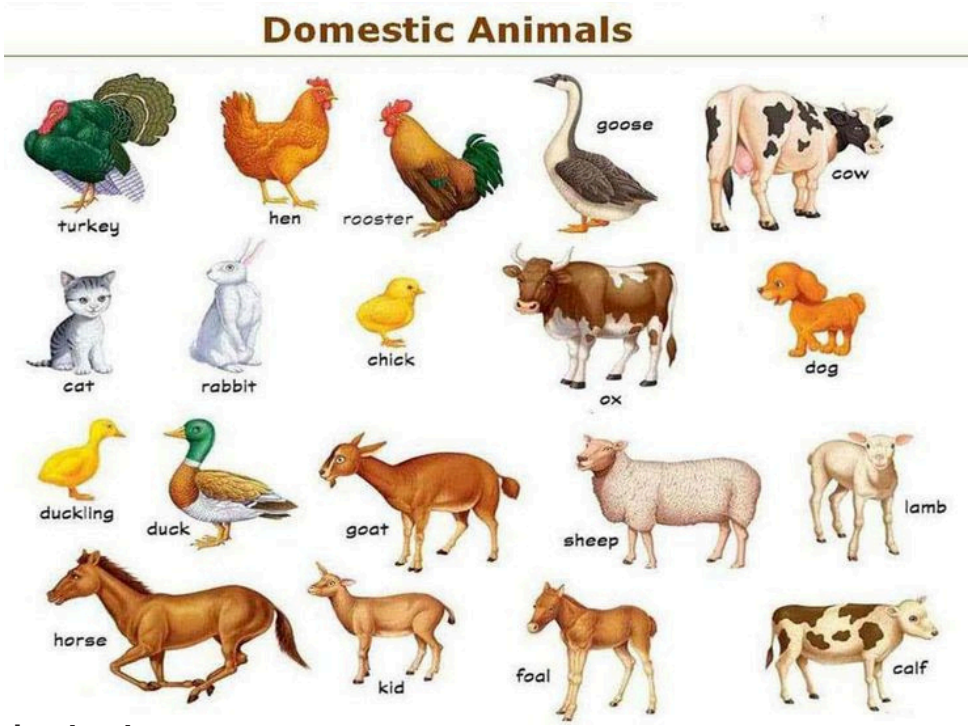
Agroecology, on the other hand, makes it possible to reconfigure livestock systems and reintegrate them into agroecosystems to ensure the well-being and health of animals, humans, and ecosystems, and to produce healthy, high-quality food while providing ecosystem service.

INTRODUCTION TO ORGANIC ANIMAL HUSBANDRY

What is Animal Husbandry: - This is looking after animals in terms of protection from predators, pests and diseases, feeding, breeding control and harvesting of their products in proximity.

Types of Livestock

Cattle, Goat, Poultry, Sheep, Rabbit, Pigs



Roles that animals play:

Production role:

- They serve as source of food,
- Provide cash income when surplus is sold.

Investment role:

- Animals provide diversification when kept together with crops and thereby reducing risks associated with crop failure.

Social-cultural obligation

Animals are used as a means of payment for dowry (bride price) during marriage.

Energy role:

They are a source for power e.g. for in ploughing and they provide materials for making domestic fuel e.g. biogas.

Nutrient role

Animals are a source of such foods as beef, milk, eggs, pork, mutton, etc.

Gestation period of some animals

Animal	**Period**
Cow	9 months
Goats and Sheep	5-6 months
Poultry	21 days
Rabbit	1 month
Pigs	3 Months, 3 weeks, 3 days

IMPORTANCE OF LIVESTOCK IN ORGANIC FARMING

- Integrated pest management – Animal play role of pest control eg chicken and other help to control insect pest in the farm by feeding them.
- Nutrient cycle – animal provide manure which is used as fertilizer that helps to maintain soil fertility.
- Soil health – Animals through grazing and trampling improves soil structures and promote aeration. They also contribute the breakdown of organic matter aiding in the formation of humus.
- Weed control – certain animals feed on weeds that grows on farm together with crops e.g. black jack wandering jaw etc. so animals help in minimize of competition between crop and weed.
- Sources of fuel – Many farmers use animal mature to make biogas that their used as form of energy.
- Interaction in habits /shelter –Animal depends on crops to provide them in shade during hot seasons.

CHALLEGES FACED IN LIVESTOCK PRODUCTION

1. Nutrition and feed supply
2. Inadequate Breeding Programmed and poor crossbreeding
3. Disease and Pest Infectious
4. Lack of land Ownership and Usage
5. Low Investment
6. Lack of skills
7. Poor Record and Planning

Examples of cattle kept in dry areas and Cold areas

Dry areas: - Boran, Red Bull, Sahiwal, Hereford
Cold areas: - Freshian, Guernsey, Ayrshire, Jersey
Note: Jersey and Sahiwal can be kept on areas that are neither cold nor dry
Breeds of Cattle
Freshian, Jersey, Ayrshire and Guernsey are the main daily cattle. Their body is thin and wedge-shaped. They have a big stomach and a big udder

Freshian
It is black and white in color. Its feet and lower part of the tail (switch) are white in color. Its head has a white star

Jersey
Its color varies from yellow brown to black. There is usually a black ring around its eyes
Ayrshire
It is usually red brown in color. It has white markings or white with reddish brown markings
Guernsey
Its color varies from light brown to red. It has white markings on legs, face flank and switch.

Breeds of Beef Cattle

The Hereford, Charolais and Boran are the main beef cattle. They have short legs, small udder and long wide backs. Unlike daily cattle, they are block shaped.
Hereford: It is dark red in color. Its face, chest, legs, belly, brisket, and lower part of the tail are white in color.

Charolais: It is white in color. It is a very heavy animal

Boran: It is quite large in size. Its hump is wide and legs are long. It has different colors such as white, red, grayish white etc.

Characteristics of Indigenous Cattle

- Are humped/they have humps
- Low fertility rate with long calving interval more than one year
- Produce less milk and meat
- Small body size hence less meat
- Good resistance to tropical diseases like East Coast Fever (Theileriosis)
- Tolerate hardy areas
- Are high tolerant to tropical heat
- Late maturing

Examples: Boran and small East African Zebu e.g. Maasai zebu, Ankole zebu

Characteristics of good dairy breeds

- Triangular shaped
- Well attached udder with well-shaped teats
- Prominent milk veins
- Little flesh on the body
- Short, well-set legs
- Lean, thin neck
- Well-developed hindquarters
- Docile
- Long thin tail

Characteristics of a good beef animal

- Long, trim, deep sided body (blocky in shape)
- No excess fat on the brisket, fore flank, and hind flank
- No extra hide around the throat, dewlap or sheath
- Heavily muscled forearm
- Correct muscling throughout the body
- Proper height to the point of the shoulders
- Maximum development of the round, rump loin and rib.
-

Digestion in polygastric (ruminant) animals

They chew cud and Include: cattle, goats and sheep. The stomach is divided into four compartments namely: rumen, reticulum, Omasum and abomasum. No enzymatic digestion takes place in the mouth as they do not have ptyalin in their saliva.

