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Renewable Energy and Agriculture: A Partnership for Sustainable Development

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ABSTARCT: *Agriculture is the sole provider of human food. Most farms 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 energy resources such as solar, wind, biomass, small hydro, and biofuels. These renewable resources have a huge potential for agriculture industry. 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 generator 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. This article details the role of renewable energy in farming by connecting all aspects of environment, societal change and ecology.*

Keywords: *Renewable energy, agriculture, sustainable development*

I. INTRODUCTION

Worldwide, agriculture contributes between 14 and 30 percent of human-caused greenhouse gas (GHG) emissions because of its heavy land, water, and energy use—that's more than every car, train, and plane in the global transportation sector. Livestock production alone contributes around 18 percent of global emissions, including 9 percent of carbon dioxide, 35 percent of methane, and 65 percent of nitrous oxide. Activities like running fuel-powered farm equipment, pumping water for irrigation, raising dense populations of livestock in indoor facilities, and applying nitrogen-rich fertilizers all contribute to agriculture’s high GHG footprint.

Agriculture is one of the main energy users and there are a number of examples of small energy requirements for agricultural end uses such as drying, small scale processing, maize pulping, threshing, milling, preserving (cool rooms), sorting and packaging, plowing, watering/irrigation, etc. Priority of use of renewable energy in agriculture should go for productive uses. Solar photovoltaic systems could be applied for agriculture such as: cooling, heating and extended lighting of poultry farms, irrigation including drip irrigation, electric fencing for grazing management, pest control, veterinary clinics, cool houses for fruit preservation, cattle watering points, aeration pumps for aquaculture, egg incubators, crop dryers, agro processing, etc.

Agriculture plays a double role towards energy: it is a major energy user while it also a major source of renewable - specifically bioenergy. Energy and agriculture are fully connected through the bioenergy linkage and could generate synergy so that the farmer can produce them, agro-industry can contribute to the energy balance such as bagasse in sugar factories, while at the same time bioenergy lacks the diversification of agriculture. Alternative energy sources support rural development by way of providing new opportunities to rural population, creating new infrastructure, backing diversification and attracting new investments in rural locations. Alternative and renewable energy sources also have an impact on sustainability of development initiatives as they affect from the social, economic and environmental points of view. Renewable energy, particularly bioenergy, could greatly contribute to enhancing sustainable development from both perspectives of environmental sustainability and productivity improvement. It is, therefore, vital that bioenergy applications are upgraded from traditional uses only to cleaner, efficient, transportable and more versatile uses such as: combustion, gasification, pyrolisis, carbonization, fermentation to alcohol, fermentation to methane (biogas) and oil extraction. Regarding their impacts on social development, they contribute to a better quality of life, improve health conditions, create confidence, help consolidate equity and integrate farmers to modern activities.

From the economic perspective, alternative energies create new jobs, give new impetus to agriculture and agro-industries development, create synergy between agriculture and energy, enhance productivity and create interactions leading to ample and long lasting economic benefits.Environmentally, alternative energies would contribute to attain clean development, enable better management of resources, help substitute of CO_2 emissions, help reduce pollution from the transport sector and would contribute to reducing indoor pollution. A very important condition for such positive impacts and attainment of synergies between agriculture and energy is through avoiding competition of land and other resources between the two. In the African countries, a transition to sustainable energy systems is needed to accelerate the growth of basic food production, harvesting and processing. However, breaking the current energy bottleneck must also be sustainable - i.e. environmentally sound, socially acceptable and economically viable. Such a transition involves a commitment to long-term developmental goals and requires innovative policy and technological solutions.

