SUSTAINABLE FARMING:

What is Sustainable Agriculture ?

Agriculture has changed dramatically, especially since the end of World War II. Food and fiber productivity soared due to new technologies, mechanization, increased chemical use, specialization and government policies that favored maximizing production. These changes allowed fewer farmers with reduced labor demands to produce the majority of the food and fiber in the U.S.

Although these changes have had many positive effects and reduced many risks in farming, there have also been significant costs. Prominent among these are topsoil depletion, groundwater contamination, the decline of family farms, continued neglect of the living and working conditions for farm laborers, increasing costs of production, and the disintegration of economic and social conditions in rural communities.

A growing movement has emerged during the past two decades to question the role of the agricultural establishment in promoting practices that contribute to these social problems. Today this movement for sustainable agriculture is garnering increasing support and acceptance within mainstream agriculture. Not only does sustainable agriculture address many environmental and social concerns, but it offers innovative and economically viable opportunities for growers, laborers, consumers, policymakers and many others in the entire food system.

Sustainable agriculture integrates three main goals--environmental health, economic profitability, and social and economic equity. A variety of philosophies, policies and practices have contributed to these goals. People in many different capacities, from farmers to consumers, have shared this vision and contributed to it. Despite the diversity of people and perspectives, the following themes commonly weave through definitions of sustainable agriculture.

Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. Therefore, stewardship of both natural and human resources is of prime importance. Stewardship of human resources includes consideration of social responsibilities such as working and living conditions of laborers, the needs of rural communities, and consumer health and safety both in the present and the future. Stewardship of land and natural resources involves maintaining or enhancing this vital resource base for the long term.

A *systems perspective* is essential to understanding sustainability. The system is envisioned in its broadest sense, from the individual farm, to the local ecosystem, *and* to communities affected by this farming system both locally and globally. An emphasis on the system allows a larger and more thorough view of the consequences of farming practices on both human communities and the environment. A systems approach gives us the tools to explore the interconnections between farming and other aspects of our environment.

A systems approach also implies *interdisciplinary efforts in research and education*. This requires not only the input of researchers from various disciplines, but also farmers, farm workers, consumers, policymakers and others.

Making the transition to sustainable agriculture is a process. For farmers, the transition to sustainable agriculture normally requires a series of small, realistic steps. Family economics and personal goals influence how fast or how far participants can go in the transition. It is important to realize that each small decision can make a difference and contribute to advancing the entire system further on the "sustainable agriculture continuum." The key to moving forward is the will to take the next step.

Finally, it is important to point out that reaching toward the goal of sustainable agriculture is the responsibility of all participants in the system, including farmers, laborers, policymakers, researchers, retailers, and consumers. Each group has its own part to play, its own unique contribution to make to strengthen the sustainable agriculture community.

The remainder of this document considers specific strategies for realizing these broad themes or goals. The strategies are grouped according to three separate though related areas of concern: Farming and Natural Resources, Plant and Animal Production Practices, and the Economic, Social and Political Context. They represent a range of potential ideas for individuals committed to interpreting the vision of sustainable agriculture within their own circumstances.

Importance of Sustainable Agriculture

Sustainable agriculture is an agricultural production and distribution system that

- Achieves the integration of natural biological cycles and controls.
- Protects and renews soil fertility and the natural resource base.
- Optimizes the management and use of on-farm resources.

- Reduces the use of non-renewable resources and purchased production inputs.
- Provides an adequate and dependable form of income.
- Promotes opportunity in family farming and farm communities

Sustainable agriculture can be achieved by adapting:

- Mixed farming
- Mixed cropping
- Crop rotation
- Crop selection
- Varietal Improvement.

1) Multiple cropping

Multiple cropping is growing more than one kind of crop in the same area. This can be done in a number of different ways. There is relay cropping and double cropping. Relay cropping is starting one crop among another crop that has matured. Double cropping is another form of multiple cropping where one crop is started after the growing season for the previous crop has ended. This agricultural technique normally is used to help maintain nutrient levels in the soil.