- Rumen. Also known as paunch. Is Large and is the first stomach compartment. Acts as a temporal store of food before being regurgitated to the mouth for further chewing. Digestion is microbial. Food is fermented, a condition necessary for microbial digestion.

Microbial activities in the rumen

- Fermentation of food.
- Synthesis of vitamin B complex (Thiamine, Lacto Flavin, Pyridoxine and vitamin K.
- Synthesis of amino acids from ammonia gas
- Breakdown of proteins to peptides, amino acids and ammonia
- Breakdown of carbohydrates and cellulose to CO2, and volatile acids VAS such as acetic, butyric, propionic and formic acids.

- Ammonia gas and volatile fatty acids are absorbed through the wall of the rumen.
- Ammonia is recycled through the liver to saliva making saliva alkaline.
-Gases like methane, CO2, and hydrogen are released through bleaching.

- **Reticulum/honeycomb**. Has a comb-like structure. Receives food from the mouth after regurgitation.
- **Oesophageal groove.** Skin fold at the entrance of the rumen which closes to let food into the reticulum.

Functions of reticulum;

- Sieving and separating fine from coarse food materials
- Retaining foreign and indigestible materials such as polyethene papers, wires which might have been swallowed accidentally.
- Omasum (many piles/book) -Contains many suspended parallel rough-surfaced leaves that lie on top of each other like pages of a book.

Functions:

- Absorbs water and to grind and sieve food particles
- Temporal storage of food.
- **Abomasum/true stomach**. Known as true stomach because enzymatic digestion of proteins takes place here like in non- ruminants.

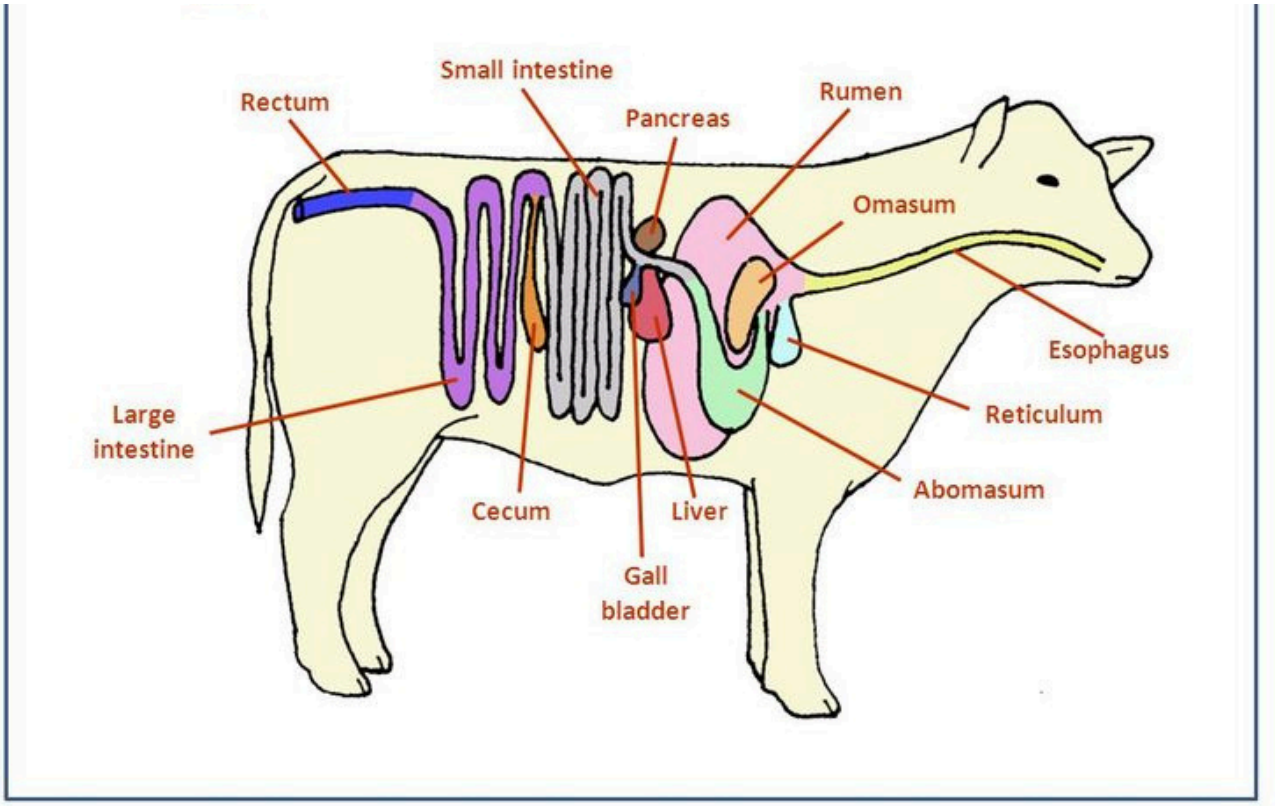
COMPARISON BETWEEN DIGESTION IN RUMINANTS AND NON-RUMINANTS

Ruminants.	**Non-ruminants**
1. Chew cud	Do not chew cud.
2. Has four stomach chambers thus polygastric	Has one stomach chamber thus monogastric
3. Regurgitate food	Cannot regurgitate food once swallowed
4. Can digest cellulose- Have microorganisms in the rumen that digest cellulose	Have no micro-organisms in the stomach hence cannot digest cellulose expect those animals with micro-organisms in the caecum
5. Have no ptyalin in saliva hence no enzymatic digestion in the mouth	. Have ptyalin in saliva hence enzyme digestion starts in the mouth
6. Most digestion and absorption take place in the rumen	Most digestion and absorption take place in small intestine
7. Have alkaline saliva due to presence of ammonia	The saliva is neutral in pH

Similarities

- Digestion in young ruminant is similar to that of monogastric as they don't have a developed rumen-reticulum complex.
- The final protein digestion takes place in the small intestines.
- Water absorption takes place in the colon in both ruminant and non-ruminants

RUMINANT DIGESTIVE ANATOMY



When selecting animals for breeding the following factors are considered:

1. **Appearance of the animal**

These will include: size, shape of the body, shape of the udder. For meat production animal is full of muscles all over the body. Animal for milk shows evidence of giving a lot of milk by having a big, well-shaped udder.

1. **Records –** Consider the production records of the animal you are buying.
2. **Environmental factors** i.e. rainfall, temperature and altitude. Choose the animals according to the climate.

Appropriate Housing for Livestock

The housing environment should provide the following:

- Enough space for sufficient movement
- Sufficient fresh air and natural daylight
- Protection against excessive sunlight, heat, rain and wind
- Enough lying and resting area according to the animals behavior
- The house design should allow for easy and efficient collection of manure
-

Feeding and Nutrition

Animals should be fed on a balanced diet of carbohydrates (70%), proteins (25%), vitamins, minerals and oils (5%).

Carbohydrates

- Provide energy for maintenance of good health such as during work and pregnancy and also for production e.g. of milk and eggs
- All grasses and maize stoves are good source of carbohydrates for ruminants
- Cereal grains and tubers are good for poultry, rabbits and pigs.