For Africa, an energy transition would be characterized by a move from the present levels of subsistence energy usage based on human labour and fuel wood resources, to a situation where household, services and farming activities use a range of sustainable and diversified energy sources. Obvious benefits are greater resilience in the production system, higher productivity, improved efficiency and higher incomes to farmers. Environmental degradation, driven primarily by poverty, would be minimized. The investment required to make such a transition would not be significantly different from that required for conventional approaches. However, the process of identifying needs and promoting investment in a range of technological options would be considerably different. Among current problems are the following:

- Price policies rarely reflect the energy needs of rural populations;
- Energy plans and agricultural programmes are not linked;
- Energy requirements for agro-activities are seldom quantified;
- Energy policies and plans in most countries do not focus on the agricultural and rural sectors, except occasionally, on an aggregate basis

II. SUSTAINABLE AGRICULTURE

The first and foremost role of agriculture is the production of food and other primary goods and thereby contributing to food security. Food and Agriculture Organization (FAO) has defined sustainable agriculture and rural development (SARD) as:

"...the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of the human needs for present and future generations. Such sustainable development (in agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable. "

Agriculture can deliver a wide range of non-food goods and services. This can include its use as a viable, sustainable source of energy, as set out in the FAO perspective (FAO/Netherlands, 1999) on the "Multifunctional Character of Agriculture and Land (MFCAL)". The perspective recognizes that agricultural activity and related land-use contribute directly to other, non-agricultural functions comprising social, environmental, economic and cultural goods and services. These can result in significant benefits or costs. Evidence suggests that, in addition to food security, agriculture makes a major contribution to achieving sustainability in rural development, energy and the environment at local, national and global levels. The effective operation of the market stimulates the identification and enhancement of these multiple functions and the emergence of new techniques and technologies.

Despite adequate global food production, many still go hungry because increased food supply does not automatically mean increased food security. What is important is who produces the food, who has access to the technology and knowledge to produce it, and who has the purchasing power to acquire it (Pretty and Hine, 2001). Sustainable agricultural approaches thus allow farmers to improve local food production with low-cost, readily available technologies and inputs, without causing environmental damage.

Sustainable agriculture can also contribute significantly to increased food production, as well as make a significant impact on rural people's welfare and livelihoods. However, without appropriate policy support at a range of levels, these improvements will remain at best localized in extent, or worse, will wither away. A thriving and sustainable agricultural sector requires both integrated action by farmers and communities, and integrated action by policy makers and planners. It is also vital for farmer-to-farmer learning and sharing of experiences to be encouraged and facilitated.

2.1 Principles Of Agricultural Sustainability

The lack of a commonly agreed upon definition for sustainable agriculture is believed by some to be an impediment to meaningful dialogue. It is suggested that sustainable agriculture should not be understood as a specific agricultural practice, technology or system. Rather, agricultural sustainability is a societal goal to be pursued forever and for everyone and guided by general principles. The following principles are offered for purposes of discussion.

- **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.
- **A sustainable agricultural system protects the integrity of natural systems so that natural resources are continually regenerated.** Our 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.
- **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 or in better condition than it was received.
- **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.
- **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.

Sustainable agricultural practices include:

- Crop rotations that mitigate weed, disease, and insect problems; increase available soil nitrogen and reduce the need for synthetic fertilizers; and in conjunction with conservation tillage practices, reduce soil erosion.
- Integrated pest management (IPM), which reduces the need for pesticides by crop rotations, scouting, timing of planting, biological pest controls.
- Management systems to improve plant health and crops' abilities to resist pests and disease.
- Soil conserving tillage.
- Water conservation and water harvesting practices.
- Planting of leguminous crops and use of organic fertilizer or compost to improve soil fertility.

III. RENEWABLE ENERGY IN AGRICULTURE

Modern agriculture is heavily dependent on non-renewable energy sources, especially petroleum. The continued use of these energy sources cannot be sustained indefinitely, yet to abruptly abandon our reliance on them would be economically catastrophic. However, a sudden cutoff in energy supply would be equally disruptive. In sustainable agricultural systems, there is reduced reliance on non-renewable energy sources and a substitution of renewable sources or labour to the extent that is economically feasible.

There is significant potential for agricultural involvement in the production and consumption of solar, wind, geothermal, and biomass energy. Renewable resources are abundant and widely distributed throughout the world. A number of commercial technologies are available to harness these resources, and with appropriate support, additional technologies - some potentially paradigm-shifting - could be brought to market.