Multiple cropping is very useful for a number of reasons. Both relay and double cropping are good for replacing nutrients in the soil that one type of plant might have used heavily. There are some plants that need a large amount of nitrogen to grow, for example. These plants use up the nitrogen stores in the soil, so another kind of plant that puts nitrogen in the soil is planted in the off season. Legumes are a well-known nitrogen fixing plant.

This agricultural cropping technique is not only beneficial because it produces more than one crop out of the same soil in a year, but each of the crops can help one another; different kinds of plants put different nutrients in the soil, and some may provide protection against harmful plants as well. More nutrient-rich soil may yield better crops as well. Relay cropping is also beneficial because it can help cut planting costs down, as the second crop also benefits from the moisture the first has amassed in the soil.

Although there are many benefits to multiple cropping, there are also some complications. When growing more than one crop in the same soil, a great deal of research must be done. The growing seasons generally need to be planned correctly, and the right types of crops must be mixed. The rotating crops should bring some diversity and unique benefit to the rest of the crops without hurting one another's growing cycle.

When growing more than one crop in the same soil, more nutrients as well as water normally will be needed. Having crops year long can also make it more difficult to weed, as many modern weeding tools are typically too invasive to use between growing crops. It may also be difficult to switch to a different planting technique if crops are constantly growing. Taking a break for a season may help solve this problem.

This kind of cropping, however, may help a farmer to get more from a limited amount of land. It can help balance the nutrients and suppress weeds. For many farmers, these benefits are more than enough to justify the disadvantages of multiple cropping.

2) Crop Rotation

Crop rotation is the practice of growing a series of dissimilar/different types of crops in the same area in sequential seasons.

Crop rotation gives various benefits to the soil. A traditional element of crop rotation is the replenishment of nitrogen through the use of green manure in sequence with cereals and other crops. Crop rotation also mitigates the build-up of pathogens and pests that often occurs when one species is continuously cropped, and can also improve soil structure and fertility by alternating deep-rooted and shallow-rooted plants.

Crop rotation is one component of polyculture.

Rationale : Growing the same crop in the same place for many years in a row disproportionately depletes the soil of certain nutrients. With rotation, a crop that leaches the soil of one kind of nutrient is followed during the next growing season by a dissimilar crop that returns that nutrient to the soil or draws a different ratio of nutrients: for example, rice followed by cotton.

Implementation :

Choice of crops

The choice and sequence of rotation crops depends on the nature of the soil, the climate, and precipitation which together determine the type of plants that may be cultivated. Other important aspects of farming such as crop marketing and economic variables must also be considered when deciding crop rotations.

Crop rotations may include two to six or more crop rotations over numerous seasons. A two crop rotation such as corn and soybean in cash grains or corn and alfalfa in forage systems use legumes to help fix nitrogen in the soil for utilization over the long term. Multiple cropping systems, such as intercropping or companion planting, offer more diversity and complexity within the same season or rotation. Carrots can be shaded by tomatoes and loosen soil below them. Double cropping is common where two crops, typically of different species, are grown sequentially in the same growing season. Winter rye and barley can be sown after oats or rice and harvested before the next crop goes in of oats or rice. These systems can maximize benefits of the rotation as well as available land resources.

More complex rotations commonly utilize people for greater use of on-farm nutrient management and additional farm products. A soil-feeding crop of clover could be replaced or aided by an application of manure to set up a field for a double crop of winter grains after potatoes. Soil building and pest population management benefits can be further utilized with different complexities of crop rotation. In general the complexity of a field's rotation is limited by what soil, climate, and other environmental conditions permit. This also includes the current or desired management tools and goals of the farmer.

Benefits:

Using some forms of crop rotation farmers can keep their fields under continuous production, instead of letting them lie fallow, as well as reducing the need for artificial fertilizers, both of which can be expensive.

A general effect of crop rotation is that there is a geographic mixing of crops, which can slow the spread of pests and diseases during the growing season. The different crops can also reduce the effects of adverse weather for the individual farmer and, by requiring planting and harvest at different times, allow more land to be farmed with the same amount of machinery and labour.