Proteins

Are needed by the body for the growth and repair. Lack of this in the diet results to poor growth, reduced production, less weight and late maturity. Sources of proteins include leguminous fodder e.g. *caliandra*, *leucaena*, *sesbania*, Lucerne, desmodium, etc. Others are small insects for chicken and offal for pigs

Vitamins

They are needed in small amounts and are plenty in vegetables and fruits. When they lack in the diet, the animals are exposed to assorted diseases prevalent in their environment.

Mineral Salts

They provide essential minerals e.g. calcium and phosphorous. They are needed for egg formation and muscle contraction. They are found in comfrey, Amaranthus, eggshells and stinging nettle.

Lack of these leads to:

- Reduced growth and production
- Rickets / bent bones and soft bones that fracture easily
- Strange habits of eating bones, soap etc

Fats and Oils

They are needed in traces. They provide a layer of insulation below the skin for protection against cold. They are also important for fattening animals and are found in sunflower, groundnuts, offal (slaughter wastes for pigs).

Indicators of illness

The following are indicators of possible illness in animals:

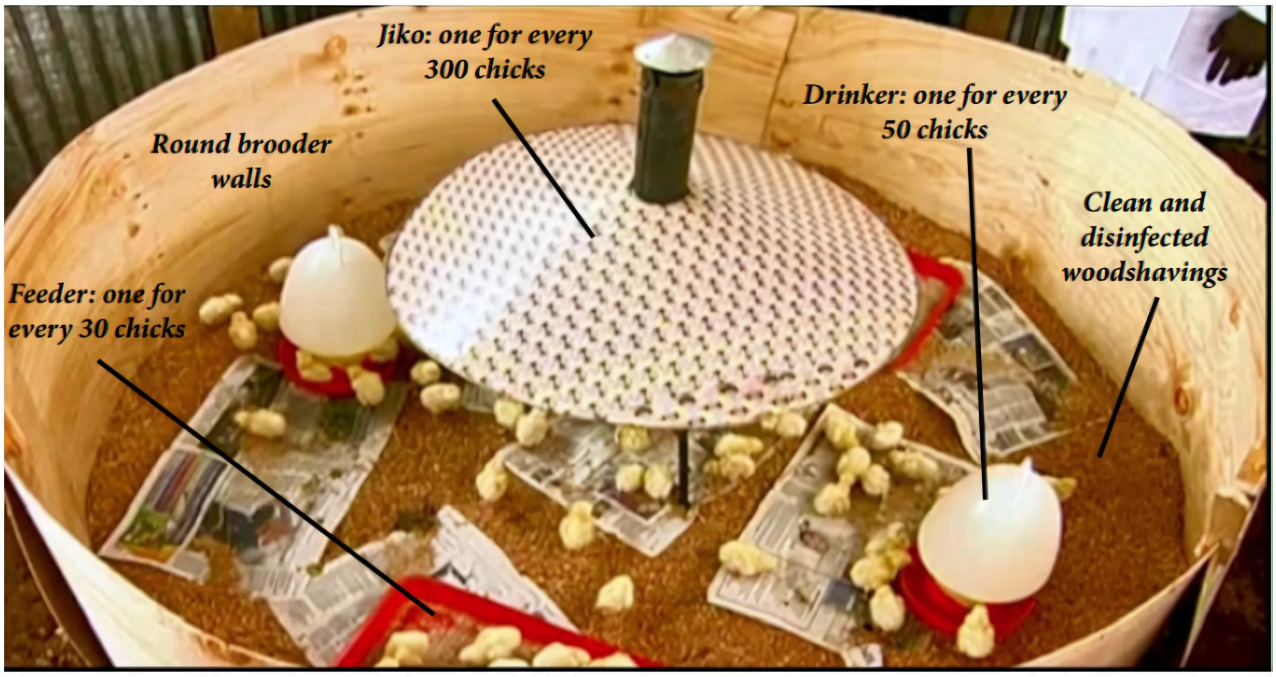
- Loss of appetite and loss of weight
- Dullness
- Difficulty in breathing and walking
- Watery eyes and rough skin
- Isolation
- Bloody urination.

POULTRY REARING SYSTEM

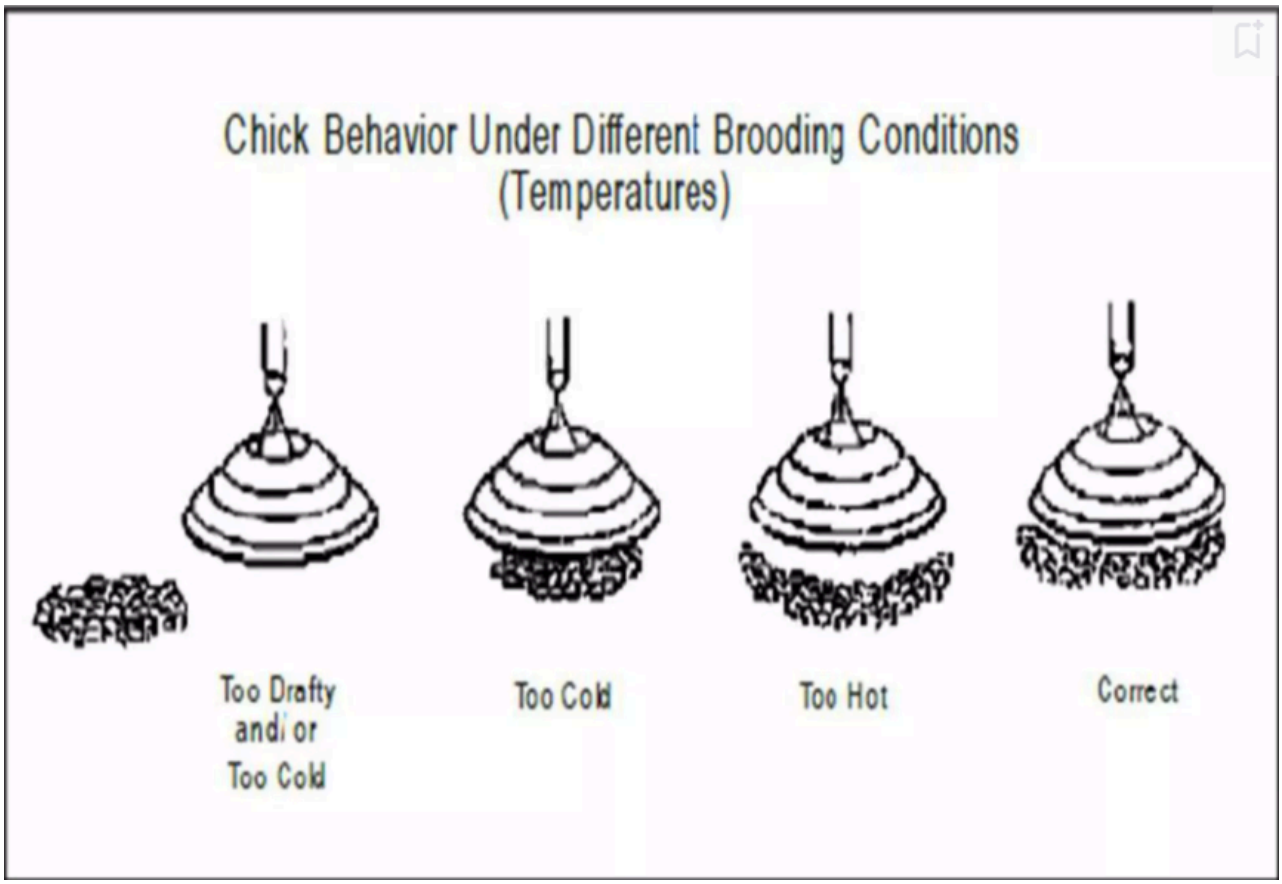
Things done when receiving chick:

1. Cleaning and disinfection of houses
2. Spreading the litters and disinfect them
3. Putting newspaper, sources of light etc.
4. Put water 1-2 hours before the arrival, add sugar/ glucose, vitamins supply e.g. stress pack, chick formula
5. 10 ml of paraffin/ kerosene per drink 1-2 days this help in cleaning and preparing digestion system of chicks to prevent constipation
6. Switch on the heat source 2-3 hours before arrival of the chicks and the temperature 33-35 degrees per chick and 30- 32 of the room
7. After arrival put the boxes in the brooding are and wait for 10 minutes to remove them from the boxes and moist the beak of each chick by dipping on the drinker – this service as training then to know water
8. Wait for 30 minutes and provide them with feed chick starter or chick mash
9. Water the behavior's either to eliminate or add the heat source
10. 24- hours lighting program may be adopted for 8 days of age. but one-hour darkness starting on the day 5 to train then incase power goes off
11. 3 -5 days remove the newspaper and spread another if necessary.

BROODER STRUCTURE



RIGHT TEMPERATURE.



REARING SYSTEM

EXTENSIVE SYSTEM/ FREE RANGE

- Birds are set free throughout the day to fed themselves
- There are confined in the night shelters
- There are no supplements

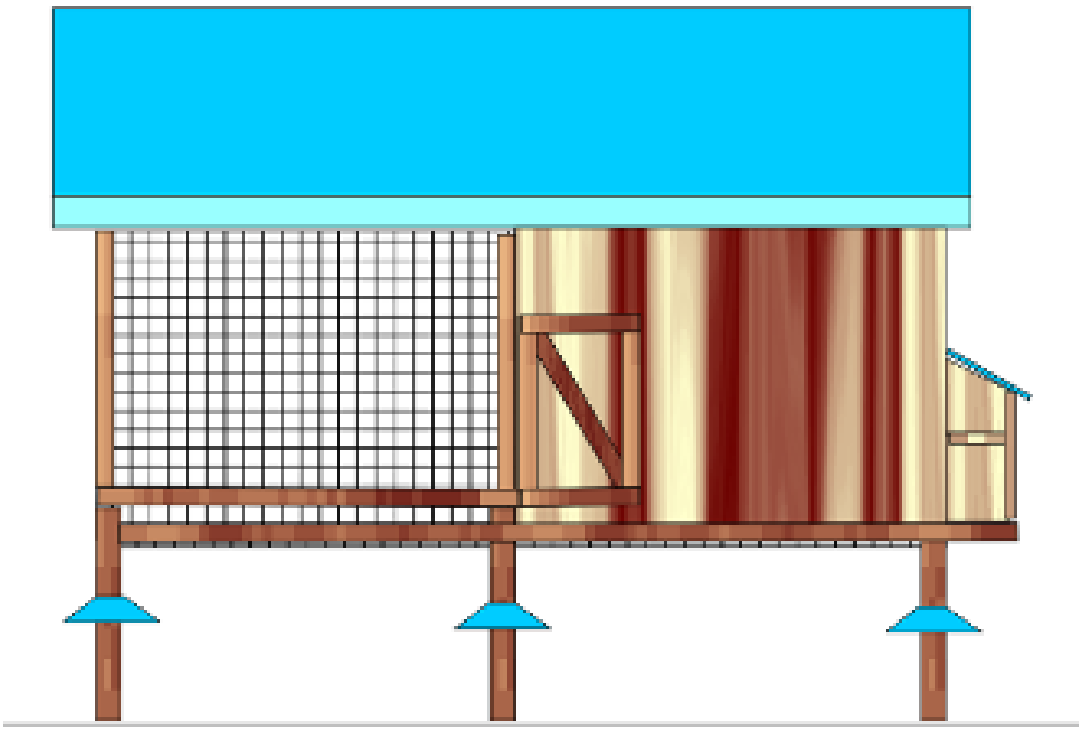
ADVANTAGES

1. Birds eat insect and greens leaves therefore less feed is required
2. Cannibalism and egg eating are reduced since the birds are not crowded
3. Manure is spread evenly
4. Low labour required
5. Birds get plenty of exercise thus helping to keep in good health
6. No need of provide grit as birds pick it from the soil.

DISDAVANTAGES

1. More land is required if a farmer wants to rear many birds
2. Birds can be stolen or eaten by predators
3. Egg gets loss in the vegetation or stolen
4. Difficult to determine layer from non- layer
5. Infected by parasite and diseases
6. Breeding Programme is not easy to follow
7. Birds destroys crops where perimeter fencing is not constructed
8. Low productivity per unit area.

SAMPLES OF FREE-RANGE UNIT



SEMI-INTENSIVE SYSTEM/ FOLD SYSTEM

- Birds are confined in a small portable structure called fold
- A fold measures 3.5 cm long 1.5 cm wide and 1.5 height.
- 1/3 of the fold is roofed while the rest is enclosed with wire mesh
- Bird gets plenty of sunlight and get fresh grass as fold move to new ground.

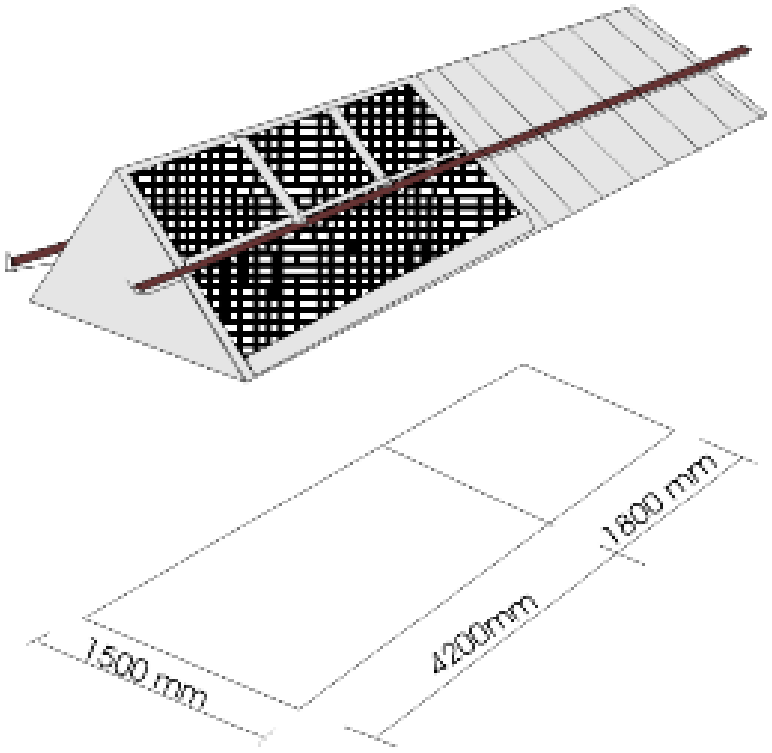
ADVANTAGES

1. Manure is evenly spread in the field
2. Less feed is used because birds are eating grass
3. Reduce build-up of parasite and diseases since the fold is moving often
4. Birds are protected from predators.