Renewable energy can address many concerns related to fossil energy use. It produces little or no environmental emissions and does not rely on imported fuels. Renewable resources are not finite (as fossil fuels are) and many are available throughout the country. Different renewable technologies are at different points in their development. Some are commercially available or nearly so, and others have potential for the longer term. Unfortunately, many benefits that renewable energy can provide are not monetized — they cannot be perceived through price signals. Policies are needed to push or pull these new technologies to full commercial development. This article examines the domestic status and opportunities for a number of renewable energy technologies — solar, wind, geothermal, and biomass.

3.1 Solar

Solar technologies produce electrical or thermal energy. Photovoltaic (PV) cells (or "solar cells") that convert sunlight directly into electricity are made of semiconductors such as crystalline silicon or various thin-film materials. Solar thermal technologies collect heat from the sun and then use it directly for space and water heating or convert it to electricity through conventional steam cycles, heat engines, or other generating technologies (concentrating solar systems).

In agriculture, PV can economically provide electricity where the distance is too great to justify new power lines. Solar electric systems are used to provide electricity for lighting, battery charging, small motors, water pumping, and electric fences. Livestock and dairy operations often have substantial air and water heating requirements. For example, commercial dairy farms use large amounts of energy to heat water for cleaning equipment. Heating water and cooling milk can account for up to 40 percent of the energy used on a dairy farm. Solar water heating systems may be used to supply all or part of these hot water requirements. Other solar applications include greenhouse heating and solar crop drying.

3.2 Wind Energy

Wind technologies provide mechanical and electrical energy. Wind turbines operate on a simple principle: Wind turns rotor blades, which drive an electric generator, turning the kinetic energy of the wind into electrical energy. The wind is a renewable energy source, and windmills do not produce harmful environmental emissions. Wind power technology is already in widespread use due to substantial progress in reducing costs for areas with consistently high wind speeds.

Small wind systems can serve agriculture in traditional ways, such as using mechanical energy to pump water or grind grain. As costs decrease, small systems used to generate electricity may also become economically efficient by avoiding the expense of installing transmission wires, especially in more remote applications. Where connected to the electricity distribution grid, small windmills can generate revenue through electricity sales when generation exceeds internal requirements. Decentralized wind systems can be combined with other energy sources to create a hybrid energy system, where the low cost and intermittent wind resource is supplemented by more expensive small generators such as diesel generators or batteries, to provide power that is both relatively inexpensive and reliable.

3.3 Geothermal

Geothermal technologies produce electrical or thermal energy. Three types of geothermal power plants are operating today: dry steam plants, flash steam plants, and binary-cycle plants. High-temperature geothermal resources (greater than 300°F) are used for power generation.

Individual power plants can be as small as 100 kW or as large as 100 MW. The technology is suitable for rural electric mini-grids, as well as national grid applications. The heat from geothermal energy can also be utilized directly. Geothermal fluids can be used for such purposes as heating buildings, growing plants in greenhouses, dehydrating onions and garlic, heating water for fish farming, and pasteurizing milk. Generally, low-to-medium temperature resources (between 70°F and 300°F) are used. Another technology, geothermal heat pumps, can provide space heating and cooling. This technology does not require a hydrothermal (hot water) resource, but instead uses the near-surface ground as a heat source during the heating season and as a heat sink during the cooling season.

Geothermal energy has many agricultural applications. Vegetables, flowers, ornamentals, and tree seedlings are raised in 43 greenhouse operations heated by geothermal energy. Forty-nine geothermal aquaculture operations raise catfish, tilapia, shrimp, alligators, tropical fish, and other aquatic species. Agri-industrial applications include food dehydration, grain drying, and mushroom culture. The drying of onions and garlic is the largest industrial use of geothermal energy.

3.4 Biomass

Biomass energy forms another perfect integration with agriculture such that it could be used in generating electricity, producing solid, liquid and gaseous fuels and generating thermal energy for either drying or mechanical drive. Bioenergy is of particular importance to FAO and is managed in two programmes: wood energy (fuel wood plantations and forest resources) and agro-energy (including agricultural residues, livestock and municipal residues, crop residues and energy crops like sugar cane and sugar beats, sorghum, oilseeds and grasses).