Agronomists describe the benefits to yield in rotated crops as "The Rotation Effect". There are many found benefits of rotation systems: however, there is no specific scientific basis for the sometimes 10-25% yield increase in a crop grown in rotation versus monoculture. The factors related to the increase are simply described as alleviation of the negative factors of monoculture cropping systems. Explanations due to improved nutrition; pest, pathogen, and weed stress reduction; and improved soil structure have been found in some cases to be correlated, but causation has not been determined for the majority of cropping systems.

Other benefits of rotation cropping systems include production costs advantages. Overall financial risks are more widely distributed over more diverse production of crops and/or livestock. Less reliance is placed on purchased inputs and overtime crops can maintain production goals with fewer inputs. This in tandem with greater short and long term yields makes rotation a powerful tool for improving agricultural systems.

Risks**:**Balancing the commitment to new crops or livestock with increased yield potentials and long term sustainability is the task of many farmers and agricultural scientists. With this research many new rotations have been developed and become widely accepted.

Risks of crop rotation include less overall profitability due to decreased acreage of the most valuable crop. Greater investment and lower relative efficiency in machinery used for different crops is also a possible outcome. More complex rotations require more crop species and livestock. This means the farmer must have additional skills and make more time and equipment investments initially. Also the more complex the system, the less flexible it becomes in terms of long term land management. Starting a rotation of a new crop may add profitability and farm resilience over time, but benefits are initially subject to being over-shadowed by volatile markets or high startup investments which can take time to overcome. Overall many farmers and agronomists agree finding a suitable rotation can benefit the overall productivity and sustainability of the farm.

3) Bio tech approach

biotechnology is technology based on biology - biotechnology harnesses cellular and biomolecular processes to develop technologies and products that help improve our lives and the health of our planet. We have used the biological processes of microorganisms for more than 6,000 years to make useful food products, such as bread and cheese, and to preserve dairy products.

Modern biotechnology provides breakthrough products and technologies to combat debilitating and rare diseases, reduce our environmental footprint, feed the hungry, use less and cleaner energy, and have safer, cleaner and more efficient industrial manufacturing processes.

Currently, there are more than 250 biotechnology health care products and vaccines available to patients, many for previously untreatable diseases. More than 13.3 million farmers around the world use agricultural biotechnology to increase yields, prevent damage from insects and pests and reduce farming's impact on the environment. And more than 50 biorefineries are being built across North America to test and refine technologies to produce biofuels and chemicals from renewable biomass, which can help reduce greenhouse gas emissions.

Biotech is helping to heal the world by harnessing nature's own toolbox and using our own genetic makeup to heal and guide lines of research by:

- Reducing rates of infectious disease;
- Saving millions of children's lives;
- Changing the odds of serious, life-threatening conditions affecting millions around the world;
- Tailoring treatments to individuals to minimize health risks and side effects;
- Creating more precise tools for disease detection; and
- Combating serious illnesses and everyday threats confronting the developing world.

Biotech uses biological processes such as fermentation and harnesses biocatalysts such as enzymes, yeast, and other microbes to become microscopic manufacturing plants. Biotech is helping to fuel the world by:

- Streamlining the steps in chemical manufacturing processes by 80% or more;
- Lowering the temperature for cleaning clothes and potentially saving $4.1 billion annually;
- Improving manufacturing process efficiency to save 50% or more on operating costs;
- Reducing use of and reliance on petrochemicals;
- Using biofuels to cut greenhouse gas emissions by 52% or more;
- Decreasing water usage and waste generation; and
- Tapping into the full potential of traditional biomass waste products.

Biotech improves crop insect resistance, enhances crop herbicide tolerance and facilitates the use of more environmentally sustainable farming practices. Biotech is helping to feed the world by:

- Generating higher crop yields with fewer inputs;
- Lowering volumes of agricultural chemicals required by crops-limiting the run-off of these products into the environment;
- Using biotech crops that need fewer applications of pesticides and that allow farmers to reduce tilling farmland;
- Developing crops with enhanced nutrition profiles that solve vitamin and nutrient deficiencies;
- Producing foods free of allergens and toxins such as mycotoxin; and
- Improving food and crop oil content to help improve cardiovascular health.

