What is Sustainable Agriculture?

• Latin *sustinere* (sus-, from below and *tenere*, to hold)
• to keep in existence or maintain
• implies long-term support or permanence.
• **Sustainable farming systems** are capable of maintaining their productivity and usefulness to society indefinitely. They must be:
  
  • economically competitive (E)
  • environmentally sound (E) and resource conserving
  • socially supportive (S)
• SA produces abundant food without depleting the earth’s resources or polluting its environment.

• SA follows principles of nature to develop systems for raising crops and livestock that are, like nature, self-sustaining.

• SA is agriculture of social values, one whose success is similar to those from vibrant rural communities with wealth and wholesome food for everyone.

• But in the beginning of this 21st Century, SA, as a model farm economy, is still in its infancy.
• Conventional 20\textsuperscript{th}/21\textsuperscript{st} C agriculture takes \textit{industrial production} as its model.

• Together with big government subsidies, food is \textit{abundant and cheap} in \textit{developed countries}.

• Agriculture treated as \textit{manufacturing} not \textit{biological systems}, without social considerations

• Degrades soil and water, reduces biodiversity and \textit{cripples} small, \textit{rural} communities
SA means growing crops and livestock in ways that meet three objectives simultaneously:

1. Economic development (E)
2. Environmental conservation (E)
3. Social benefits to farm and community (S)
TOPIC 1:

ECONOMIC DEVELOPMENT
1. Selecting Profitable Enterprises to Ensure Economic Sustainability

Explore income opportunities other than traditional commodity crops and practices such as:

- Growing alternative crops like herbs and mushrooms

- Mixed cropping such as chilli and groundnuts
– Mixed plant and animal farming

– Contract growing of seeds for vegetable, rice and specialty crops

– Organic farming

However some of these involve niche markets
2. Financial planning

An overall sound financial plan with capital resources, expenditure and income projections must be made.
3. Marketing plan

- Marketing ranges from **passive** marketing to a commodity chain all the way up to **direct** marketing of a retail product to consumers.

- Market research is essential for big enterprises to gauge competition, consumer trend and prices.

- **Specialty and direct markets** such as organic, GMO-free, and other "green" markets yield more income but require more marketing by the producer.
Characteristics of Economic Development

- Finance of family increases
- Family debt decreases
- Less reliance on government subsidies
- Profits increase every year
- External purchase of feeds and fertilizers decreases
TOPIC 2:
ENVIRONMENTAL CONSERVATION
• Farms become environmentally sustainable by imitating natural healthy ecosystems

• Nature tends to function in cycles, so that waste from one process or system becomes input for another.

• Industrial agriculture, in contrast, tends to function in a linear fashion similar to a factory: inputs go in one end, and products and wastes (such as suspended soil, nitrates, pesticides) come out the other.

• In SA, a farm is a nature-based system, not a factory.
Biodiversity is important to SA

- The simpler we try to make agriculture, the more vulnerable it becomes to natural disasters and marketplace changes.

- When we try to produce a single product such as wheat or soybeans we are taking on a huge risk.

- If instead we diversify crops and integrate plant and animal agriculture, overhead is spread, reducing risk and increasing profit.

- In industrial agriculture, farming is a linear industrial factory, mainly monoculture while a biological farm model is an ecosystem utilizing a cyclical process involving a diversity of plants and animals.
Environmental conservation involves keeping in good condition the 4 ecosystem processes:

- Energy flow (E)
- Water cycle (W)
- Mineral cycle (M)
- Ecosystem dynamics (E)

These are observable and manageable and conserve soil and water resources.
Energy Flow

- **Energy flow** is the non-cyclical path of solar energy (sunlight) going into and through any biological system.

- The natural world runs on sunlight. Our management decisions affect how much of it is captured and put to good use on the farm.

- Energy flow:

  1. sunlight is converted into plant growth (photosynthesis)
  2. animals consume plants
  3. predator animals consume prey
  4. plants and animals die
  5. microorganisms decompose dead plants and animals.
  6. nutrients recycled into soil
  7. plants absorb nutrients from soil
• Some energy is lost as heat at every transfer point in the food chain. On the farm, energy capture is enhanced by maximizing—both in space and in time — the leaf area available for photosynthesis, and by efficiently cycling the stored solar energy through the food chain.

• Off-season cover crops, perennial vegetation, and intercropping are among the tools for capturing more solar energy.

Capturing sunlight and converting it to dollars is the original source of all wealth.
Water Cycle

An effective water cycle is typified by:
1. little soil erosion
2. fast water entry into the soil
3. the soil's capacity to store large amounts of water.

- Streams flow year-round from the slow release of water stored in the soil.
- The water cycle is improved by management decisions that add to or maintain:
  1. groundcover percentage and
  2. soil organic matter levels

Goal is to get as much water as possible into the soil during each rainfall.
Ground cover

• A surface mulch layer speeds water intake, reduces evaporation and protects the soil from erosion.

• Minimizing tillage (ploughing), growing high-residue crops and cover crops, and adding compost (manure) maintains ground cover. These also add to organic matter.
Soil organic matter

• Raising the percentage of organic matter from 1% to 2% in sandy soil (Hudson, 1994) increased available water content by 60%.

