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Abstract – Agriculture is the sole provider of human food. Most farm machines are driven by fossil fuels, which contribute to greenhouse gas emissions and, in turn, accelerate climate change. Such environmental damage can be mitigated by the promotion of renewable resources such as solar, wind, biomass, tidal, geo-thermal, small-scale hydro, biofuels and wave-generated power. These renewable resources have a huge potential for the agriculture industry. The farmers should be encouraged by subsidies to use renewable energy technology. The concept of sustainable agriculture lies on a delicate balance of maximizing crop productivity and maintaining economic stability, while minimizing the utilization of finite natural resources and detrimental environmental impacts. Sustainable agriculture also depends on replenishing the soil while minimizing the use of non-renewable resources, such as natural gas, which is used in converting atmospheric nitrogen into synthetic fertilizer, and mineral ores, e.g. phosphate or fossil fuel used in diesel generators for water pumping for irrigation. Hence, there is a need for promoting use of renewable energy systems for sustainable agriculture, e.g. solar photovoltaic water pumps and electricity, greenhouse technologies, solar dryers for post-harvest processing, and solar hot water heaters. In remote agricultural lands, the underground submersible solar photovoltaic water pump is economically viable and also an environmentally-friendly option as compared with a diesel generator set. If there are adverse climatic conditions for the growth of particular plants in cold climatic zones then there is need for renewable energy technology such as greenhouses for maintaining the optimum plant ambient temperature conditions for the growth of plants and vegetables. The economics of using greenhouses for plants and vegetables, and solar photovoltaic water pumps for sustainable agriculture and the environment are presented in this article. Clean development provides industrialized countries with an incentive to invest in emission reduction projects in developing countries to achieve a reduction in CO2 emissions at the lowest cost. The mechanism of clean development is discussed in brief for the use of renewable systems for sustainable agricultural development specific to solar photovoltaic water pumps in India and the world. This article explains in detail the role of renewable energy in farming by connecting all aspects of agronomy with ecology, the environment, economics and societal change.

1. INTRODUCTION

1.1. Sustainable agriculture

Sustainable agriculture is an alternative for solving fundamental and applied issues related to food production in an ecological way (Lal, 2008). It has its roots in a set of values that reflects an awareness of both ecological and social realities. It involves design and management procedures that work with natural processes to conserve all resources and minimize waste and environmental damage, while maintaining or improving farm profitability. Working with natural soil processes is of particular importance. Sustainable agriculture systems are designed to take maximum advantage of existing soil nutrient and water cycles, energy flows, beneficial soil organisms, and natural pest controls. By capitalizing on existing cycles and flows, environmental damage can be avoided or minimized.

Such systems also aim to produce food that is nutritious, and uncontaminated with products that might harm human health. Using a great variety of farming strategies allows producers to meet their needs: in their operations, their environments and their communities. The primary goals of sustainable agriculture (Lichtfouse et al., 2009) include:

➢ providing a more profitable farm income;
➢ promoting environmental stewardship, including:
   – protecting and improving soil quality;
   – reducing dependence on non-renewable resources, such as fuel and synthetic fertilizers and pesticides; and
   – minimizing adverse impacts on safety, wildlife, water quality and other environmental resources;
➢ promoting stable, prosperous farm families and communities.

“The best way to communicate the meaning of sustainable agriculture is through real-life stories of farmers who are...
developing sustainable farming systems on their own farms” as stated by John Ikerd, Agricultural Economist, Emeritus, University of Missouri.

Never on earth has food been produced on such a large scale and with such intensive use of land, to satisfy the needs of a growing global population. Agriculture worldwide contributes significantly to unsustainable levels of chemicals in fertilizers and pesticides, and also to the combustion of large amounts of non-renewable fossil fuel, through farm processes, and the transportation of food from field to dinner plate.

In the hot summer months, when the sun shines, the wind often does not blow. During the cool and cloudy fall and winter seasons, wind speeds are often at their highest. If the site is accommodating these climatic features then combining wind and solar can be an effective renewable energy system. Harnessing renewable energy systems in agriculture is termed as clean energy farming as reported by SARE (2006).

1.2. Principles of agricultural sustainability

Corwin et al. (1999) established that the concept of sustainable agriculture is predicated on a delicate balance of maximizing crop productivity and maintaining economic stability, while minimizing the utilization of finite natural resources and detrimental environmental impacts. Agricultural sustainability is a societal goal to be pursued forever and for everyone and guided by general principles. The following principles reported by Gerber (1992) are offered for purposes of discussion in this chapter.

(1) A sustainable agricultural system is based on the prudent use of renewable and/or recyclable resources. A system which depends on exhaustible (finite) resources such as fossil fuels cannot be sustained indefinitely. A sustainable system would use renewable energy sources such as biological, geothermal, hydroelectric, solar or wind. Use of recyclable resources such as groundwater at rates greater than recharge depletes reserves and cannot be sustained.

(2) A sustainable agricultural system protects the integrity of natural systems so that natural resources are continually regenerated. The current thinking focuses on reducing the rate of degradation of natural and agricultural ecosystems. A system will not be sustainable as long as the goal is simply to decrease the rate of its degradation. Sustainable agricultural systems should maintain or improve groundwater and surface water quality and regenerate healthy agricultural soils.

(3) A sustainable agricultural system improves the quality of life of individuals and communities. In order to stem the rural to urban migration, rural communities must offer people a good standard of living including diverse employment opportunities, health care, education, social services and cultural activities. Young people must be afforded opportunities to develop rural enterprises, including farming, in ways which care for the land so that it may be passed onto future generations in as good as or better condition than it was received.

(4) A sustainable agricultural system is profitable. Transition to new ways of knowing, doing and being require incentives for all participants. Some of these incentives are necessarily economic. Systems and practices that do not include profitability as one of the prime motivators will not be voluntarily implemented.

(5) A sustainable agricultural system is guided by a land ethic that considers the long-term good of all members of the land community. Holistic or whole-system analysis views an agro-ecosystem as a dynamic community of soil, water, air and biotic species. All parts are important because they contribute to the whole. This ethic strives to protect the health of the land community that is its capacity for self-renewal.

Farmers and ranchers can choose many ways to improve their sustainability, and these vary from region to region, state to state and farm to farm. However, some common sets of practices have emerged, many of them aimed at greater use of on-farm or local resources. Some of those practices are illustrated here, each contributing in some way to long-term farm profitability, environmental stewardship and improved quality of life.

1.2.1. Precision agriculture

Precision agriculture is a key crop management system to achieve agricultural sustainability through the use of new information technologies.

1.2.2. Integrated pest management (IPM)

IPM is an approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks.

1.2.3. Rotational grazing

Management-intensive grazing systems take animals out of the barn and into the pasture to provide high-quality forage and reduced feed costs while avoiding manure buildup.

1.2.4. Soil conservation

Many soil conservation methods, including strip cropping, reduced tillage and no-till, help prevent loss of soil due to wind and water erosion.

1.2.5. Water quality/wetlands

Water conservation and protection have become important parts of agricultural stewardship. Practices such as planting riparian buffer strips can improve the quality of drinking and surface water, as well as protect wetlands.