4) Nitrogen fixation

Nitrogen fixation is a process by which nitrogen (N_2) in the atmosphere is converted into ammonia (NH_3). Atmospheric nitrogen or molecular nitrogen (N_2) is relatively inert: it does not easily react with other chemicals to form new compounds. Fixation processes free up the nitrogen atoms from their diatomic form (N_2) to be used in other ways.

Nitrogen fixation, natural and synthetic, is essential for all forms of life because nitrogen is required to biosynthesize basic building blocks of plants, animals and other life forms, e.g., nucleotides for DNA and RNA and amino acids for proteins. Therefore nitrogen fixation is essential for agriculture and the manufacture of fertilizer. It is also an important process in the manufacture of explosives (e.g. gun powder, dynamite, TNT, etc.). Nitrogen fixation occurs naturally in the air by means of lightning.

Nitrogen fixation also refers to other biological conversions of nitrogen, such as its conversion to nitrogen dioxide. Microorganisms that can fix nitrogen are prokaryotes (both bacteria and archaea, distributed throughout their respective kingdoms) called diazotrophs. Some higher plants, and some animals (termites), have formed associations (symbioses) with diazotrophs.

5) TISSUE CULTURE

Tissue culture is the growth of tissues or cells separate from the organism. This is typically facilitated via use of a liquid, semi-solid, or solid growth medium, such as broth or agar. Tissue culture commonly refers to the culture of animal cells and tissues, with the more specific term plant tissue culture being used for plants.

Historical usage: In 1885 Wilhelm Roux removed a section of the medullary plate of an embryonic chicken and maintained cyclopasma, it in a warm saline solution for several days, establishing the basic principle of tissue culture. In 1907 the zoologist Ross Granville Harrison demonstrated the growth of frog nerve cell processes in a medium of clotted lymph. In 1913, E. Steinhardt, C. Israeli, and R. A. Lambert grew vaccinia virus in fragments of guinea pig corneal tissue. In 1996, the first use of regenerative tissue was used to replace a small distance of a urethra, which led to the understanding that the technique of obtaining samples of tissue, growing it outside the body without a scaffold, and reapplying it, can be used for only small distances of less than 1 cm.

Modern usage: In modern usage, **tissue culture** generally refers to the growth of cells from a tissue from a multicellular organism *in vitro*. These cells may be cells isolated from a donor organism, primary cells, or an immortalised cell line. The term tissue culture is often used interchangeably with **cell culture**

The literal meaning of tissue culture refers to the culturing of tissue pieces, i.e. explant culture.

Tissue culture is an important tool for the study of the biology of cells from multicellular organisms. It provides an *in vitro* model of the tissue in a well defined environment which can be easily manipulated and analysed.

6) AQUACULTURE

Aquaculture, also known as **aqua farming**, is the farming of aquatic organisms such as fish, crustaceans, molluscs and aquatic plants. Aquaculture involves cultivating freshwater and saltwater populations under controlled conditions, and can be contrasted with commercial fishing, which is the harvesting of wild fish. Broadly speaking, finfish and shellfish fisheries can be conceptualized as akin to hunting and gathering while aquaculture is akin to agriculture. Mariculture refers to aquaculture practiced in marine environments and in underwater habitats.

According to the FAO, aquaculture "is understood to mean the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated." The reported output from global aquaculture operations would supply one half of the fish and shellfish that is directly consumed by humans;[7] however, there are issues about the reliability of the reported figures.[8] Further, in current aquaculture practice, products from several pounds of wild fish are used to produce one pound of a piscivorous fish likesalmon.

Particular kinds of aquaculture include fish farming, shrimp farming, oyster farming, alga culture (such as seaweed farming), and the cultivation of ornamental fish. Particular methods include aqua ponics and Integrated multi- trophic aquaculture, both of which integrate fish farming and plant farming.

INTEGRATED AGRICULTURE

-Dairy Farming:is a class of agricultural, or an animal husbandry, enterprise, for long-term production of milk, usually from dairy cows but also from goats, sheep and camels, which may be either processed on-site or transported to a dairy factory for processing and eventual retail sale.