Agricultural activities generate large amounts of biomass residues. While most crop residues are left in the field to reduce erosion and recycle nutrients back into the soil, some could be used to produce energy without harming the soil. Other wastes such as whey from cheese production and manure from livestock operations can also be profitably used to produce energy while reducing disposal costs and pollution.

Discussion of renewable energy from biomass centers on the concept of the "biorefinery," where new technologies are being used to extract energy and other valuable products from biomass resources. Like oil refineries, biorefineries are envisioned as industrial facilities that convert a stream of raw material into a varied slate of products, maximizing value by shifting the mix of output to match dynamic market conditions. Potential biorefinery products include liquid fuels, such as ethanol and biodiesel, electricity, steam, and high-value chemicals and materials. Many of these products have the potential to replace petroleum, either as a vehicle fuel or as a chemical feedstock, resulting in increased energy security and reduced environmental emissions.

In a sense, biorefineries already exist. They process corn into ethanol, corn syrup, animal feed, and other products, or transform trees into a variety of wood products, electricity, and heat, to name two examples. Most biomass is converted to energy the same way it always has been—by burning it. The heat can be used directly for heating buildings, crop drying, dairy operations, and industrial processes. It can also be used to produce steam and generate electricity. For example, many electric generators and businesses burn biomass by itself or with other fuels in conventional power plants.

Biomass can also be converted into liquids or gases to produce electricity or transportation fuels. Ethanol is typically produced through fermentation and distillation, in a process much like that used to make beer. Soybean and canola oils can be chemically converted into a liquid fuel called biodiesel. These fuels can be used in conventional engines with little, if any, modification. Biomass can be converted into a gas by heating it under pressure and without oxygen in a "gasifier." Manure too can be converted using a digester. The gas can then be burned to produce heat, steam, or electricity

IV. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

Renewable energy technologies are being used in a variety of applications on farms and ranches and there are many opportunities to expand their use in the future. For example, renewable, farm-based biomass and other renewable energy sources may be able to fuel hydrogen production; agricultural vehicles running on hydrogen could have the same efficiency and environmental benefits planned for light-duty cars and trucks; and hydrogen fuel cell technology could provide power for remote locations and communities. Where do we go from here to encourage renewable sources of energy that are important to agriculture, such as solar, wind, geothermal, and biomass? The development of a new energy future will require research, development, demonstration, deployment, and commercialization of new technologies. Each of these activities must function as part of a continuum flowing from the research bench to commercial application, with feedback loops among the various steps. Collaboration, education, and policy will all be important.

4.2 Recommendations

The following are some suggestions to move towards mainstreaming sustainable agriculture, at a national level:

- Conduct an in-depth integrated assessment of general agriculture policies, programmes and plans to see where the gaps are, in terms of sustainable agriculture. Policies that provide disincentives against sustainable agriculture need to be changed.
- General and sustainable agriculture policies should support each other to the greatest extent possible to promote effective policy coherence.
- Agriculture has always been closely associated with the environment. Better integration of agricultural and environmental policies would provide mutual benefits. The goal is to move rapidly toward "environmentally friendlier" sustainable agricultural practices.
- Develop a sustainable agricultural policy and action plan, with clear objectives, targets and timeframes. This process should be participatory and involve relevant agencies, farmers and their organizations, the private sector and NGOs. A lead agency/department should be identified to carry the work forward.
- Promote and facilitate the adoption of sustainable and lower input agriculture, and environmentally friendly technologies and practices. This may include the use of economic instruments and incentives for farmers to switch to sustainable agriculture, including organic agriculture.
- Promote and facilitate practices that encourage local biodiversity and endemic varieties. Encourage local seed banks so that traditional and diverse varieties of seeds are maintained.
- Plan with reference to water management, including growing traditional crops that do not have high water demands and integrating soil management using organic matter, which has higher water-holding capacity.
- Sustainable agriculture should be integrated into the education system, including at the tertiary level. Specialized institutions involved in training for sustainable agriculture should be supported

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