DISDAVANTAGES

1. Few birds are kept per fold
2. Its laborious since the fold are moved from one place to another
3. Individual egg production record is difficult to keep
4. The fold does not last long because of high frequency of handling
5. The return per unit is is low.

FOLD SYSTEM UNIT



INTENSIVE SYSTEM DEEP LITTER SYSTEM

- Birds are confined in a house throughout their life
- The floor of the house is made up of litter which accumulate over the time
- Enough water, feed, and laying boxes are provided depending on the number of bird available.

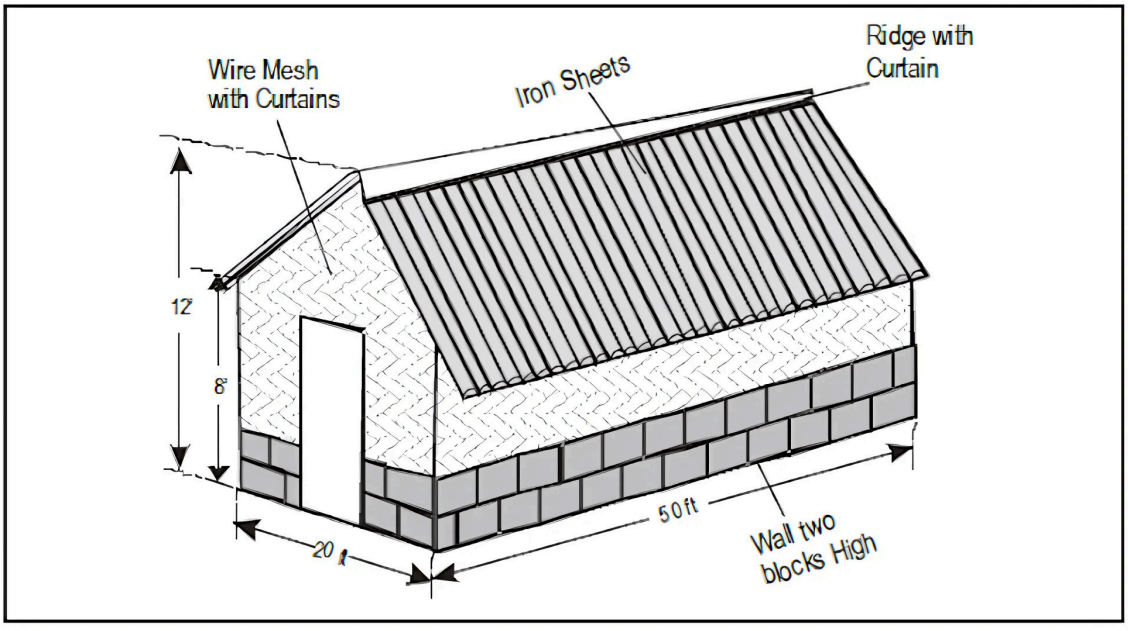
ADVANTAGES

- Safety of birds is guaranteed from predators
- No loss of eggs
- Easy collection of eggs
- Regular cleaning of the house is not necessary since the litter absorb the dropping.

DISDAVANTAGES

- High incidences of cannibalism, feather plucking and toe pecking
- Pest and diseases causing organism accumulate in the litters
- Individual records of birds are not possible
- May be difficult to get litter
- Feeders and water are contaminated by litters
- If any outbreak of disease it can spread very quickly throughout the house due to communal house
- High cost of building deep litter houses.

DEEP LITTER SYSTEM UNIT



BATTERY CAGES SYSTEM

- Bird is confined in cages which are placed in the poultry house
- The cages are made of wire mesh and each contains 1 to 3 birds
- Water and feed trough together with egg trays are fitted along the front side of the cages
- The floor of the cages should be slanting to allow the egg to roll out of the cage
- Dropping from the cages fall behind for easy cleaning.

ADVANTAGES

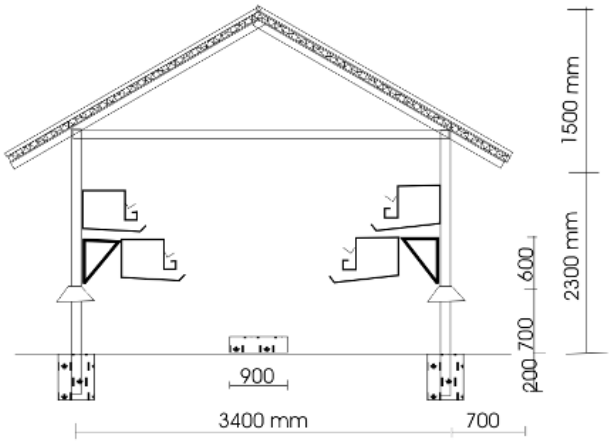
1. Records are easily kept therefore culling is easy
2. Birds do not become broody
3. More eggs are collected due to restricted movement of the hens and complete control egg eating
4. No bullying during feeding
5. Wires floors prevent re-infection of parasitic worms and coccidiosis
6. Birds do not contaminate water and food
7.

DISDAVANTAGES

1. Initial cost of cages, equipment's and house are expensive
2. Requires high level of management
3. Higher maintenance cost where automation used
4. Birds get fatigue due to lack of exercise thus lowering productivity
5. Cannot be used for brooding young chicks

Not useful when rearing **breeding stock and when rearing broilers.**

BATTERY CAGE UNIT



CHICKEN BREEDS

Chickens are mainly kept for meat and egg productions.

Characteristic of layers

- Have red waxy combs and wattles
- Beak is free from yellow pigmentation
- Abdomen are soft and pliable to touch
- Good distance between pelvic bones and breastbone
- Well- developed bone
- Bent is crescent shaped, moist and white in Color
- Body is light.

Examples of layers

1: leghorn
Origin: Italy
Color: white, yellow skin, eye is reddish
Excellent layers lay around {280 per year} with superior feed to egg conversion ratio. It's a light breed.

2: Minorca
Color – plumage black and white skin eyes is brown
The egg Color are white.

CHARACTERISTICS OF BROILER

- Heavier and bigger than layer
- Grow very fast
- Female lay very few eggs

Example

1: New Hampshire

Origin – America

Color – red plumage and yellow skin. Eyes are reddish bay

The eggs are brown

Its heavy and mature very fast.

Cocks weight 4.5 kg and hen 3.5 kg.

2: Plymouth rock

Its heavy breed

Color – white plumage and yellowish skin

Egg is reddish bay.

DUAL PURPOSE

1: Rhodes island red

Origin- America

Color - dark red plumage and yellow

Cocks weigh 4 kg and hens 3 kg.

2: light Sussex

Origin – Britain

Color – white plumage the neck hackles and tail have few black feathers

Cock weigh 4 kg and hen 3 kg.