• Such an improvement in a soil's water-holding capacity will have a beneficial effect on crop growth, especially during droughts.
Effective water cycle can be seen by:

- low surface run-off
- low evaporation from soil
- reduction in droughts
- reduction in floods
- high transpiration by plants
- underground water storage
The Water Cycle
Mineral Cycle

• A well-functioning mineral cycle — movement of nutrients from soil through crops and animals and back to the soil — means less need for added fertilizer and feed.

• In nature, minerals needed for plant and animal growth are continuously recycled within the ecosystem and there is no need for added fertilizer.

• Ultimately, to be sustainable, we need to find ways to use the natural mineral cycle to minimize our off-farm purchase of minerals.

• Conditions and practices that inhibit the natural mineral cycle - erosion, nutrient leaching, organic matter depletion reduce the farm's sustainability.
The Mineral Cycle
Ecosystem Dynamics

- An effective **ecosystem dynamic** is indicated by **high diversity** of plants & animals above and below ground.
- "Diversity" refers not only to **numbers** of species, but also to **genetic diversity within species**, and **habitat diversity**
- Greater diversity produces **greater stability** within the system and **minimizes pest problems**.
- Our choices of practices and tools directly affect the level of biodiversity on the farm
## Effect of practices on biodiversity

<table>
<thead>
<tr>
<th>Increased Biodiversity</th>
<th>Intercropping</th>
<th>Crop rotation</th>
<th>Cover crops</th>
<th>Multispecies grazing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased Biodiversity</td>
<td>Monocropping</td>
<td>Tillage</td>
<td>Herbicides</td>
<td>Insecticides</td>
</tr>
</tbody>
</table>
Intercropping

• Increases crop species and therefore biodiversity

Eg are strip cropping of wheat and soybeans; cotton and alfalfa; bananas and pineapples

• Less pests because (1) more natural enemies in diverse mixtures, (2) food choice reduced for pests, and (3) reduced ability of pests to recognize host plants.

• Eg some insects can recognize rows of green plants separated by brown soil but not one uniform green expanse of plants and intercrops; or carrots intercropped with onions mask smell of carrots from flies.
Crop rotation

- Increases biodiversity
- breaks weed and pest life cycles
- provides complementary fertilization to crops in sequence with each other — nitrogen-fixing legume crops preceding grain crops such as corn supplies nitrogen, increasing yield
Cover crops, composts and fertilizers

- In nature, soil is covered with dead plant material, which prevents and moderates temperature extremes, increases water penetration and storage, and enhances aeration.

- Most importantly, the cover maintains soil structure and prevents erosion by rain and wind. Organic matter is also maintained.

- Soil erosion results in lost nutrients (requiring replacing with fertilizers) and reduced water holding ability, accounting for 50 to 75% of productivity loss.
### Effect of erosion on organic matter, phosphorus, and plant-available water.

<table>
<thead>
<tr>
<th>Erosion level</th>
<th>Organic matter</th>
<th>Phosphorus</th>
<th>Plant-available water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slight</td>
<td>3.0 %</td>
<td>69.50 Kg/ha</td>
<td>7.4 %</td>
</tr>
<tr>
<td>Moderate</td>
<td>2.5 %</td>
<td>68.38 Kg/ha</td>
<td>6.2 %</td>
</tr>
<tr>
<td>Severe</td>
<td>1.9 %</td>
<td>44.84 Kg/ha</td>
<td>3.6 %</td>
</tr>
</tbody>
</table>

*Source: Schertz et al., 1984.*
Several commercial fertilizers such as ammonium sulphate should not be used in sustainable farming because of harmful effects on soil organisms, structure and acidity.
Tillage (Ploughing)

- Soil is damaged considerably whenever it is ploughed and turned over (tillage).

- The plow brings subsoil to the surface and buries the crop residue layer so deep it is unable to decay properly.

- Virtually no soil residue is left on the surface, exposing the soil to erosion and impairing the water and mineral cycles.

- Today, millions of acres are being farmed without any tillage.
Borders, windbreaks, and special plantings

• These provide habitats for natural enemies of pests (beneficial organisms) further increasing biodiversity and stability.

• Addition of appropriate perennial crops, shrubs, and trees to the landscape enhances ecosystem dynamics still further.
**Zero Burning**

- This approach has been acknowledged by the world as an environment-friendly one that is sustainable.

- Zero burning is currently implemented in oil palm and rubber plantations.

- Upon felling, old oil palm and rubber trunks are not burned, but sliced thin and left to decompose.
  - Nutrients such as N, P, K and Mg are recycled leading to 50% reduction in fertilizer cost.
  - The rubber trunk can be marketed whole for the furniture industry.
Pest Management

• **Prevention of pests** is fundamental in any agricultural production system as pests reduce the biodiversity and productivity.

• **Chemical pesticides** can be effectively employed to suppress pests; however, there are more environmental friendly methods of control in sustainable agriculture.
• **Weeds** as a pest pose one of the greatest challenges to the sustainable production systems. However, weed populations tend to decline in severity as soil health builds.

