Agroecology

Ecological understanding of farming systems

2. Sustainability

• Food production
• Unsustainability of conventional agriculture
• Definitions
• Contexts
• Approaches
• Limitations
Many people are hungry
And there will be more to feed
Agricultural food production

• Necessary for a growing world population

• But is it sustainable?

Concern: Decelerating growth of food production (constant since 2002?)

Due to
• Dependence on capital
• Global inequality
• Violent conflicts

• Natural disasters
• Soil degradation
• Water over-use and waste
• Pollution
• Climate change
• Loss of genetic diversity
Conventional agriculture

Ways to maximize production and profit, based on science, technology and capital

- Intensive tillage (*drainage, deep rooting, aeration, mixing*)
- Monoculture (*scale, machinery, efficiency, export*)
- Inorganic fertilizer (*low cost, uniformity, easy application*)
- Chemical control (*eliminates all competing plants and herbivores*)
- Genetic manipulation (*selection, hybridization, gene splicing*)
- Expansion of agricultural land (*in remote arid, arctic and tropical regions*)
- Irrigation (*often main limiting factor for 16% of land, 40% of food*)
Sustainability

“Sustain” - Latin sustinere (sub-, from below and tenere, to hold),
= to keep in existence or maintain
- implying long-term support and permanence.
Sustainable agriculture

“As it pertains to agriculture, ‘sustainable’ describes farming systems that are capable of maintaining their productivity and usefulness to society indefinitely. Such systems... must be resource-conserving, socially supportive, commercially competitive, and environmentally sound.”

Sustainable agriculture

"...farmers in sustainable agriculture are concerned about feeding their families and paying their bills, but those are not their only goals in life. They set out to protect the land, improve their quality of life, and enhance the communities in which they live. Their day-to-day decisions are not guided by a single-minded search for profit, but by a delicate balancing act among many goals."

Sustainable development

“Sustainable development meets the needs of the present without compromising the ability of future generations to meet their needs.”

Sustainable systems

“A set of integrated industrial and ecological processes that equitably meets the biophysical needs of society while maintaining the integrity of life-supporting ecosystems over a long-term time horizon.”

Center for Sustainable Systems (CSS)
http://css.snre.umich.edu/1_8_approach.htm
Sustainable business

“Replace nationally and internationally produced items with products created locally and regionally.

Take responsibility for the effects they have on the natural world.

Do not require exotic sources of capital in order to develop and grow.

Engage in production processes that are human, worthy, dignified, and intrinsically satisfying. Create objects of durability and long-term utility whose ultimate use or disposition will not be harmful to future generations.

Change consumers to customers through education.”

Sustainable practice

“Sustainability may be defined as a potential that lies in all individuals and organisations. We may say that people and organisations are sustainable when they make use of all their qualities in interaction with their environment, i.e. market, culture and nature, and when they understand all sides of the various communities they are part of. Sustainable practise demands that everyone relates actively to resource management and understands and feels responsible for the mutual dependency between people and culture.”

The LEARNING Lab
http://www.laeringslaben.no
Sustainable harvest

Sustainable (or sustained) yield in population dynamics of predator-prey systems and fisheries:

- Prey population size (or resource production) $N_t$ vs time $t$.
- If the equivalent of net recruitment ($Y = N_{\text{born}} - N_{\text{dead}}$) is harvested per year, then population size stays constant.
- Sustained yield $Y = N_{t+1} - N_t = rN_t$ is highest at intermediate $N_t$, below which $N_t$ is low and above with $r$ is low.
- Equilibrium and time-invariance are assumed.

\[ \begin{align*}
\text{Population size } N_t \\
\text{Time } t \text{ (yr)} \\
\text{Two levels of Sustained Yield} \\
\text{Logistic curve}
\end{align*} \]

\[ \begin{align*}
\text{Yield } rN_t \\
\text{Population size } N_t \\
\text{Maximum Sustained Yield}
\end{align*} \]
Unsustainable harvest

If more than net recruitment is removed, resource populations diminish and become extinct.

Application

- Prey populations with density-dependent recruitment (collecting, hunting, fishing)
- Not in planted/seeded crops
- Defoliation of perennial plants (individuals in stead of populations)
- Renewable abiotic resources (aquifers, soil organic matter)
Sustainable activities

A sustainable activity maintains the factors that enable the activity itself.

- In population ecology it pertains to a resource-harvesting model, assuming equilibrium, time-invariance and absence of other determining factors.
- In agriculture, business and development it pertains to all possible factors determining the endurance of the activity:
  - Maintaining all economical, social, cultural, environmental, and ecological conditions,
  - Even if these factors are not directly affecting the activity.
Kinds of sustainability

“Strong Sustainability” - Requires that natural capital not be depleted and that humans live off the interest of natural capital.

In other words, strong sustainability requires that humans only use resources as quickly as the earth can naturally replace them. This approach recognizes that natural resources and ecosystems serve functions beyond acting as mere productive inputs. Therefore, humans should never draw down or reduce the amount of natural capital.

Weak Sustainability - Requires only that 'total capital' should not be depleted.

This view assumes substitutability between human created capital and natural capital. According to this theory, fish farms might be considered a substitute for wild fish, a water filtration plant may be viewed as a substitute for a healthy river system. Weak sustainability is a more human-centric view of sustainability and assumes that as long as resources, as required by humans, have not been depleted, that we are living sustainably.”

http://www.sustainmississauga.com/sustain%20define.htm
Attaining sustainability

Sustainability is attained if there are no negative effects on inputs, conditions and other values.

‘Complete’ sustainability

- Strong Conditions
- Weak Resource inputs
- Human activity
- Other values
Aim of sustainability

Sustainability = attempting to make output of human activities durable into the future.

This implies optimization instead of maximization of output (Sustained Yield), and Sufficient supply of goods, but with less profit.

Assumptions:
1. Stability of output can be attained, and
2. The system behaves predictably.
Unpredictability

Sustainability as commonly used is based on knowledge from the past, used for predictions into the future. However, complex systems change in new, unknown ways by disturbances and state-shifts.

Sustainability for stability of known processes does not deal with (unpredictable) change, but with ‘control and command’.

Therefore, sustainability should aim at resilience - the ability to maintain and restore system integrity and function after change (http://www.resalliance.org).

Sustaining resilience

Resilience

- Withstanding external force/stress
- Ability to maintain/regain function during/after change
- Capability to overcome injury/insult
- Prevention of collapse to less-desired state
- Capability to re-organize
- Adaptability and learning

Resilience is fostered by

- Taxonomic diversity
- Functional diversity
- Response diversity
- Landscape diversity (Spatial heterogeneity)
- Diversification of land use or activities

Catastrophe theory

- Two (or more) stable states
- Transitions (collapse and recovery)
- Hysteresis (different pathways and rates)
Questions

• What is the problem with conventional agriculture?
• Why is it unsustainable?
• Isn’t it at least weakly sustainable?
• Is sustainability measurable?
• Is it always attainable?