Most dairy farms sell the male calves born by their cows, usually for veal production, or breeding depending on quality of the bull calf, rather than raising non-milk-producing stock. Many dairy farms also grow their own feed, typically including corn, and hay. This is fed directly to the cows, or is stored as silage for use during the winter season.

History

Dairy farming has been part of agriculture for thousands of years. Historically it has been one part of small, diverse farms. In the last century or so larger farms doing only dairy production have emerged. Large scale dairy farming is only viable where either a large amount of milk is required for production of more durable dairy products such as cheese, butter, etc. or there is a substantial market of people with cash to buy milk, but no cows of their own.

Hand milking:

Centralized dairy farming as we understand it primarily developed around villages and cities, where residents were unable to have cows of their own due to a lack of grazing land. Near the town, farmers could make some extra money on the side by having additional animals and selling the milk in town. The dairy farmers would fill barrels with milk in the morning and bring it to market on a wagon. Until the late 19th century, the milking of the cow was done by hand. In the United States, several large dairy operations existed in some northeastern states and in the west, that involved as many as several hundred cows, but an individual milker could not be expected to milk more than a dozen cows a day. Smaller operations predominated.

For most herds, milking took place indoors twice a day, in a barn with the cattle tied by the neck with ropes or held in place by stanchions. Feeding could occur simultaneously with milking in the barn, although most dairy cattle were pastured during the day between milkings. Such examples of this method of dairy farming are difficult to locate, but some are preserved as a historic site for a glimpse into the days gone by. One such instance that is open for this is at Point Reyes National Seashore.

Milking parlors:

Innovation in milking focused on mechanizing the milking parlor (known in Australia and New Zealand as a *milking shed*) to maximize the number of cows per operator which streamlined the milking process to permit cows to be milked as if on an assembly line, and to reduce physical stresses on the farmer by putting the cows on a platform slightly above the person milking the cows to eliminate having to constantly bend over. Many older and smaller farms still have tie-stall or stanchion barns, but worldwide a majority of commercial farms have parlors.

-Poultry farming

raising of birds domestically or commercially, primarily for meat and eggs but also for feathers. Chickens, turkeys, ducks, and geese are of primary importance, while guinea fowl and squabs are chiefly of local interest.

Chickens:

Humans first domesticated chickens of Indian origin for the purpose of cockfighting in Asia, Africa, and Europe. Very little formal attention was given to egg or meat production. Cockfighting was outlawed in England in 1849 and in most other countries thereafter. Exotic breeds and new standard breeds of chickens proliferated in the years to follow, and poultry shows became very popular. From 1890 to 1920 chicken raisers stressed egg and meat production, and commercial hatcheries became important after 1920.

Breeds

The breeds of chickens are generally classified as American, Mediterranean, English, and Asiatic. The American breeds of importance today are the Plymouth Rock, the Wyandotte, the Rhode Island Red, and the New Hampshire. The Barred Plymouth Rock, developed in 1865 by crossing the Dominique with the Black Cochin, has grayish-white plumage crossed with dark bars. It has good size and meat quality and is a good layer. The White Plymouth Rock, a variety of the Barred Plymouth Rock, has white plumage and is raised for its meat. Both varieties lay brown eggs. The Wyandotte, developed in 1870 from five or more strains and breeds, has eight varieties and is characterized by a plump body, excellent meat, and good egg production. Only the white strain is of any significance today because it is used in broiler crosses where its white plumage, quality of flesh, and rapid growth are highly desirable.

An American breed, the Rhode Island Red, developed in 1857 from Red Malay game fowl crossed with reddish-coloured Shanghais—with some brown Leghorn, Cornish, Wyandotte, and Brahma blood—is good for meat production and is one of the top meat breeds for the production of eggs. It has brilliant red feathers and lays brown eggs.

The New Hampshire, developed in the U.S. in 1930 from Rhode Island Red stock, is a meaty, early maturing breed with light-red feathers and lays large brown eggs. The only Mediterranean breed of importance today is the Leghorn. This breed, originated in Italy, has 12 varieties, the single-comb White Leghorn being more popular than all of the other types combined. This breed, the leading egg producer of the world, lays white eggs and is kept in large numbers in England, Canada, Australia, and the U.S. The White Minorca, a second Mediterranean breed, is often used in crossbreeding for egg production.