• Generally weed prevention is based on developing a sound rotation, thwarting all attempts by existing weeds to set seed, and minimizing the arrival of new weed seeds from outside the field.

• **Cover crops** and **minimum tillage** will reduce weed numbers. In estates, weed management may be as simple as adding cattle to convert weeds into cash.
### Tillage and cover crop mulch effect on weed numbers and production.

<table>
<thead>
<tr>
<th>Tillage</th>
<th>Cover crop</th>
<th>Weeds/ meter²</th>
<th>Weed weight kg/ meter²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>None</td>
<td>36</td>
<td>0.66</td>
</tr>
<tr>
<td>None</td>
<td>None</td>
<td>15</td>
<td>0.42</td>
</tr>
<tr>
<td>None</td>
<td>Rye</td>
<td>2.7</td>
<td>0.3</td>
</tr>
<tr>
<td>None</td>
<td>Wheat</td>
<td>0.9</td>
<td>0.21</td>
</tr>
<tr>
<td>None</td>
<td>Barley</td>
<td>0.24</td>
<td>0.27</td>
</tr>
</tbody>
</table>

*Source: Putnam et al., 1983.*
• Insect pests can have a serious impact on biodiversity and farm income.

• SA utilizes biological (natural) control agents, crop barriers, intercropping and crop rotation to suppress pests.
• **Plant diseases** reduce biological diversity and yield.

• Their incidence can be lessened by having intrinsically healthy plants nurtured by microbially active soil.

• **Healthy soils** that suppress root diseases naturally can result from adding biologically active compost with balanced mineral levels.

• Microbial antagonists are also used to control pathogens.

• Use of **resistant cultivars** and **clean seeds** aid reduction in plant diseases.
INTEGRATED PEST MANAGEMENT (IPM)

- IPM adopts cultural, physical, biological, and chemical practices to minimize crop losses.

- Monitoring, record keeping, and life-cycle information about pests and their natural enemies are used to determine which control measures are needed to keep pests below an economic threshold.
• These four ecosystem processes (energy flow, water cycle, mineral cycle and ecosystem dynamics) function together as a whole unit, each one complementing the other.

• When we modify anyone of these, we affect the others as well. When we build our farm enterprises around these processes, we are applying nature’s principles to sustain the farm for our family and for future generations.
TOPIC 3:

SOCIO-POLITICAL BENEFITS
• Social benefits are provided for the farm family and community in terms of:

  • food security
  • land tenure
  • good health
  • maintaining the fabric of rural communities.
  • keeping money within the local economy
• Decisions made on the farm affect local community.

• Eg, expanding your farm requires taking over your neighbour’s farm. Therefore might not want to expand.

• Other examples of social decisions are:
  - buying supplies locally rather than from outside
  - networking with local consumers
  - relaying information on sustainable food production to neighbourhood.
• Marketing strategies involving direct marketing through farmers markets or road side stalls have a positive impact on the local community.

• People will choose to support local producers or their neighbours by paying a little more compared to overall market price.
• **Quality of life** for those who work and live on the farm includes **good communication, trust, and mutual support**.

• **Full family participation** in farm planning is an indication that the quality of life is high. Other indicators include **talking openly and honestly, spending time together, a feeling of progress toward goals, and a general happiness**.
TOPIC 4:
PLANNING and DECISION MAKING
• Managing the three objectives (economics, environment and society) simultaneously depends on clear goal-setting, effective decision-making, monitoring, and access to information.

• If your plan does not work, then a system should be developed to determine that failure. Eg, if the goals include increased biodiversity, the farmer needs to know quickly if the grazing or cropping system being used is actually increasing the number of plant species or not.
• **Monitoring** is important in sustainable agriculture, which relies on natural systems to replace input products like fertilizers and pesticides.

• The ability to evaluate and replan is vital to the farmer who wishes to farm more sustainably.

• The concept of planning-monitoring-controlling-replanning is a key characteristic of holistic management, referred to as the *feedback loop*. 
• Farmers selling **locally** will be more competitive by **differentiating** their products by qualities other than price, such as fresh produce, specialty items, and locally grown and processed foods.

• Apart from planning and decision-making, **access to information** is important. Fortunately, increased interest in SA has stimulated greater investment in **research and education**. Now, **useful information** is available today than ever before through various means.
SUMMARY
Sustainable farming meets economic, environmental, and social objectives simultaneously; because these three objectives always overlap, they are managed together.

Economic sustainability requires selecting profitable enterprises and doing comprehensive financial planning.

Environmental sustainability involves keeping the four ecosystem processes (effective energy flow, water and mineral cycles, and viable ecosystem dynamics) in good condition.

Social sustainability involves keeping money circulating in the local economy, and maintaining or enhancing the quality of life of the farm family.
SPECIFIC STRATEGIES

Keeping soil covered (cover crops); avoiding plowing; increasing biodiversity wherever possible through crop rotation, intercropping, integrated pest management; applying animal manures or compost; diversifying enterprises and planning for profit; integrating crop and animal enterprises; minimizing tillage, use of commercial fertilizer, and pesticides; buying supplies locally; employing local people; and including quality of life in your goals.