3: Kenbro

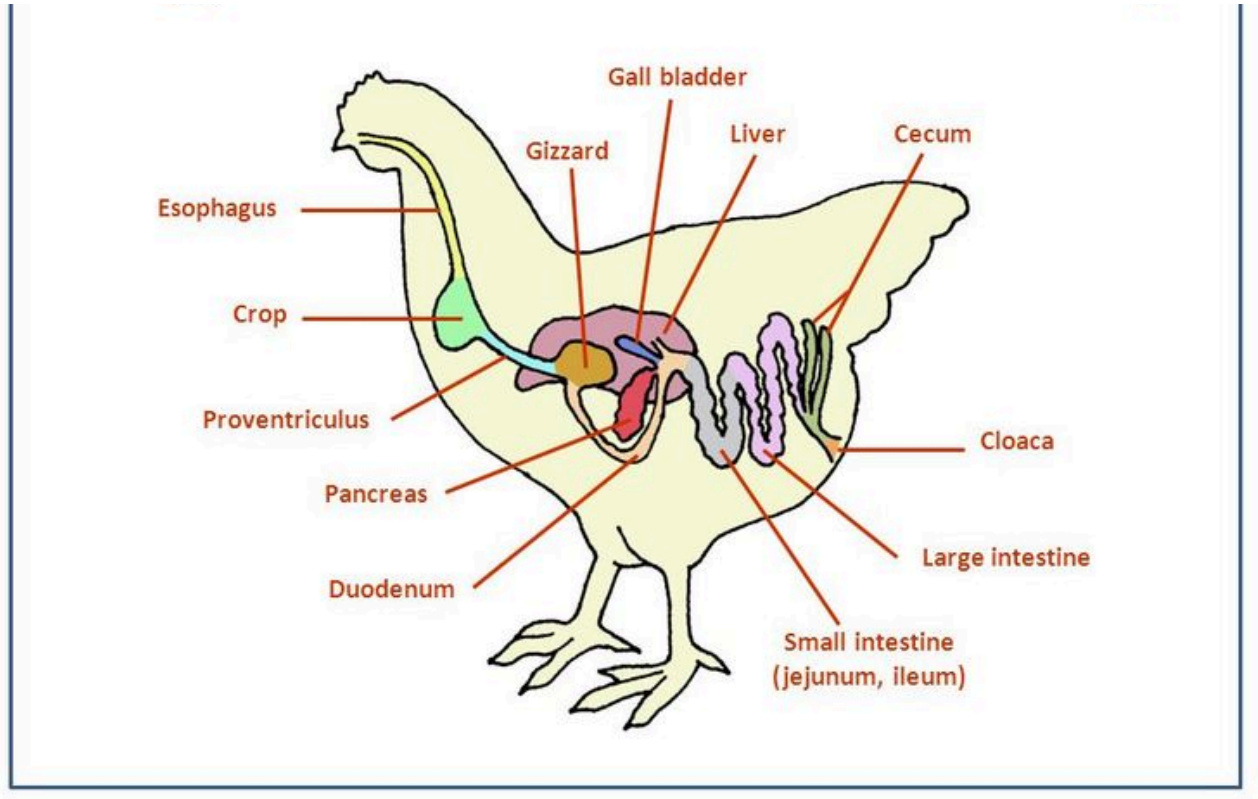
- Developed by kenchic limited
- They are meant for eggs and meat productions
- More resistant to diseases compared to hybrids birds. It can survive on free range
- Birds mature fast with proper feeding and start laying eggs at 5 months and 4 kg on maturity.

4: Kuroiler

- Kuroiler is a hybrid that was developed in India
- A dual-purpose breed producing egg and meat
- Can live on a diet of kitchen waste and agricultural waste and produce around 150 eggs per year
- Male weigh approximately 3.5 kg and female about 2. 5 kg
- They are resistance to diseases.

5: Rainbow Rooster

- Multi- colored
- Dual – purpose
- Low –input birds
- Age at maturity is 160 days
- Eggs per birds up.



PARASITES AND DISEASE CONTROL

- **Vaccination**

Practice of introducing active disease causing organisms which are reduced in strength virulent or dead into the animal's body to induce immunity.

Administration of Vaccination done Through:

- By injection
- Orally through the mouth
- By inhalation through the nose
- Eye drops.
- Through the cloaca

DEEP LITTER SYSTEM UNIT

1. Live virulent vaccines. Living organisms capable of causing diseases to animal. They cause the diseases thus stimulating production of antibodies against it. It is not commonly used.

Virulent means highly infectious.

2.Live attenuated vaccines. Diseases causing organisms whose ability to cause the disease has been reduced. Used in anthrax, brucellosis, rinderpest, foot and mouth. If stored for long, they mutate to virulent forms. Stimulate production of high level of antibodies.

3.Killed or dead vaccines. Diseases organisms that are completely killed by use of phenol or formaldehyde.

4.Toxoids. Are made from toxins produced by disease causing microorganisms and then treated with formalin to produce toxoid vaccines.

Properties of a Good vaccine.

- Immunity it produces should be as good as natural immunity.
- Should have a long keeping life. Σ Should be easy to administer to the animal.
- Should have no side effects when inoculated.
- Should be compatible with other vaccines given to the animal.
- A single dose should produce lifelong immunity. Care in handling vaccines.
- Keep under freezing temperatures -20 to -4 degree Celsius.
- Vaccination equipment's should be sterilized.
- Correct dosage should be adhered to.
- Use the correct route of administration

Deworming

Practice of killing/removing internal parasites by administering drugs known as dewormers/antihelmitics.Have a deworming programme on the farm. As a routine deworm after 3 months Example of dewormers in the market in Kenya; Albendazole, Mectin e.g. Ivermectin & Paramectin, Piperin, Ascarex, Nefluke, Nilzan.

- ***Dipping and Spraying***

These are methods of applying acaricides on the animals to control external parasites. Examples of chemicals use; duo-dip, tixfix, triatix, delete, grenade, ectomin.

Dusting

It is the application of chemical powders on the animal body or on the walls of the animal house to control external parasites

It is used to control stick-fast parasites and fleas in poultry, example dudu dust.

APICULTURE

Apiculture this is the scientific methods of rearing honeybees.

An apiary is a bee yard where honeybees are reared for their products (domestic or commercial) and pollination purposes. The number of hives in an apiary can vary depending on the availability of bee forage. However, an ideal apiary should not have more than 50 hives.