The only English breed of modern significance is the Cornish, a compact and heavily meated bird used in crossbreeding programs for broiler production. It is a poor producer of eggs, however.

The only Asiatic breed of significance today, the Brahma, which originated in India, has three varieties, the light Brahma being preferred because of its size.

Chicken breeding is an outstanding example of the application of basic genetic principles of inbreeding, line breeding, and crossbreeding, as well as of intensive mass selection to effect faster and cheaper gains in broilers and maximum egg production for the egg-laying strains. Maximum use of heterosis, or hybrid vigour, through in crosses and crossbreeding has been made. Crossbreeding for egg production has used the single-comb White Leghorn, the Rhode Island Red, the New Hampshire, the Barred Plymouth Rock, the White Plymouth Rock, the Black Australorp, and the White Minorca. Crossbreeding for broiler production has used the White Plymouth Rock or New Hampshire crossed with White or Silver Cornish or inc rosses utilizing widely diverse inbred strains within a single breed. Rapid and efficient weight gains, and high quality, plump, meaty carcasses have been achieved thereby.

The male sperm lives in the hen's oviduct for two to three weeks. Eggs are fertilized within 24 hours after mating. Yolks originate in the ovary and grow to about 1.6 inches (4 cm) in diameter, after which they are released into the oviduct, where the thick white and two shell membranes are added. The egg then moves into the uterus where the thin white and the shell are added. This process requires a total of 24 hours per egg. The hatching of fertilized eggs requires 21 days, with the heavy breeds requiring a few more hours and the lighter breeds slightly fewer. Ideal hatching temperature approximates 100 °F (38 °C) with control of air flow, humidity, oxygen, and carbon dioxide being essential. Standardized egg-laying tests and official random sample tests have been used for many years to measure actual productivity.

-Biogas: is a renewable energy source with many different production pathways and various excellent opportunities to use.

Biogas means a gas produced by the anaerobic digestion or fermentation of organic matter. The organic matter can be manure, sewage sludge, municipal solid waste, biodegradable waste or any other biodegradable feedstock. Biogas is mainly methane and carbon dioxide. One main Advantage of biogas is the waste reduction Potential. Biogas production by anaerobic digestion is popular for treating biodegradable waste because valuable fuel can be produced while destroying disease-causing pathogens and reducing the volume of disposed waste products.

biogas burns more cleanly than coal, and produces more energy with less emissions of carbon dioxide. The harvesting of biogas is an important role of waste management because methane is a greenhouse gas with a greater global warming potential than carbon dioxide. The carbon in biogas was generally recently extracted from the atmosphere by photosynthetic plants, so releasing it back into the atmosphere adds less total atmospheric carbon than the burning of fossil fuels.

Thus biogas production kills two birds with one stone : it reduces waste and produces energy. In addition, the residues from the digestation process can be used as high quality fertilizer. This closes the nutrient cycle. therefore, biogas is a perfect energy source including many benefits!

Benefits

When biogas is used, many advantages arise. In North America, utilization of biogas would generate enough electricity to meet up to three percent of the continent's electricity expenditure. In addition, biogas could potentially help reduce global climate change. Normally, manure that is left to decompose releases two main gases that cause global climate change: nitrogen dioxide and methane. Nitrogen dioxide (NO2) warms the atmosphere 310 times more than carbon dioxide and methane 21 times more than carbon dioxide.

By converting cow manure into methane biogas via anaerobic digestion, the millions of cows in the United States would be able to produce one hundred billion kilowatt hours of electricity, enough to power millions of homes across the United States. In fact, one cow can produce enough manure in one day to generate three kilowatt hours of electricity; only 2.4 kilowatt hours of electricity are needed to power a single one hundred watt light bulb for one day. Furthermore, by converting cow manure into methane biogas instead of letting it decompose, global warming gases could be reduced by ninety-nine million metric tons or four percent. In Nepal biogas is being used as a reliable source of rural energy, says Bikash Haddi of Biogas promotion center.