Factors considered when siting an apiary

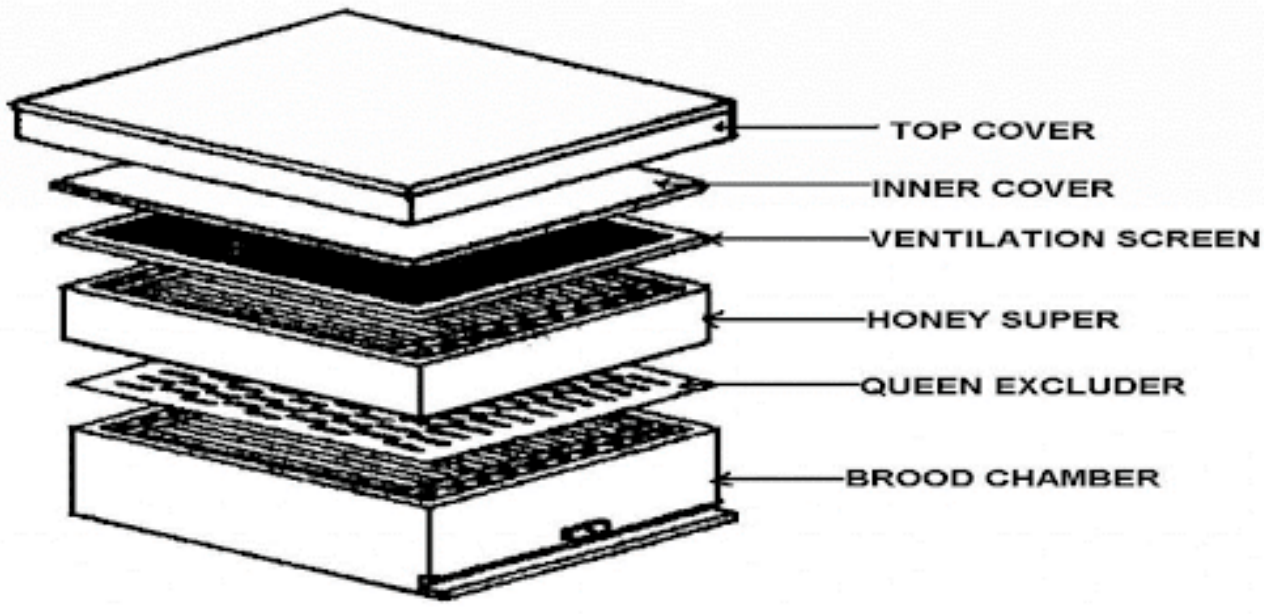
- **Food (forage)-**An apiary should be sited where there are ample acreage of nectar and pollen producing plants within 3 km throughout the growing season
- **Accessibility-**An apiary should be accessible for ease of management and transportation of products and equipment's
- **Drainage-**A well-drained place is recommended to avoid absconding due to high humidity. Water logged soils cause rotting of hives and posts. The water also leads to inaccessibility to the apiary
- **Water-**The presence of a stream of running water or fresh water within a short distance of an apiary is ideal. If there is no permanent source, water can be supplied in containers with floating sticks for bees to step on to avoid drowning. Water is also necessary for diluting feed and cooling the hive.
- **Shelter-**Colonies should be sheltered from frost, wind, floods and high temperatures. Winds cause drifting of bees, communication and short duration of floral secretion. Artificial or natural shade is necessary to reduce the effects of strong winds and high temperatures.
- **Fence-**Trees and bushes or hedges to surround the apiary cause the bees to fly high when leaving and returning to the apiary, thus reducing the risk of them becoming a nuisance to the nearby farms activities. The area should be fenced to exclude livestock and other animals that might disturb bees
- **Proximity-**It should be sited away from cultivated fields where large numbers of people work every day. Schools, highways and estates should be avoided so that bees do not become a nuisance to people.

Distance between Apiaries-This depends on acreage of floral sources and the number of colonies within the area. Commercially, apiaries should be at least 2-3km apart. It is recommended that each apiary should not have more than 25 colonies.

Development of honey bee

Bees have a complete metamorphosis life cycle of egg - larva – pupa – adult

Ruminants.	**Non-ruminants**
1. Chew cud	Do not chew cud.
2. Has four stomach chambers thus polygastric	Has one stomach chamber thus monogastric
3. Regurgitate food	Cannot regurgitate food once swallowed
4. Can digest cellulose- Have microorganisms in the rumen that digest cellulose	Have no micro-organisms in the stomach hence cannot digest cellulose expect those animals with micro-organisms in the caecum
5. Have no ptyalin in saliva hence no enzymatic digestion in the mouth	. Have ptyalin in saliva hence enzyme digestion starts in the mouth
6. Most digestion and absorption take place in the rumen	Most digestion and absorption take place in small intestine
7. Have alkaline saliva due to presence of ammonia	The saliva is neutral in pH



LANGSTROTH HIVE PARTS


PURE
HONEY

Hive inspection and honey harvesting

- Hives should be inspected regularly
- It helps in detecting incidences of disease and pest outbreak/reproductive efficiency of the queen replacement of the bars and checking if honey is ready for harvesting
- When bars are ready for harvesting bee keeper should get all equipment's ready and this include

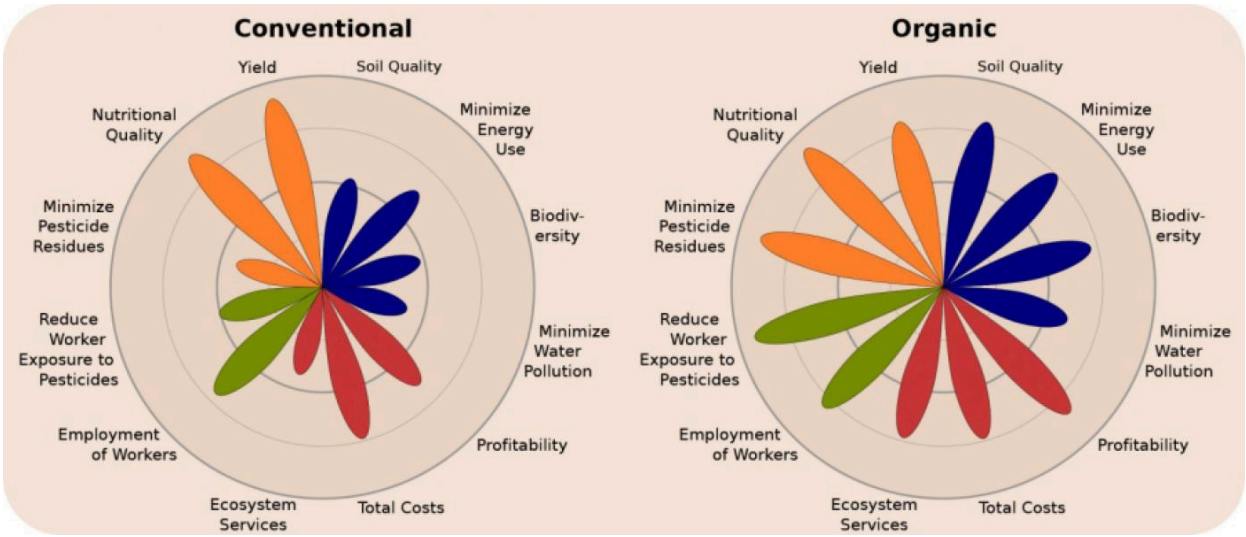
1. White gown covering the whole body
2. Veil used to cover the face region
3. Boots to protect the legs
4. Gloves for hand, protection should be from materials that do not allow stain to pass through
5. Bee Smoker is used to generate smoke which when directed to bees makes them suck much honey reducing their ability to sting. When smoke is puffed on bees it helps to subdue them and hence they become docile facilitating ease of carrying out the intended operation.
6. Hive tool – Knife like iron bar for separating top bars, can also be used for scrapping propolis from bars or for cutting honey combs if ready for harvest. The sharpened side can be used for scrapping of excess propolis from inside the hive or top bars.
7. Bucket (containers for collecting ready honey)

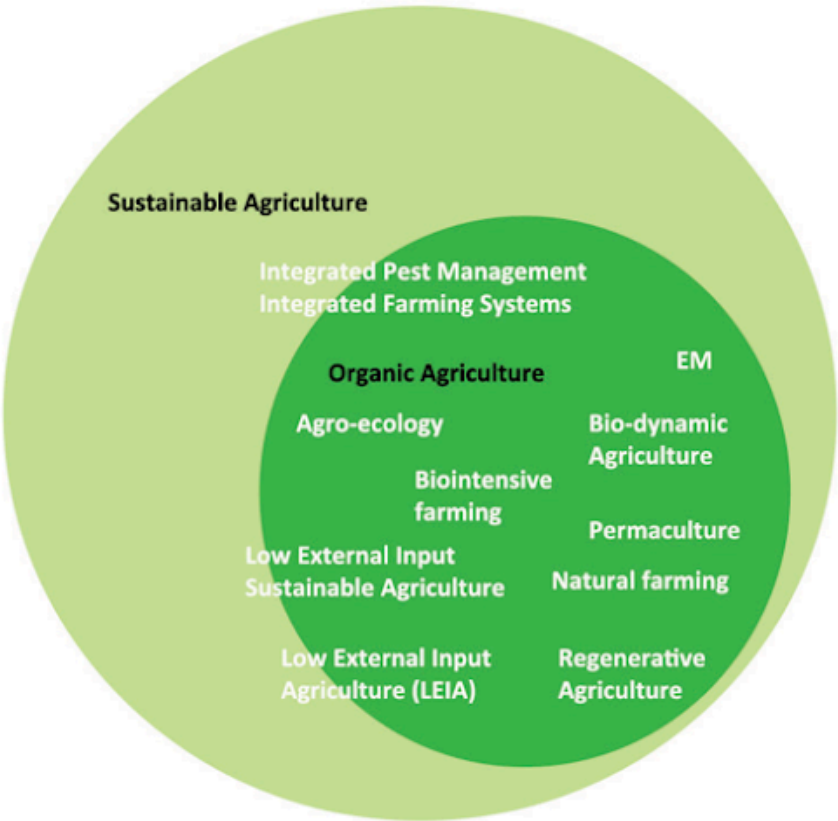
viii) Catcher box is a small box with four top bars, the top of which is covered with a bee tight wire mesh, used for trapping swarms which are transported into a Kenya Top Bar hive. Also used for making divisions and for transporting bees

ix) Bee brush – Is made of sisal fibres and is used to sweep off the bees from the combs to allow better sight.

X) Queen Excluder is a framed wire mesh with small holes, small enough to allow only the workers to pass through and the queen being larger is unable to pass through to the other side. Restricts the queen to the brood area so that the workers can store more honey in the comb cells during honey flow season and to prevent the colony from swarming since the bees will not leave the hive without the queen.

COMPARISON OF ORGANIC AGRICULTURE AND CONVECTION AGRICULTURE





c) Fairness

Support dignified and robust livelihoods for all actors engaged in food systems especially small-scale food producers, based on fair trade, fair employment and fair treatment of individual.

d) Connectivity

Ensure proximity and confidence between producers and consumers through promotion of fair and short distribution networks and by re-embedding food systems into local economies.

MODULE 8: PARTICIPATION AND LAND AND RESOURCE GOVERNANCE

1. **Participation**

Encourage social organization and greater participation in decision making by food producers and consumers to support decentralized governance and local adaptive management of agricultural and food systems.

Agroecology incorporates a set of practices including organic agriculture, regenerative agriculture, permaculture, ecological agriculture, soil and water conservation and management, agroforestry, and integrated pest management.

2. Land and resource governance

Recognize and support the needs and interests of family famers, smallholders, and peasant food producers as sustainable managers and guardians of natural and genetic resources.

WATER HARVESTING

Water harvesting encompasses rainwater harvesting, floodwater harvesting, and in-situ water harvesting and conservation. Water harvesting is an indigenous way of improving the productivity of semi-arid zones.

The major advantages include:

- Water harvesting stores excess rainfall, thus reducing runoff and converting it from a destroyer into an asset
- Restoring the productivity of land that suffers from inadequate rainfall, Increasing vegetation on denuded rangelands
- Offers resilience in food security through supplemental irrigation and minimizes the impacts of drought, and prolonged dry spells.
- Combating desertification by the establishment of vegetation in rangelands
- Provides water for domestic use and livestock consumption,
- Climate change adaptation and resilience by re-greening agricultural and rangeland ecosystems

They include zai pits, tumbukiza pits, swales, and demi-lunes

1. **Zai Pits**

The Zai system consists of small individual basins spaced about 1 m apart and large enough to catch all the rainfall that falls. The pits are shallow and wide, measuring about 30-60 cm in diameter and 15-30 cm deep. Zai pits are used in semi-arid zones where soils are poor, encrusted soils receive low and often highly variable rainfall. The pits are important for water harvesting and conservation. Higher rainfall amounts could cause water-logging of the pits. The Zai system allows farmers to concentrate both soil fertility and moisture in the crop roots and, improves crop production when faced with inadequate rainfall.

Zai pits improve plant production by concentrating runoff around growing plants, improve soil fertility and structure when manure/compost is added in pits and it can be used up to four crop seasons or two seasons without the need to add more manure.

3. Regurgitate food

Ruminants. 1. Chew cud 2. Has four stomach chambers thus
polygastric
4. Can digest cellulose- Have microorganisms in the rumen that digest cellulose
5. Have no ptyalin in saliva hence no enzymatic digestion in the mouth
6. Most digestion and absorption take
place in the rumen
7. Have alkaline saliva due to presence of
ammonia
The saliva is neutral in pH
Non-ruminants Do not chew cud. Has one stomach chamber thus
monogastric
Cannot regurgitate food once
swallowed
Have no micro-organisms in the
stomach hence cannot digest
cellulose expect those animals
with micro-organisms in the
caecum
. Have ptyalin in saliva hence enzyme digestion starts in the mouth
Most digestion and absorption
take place in small intestine

Zia Pit

2.TUMBUKIZA PITS

Involves digging huge pits, which are at least 0.6-0.9 m square or in diameter and with similar dimensions in depth. The pits are then filled with crop residues, any available vegetative material, and farmyard manure and topsoil. A space is left within the pit to create a ponding zone for water, while the subsoil is used to create a small earthen bund around the pit.

A fodder or banana crop is planted in the pit. The general arrangement should allow runoff from surrounding areas to get into the pit and increase water storage. Due to the large volume of the tumbukiza pit, the fodder therefore grows rapidly, making it possible to have at least a fodder harvest per pit per month. Moreover, the tumbukiza pit stores moisture much longer, enabling Napier grass to survive in drier environments and fodder production

Tumbukiza pits with maize plants.

3 .DEMI-LUNES

Crescent-shaped ridges typically four meters from tip to tip, and 1 – 2 m between them, constructed on the contour, which collect water and debris. Mostly used with grains such as millet and sorghum grown in the water catchment area.

Demi-lunes

4.SWALES

Swales are simply shallow, low depressions in the ground designed to encourage the accumulation of rain during storms and hold it for a few hours or days to infiltrate the soil.

Swales

Rainwater harvesting.

IWGI

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