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# APPLICATION OF GREEN TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT IN RURAL INDIA

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**ABSTRACT**

India is currently the World's second largest populated Country. It is expected that India's population will surpass the population of China by 2030. Over seventy per cent of India's population still live in rural areas. Agriculture is the largest and one of the most important sectors of the rural economy and contributes both to economic growth and employment.

In the developing countries like India, majority live in rural areas and environmental degradation is more pervasive because of rapid deforestation, watershed degradation, loss of biological diversity, fuel wood and water shortages, water contamination, soil erosion and land degradation. Thus it is a challenge today before agriculture sector to ensure people's rights to food security; at the same time the challenge also is to retain the natural resources productive for future generation.

The primary purpose of the paper is to discuss the green techniques for rural India to achieve the goal of a better future so that the present generation is engaged adequately for achieving its own well being while ensuring even better quality of life for the successive generations.
*Keywords* : Green, Technology, Sustainable, Development, Rural

## Introduction

India is currently the World's second largest populated Country. It is expected that India's population will surpass the population of China by 2030. India occupies 2.4% of the world's land area and supports over 17.5% of the world's population. Indian life revolves mostly around agriculture and allied activities in small villages, where the overwhelming majority of the population live. In 2007, India ranked $126^{th}$ on the United Nation's Human Development Index, which takes into account social, health, and educational conditions in a country.

Over seventy per cent of India's population still live in rural areas. Agriculture is the largest and one of the most important sectors of the rural economy and contributes both to economic growth and employment. A large proportion of the rural work force is poor and consists of marginal farmers and landless agricultural labourers. There is substantial unemployment and under employment among these people; both wages and productivity are low. This in turn results in poverty; it is estimated that 380 million people are still living below the poverty line in rural India.

The United Nations Asian and Pacific Centre for Agricultural Engineering and Machinery (APCAEM) has been taking initiative to promote the agro-based environment-friendly technology termed as Green Technology (GT) to promote sustainable agriculture development for the eradication of poverty and guarantee environmental sustainability. The operationalisation of Clean Development Mechanism (CDM) of the Kyoto Protocol is a significant step towards promoting sustainable

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development in developing countries.

The GT application is aimed at linking agriculture with the environment-friendly technology, which contributes to both poverty reduction and sustainable agriculture development. The present study focuses on "green technology" application for sustainable development in rural India. The environmental concerns and increasing demand for green production for raising income and achieving sustainable agriculture development are one of the several reasons for rising interest in GT.

**Green Technology**

Green Technology is the term for any application of science, knowledge or technology towards improving the relationship between human technology involvement and the impact this has on the environment and natural resources. Green technology is a broad category, in that it can cover many different facets of technology and human development - energy usage, computer technology and agriculture are just a few of the many fields that can have the principles of green technology (such as sustainable development) applied to them.

Environmental technology or Green Technology or Clean Technology is the application of the environmental sciences to conserve the natural environment and resources, and to curb the negative impacts of human involvement. Sustainable development is the core of environmental technologies. When applying sustainable development as a solution for environmental issues, the solutions need to be socially equitable, economically viable, and environmentally sound.

Its main goals are:

a. Sustainability - meeting the needs of society in ways that can continue indefinitely into the future without damaging or depleting natural resources.
b. Creating products that can be fully reclaimed or re-used.
c. Reducing waste and pollution by changing the patterns of production and consumption.
d. Developing alternatives to technologies - whether its fossil fuel or chemical intensive agriculture - that have been demonstrated to damage health and the environment.
e. Creating a centre of economic activity around technologies and products that benefit the environment, speeding their implementation and creating new careers that truly protect the planet.

There is a link between poverty reduction and growth in productivity. Productivity can be increased if local knowledge is combined with the improvement in technology to meeting particular conditions. In recent years, efforts have been made to grow food by minimizing the use of chemical pesticides and mineral fertilizers. In Asia, rice farming system is in a state of decline necessitating the need for ecologically and socially sustainable forms of agriculture, where productivity can be increased with new technological paradigm.

**Feasible Green Technologies**

**1. Solar Photovoltaic:**

Solar photovoltaic technology converts sunlight into electricity using semi conductor modules. Used generally for meeting lighting requirements, they can also be used for pumping water, refrigeration, communication, and charging batteries. Solar photovoltaic has application as green agricultural energy source for pumping water street lighting in villages, lighting in rural houses and pest management.

Since the technology efficiently produces low-cost, high-power photovoltaic cells, this new generation of solar energy can be one of the most affordable and efficient energy sources in the future. Professor W.S. Sampath from Materials Engineering Laboratory at the Colorado State observes, "Without moving parts or external fuel, photovoltaic devices directly convert absorbed sunlight into electrical current". The high –powered devices produce no waste or pollution.

In India daily solar incidence varies from 4-7 kWh per square meter depending on the location and

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averages to 5.5kWh. There are about 300 clear sunny days in most part of the country (MNRE, 2008). In the late 1990s the Ministry of Rural Development has undertaken the provision of photovoltaic systems for rural electrification.

India is endowed with rich solar energy resource. India receives the highest global solar radiation on a horizontal surface. With its growing electricity demand, India has initiated steps to develop its large potential for solar energy based power generation. In November 2009, the Government of India launched its Jawaharlal Nehru National Solar Mission under the National Action Plan on Climate Change. Under this central government initiative, India plans to generate 1 GW of power by 2013 and up to 20 GW grid-based solar power, 2 GW of off-grid solar power and cover 20 million square metres with solar energy collectors by 2020. India plans utility scale solar power generation plants through solar parks with dedicated infrastructure by state governments, among others, the governments of Gujarat and Rajasthan.

## 2. Wind Energy

Wind energy is in a boom cycle. Overall, wind energy contributes only 1% of global electricity generation, but some countries and regions are already producing up to 20%. Its importance is increasing in the sense that comparatively with other sources; the wind energy produces less air pollutants or greenhouse gases.

Wind turbine for electricity or mechanical power generation is a proven technology. Available in 75% of the world, wind turbines of sizes ranging from 900 W to 50 kW can be applied off-grid for pumping and treating drinking water, irrigation, telecommunications, homes, schools, clinics and for supplementing larger power stations. Wind turbines used in pumping water for irrigation can increase agricultural growth without carbon emission.

India has the fifth largest installed wind power capacity in the world. In 2010, wind power accounted for 6% of India's total installed power capacity, and 1.6% of the country's power output. The development of wind power in India began in the 1990s by Tamil Nadu Electric Board near Tuticorin, and has significantly increased in the last few years. Suzlon is the leading Indian company in wind power, with an installed generation capacity of 6.2 GW in India. Vestas is another major company active in India's wind energy initiative.

As December 2011, the installed capacity of wind power in India was 15.9 GW, spread across many states of India. The largest wind power generating state was Tamil Nadu accounting for 30% of installed capacity, followed in decreasing order by Maharashtra, Gujarat, Karnataka, and Rajasthan. It is estimated that 6 GW of additional wind power capacity will be installed in India by 2012. In Tamil Nadu, wind power is mostly harvested in the southern districts such as Kanyakumari, Tirunelveli and Tuticorin. The state of Gujarat is estimated to have the maximum gross wind power potential in India, with a potential of 10.6 GW.

## 3. Bio-fuel

Bio-fuel as bio-ethanol and bio diesel have the potential to assume an important portfolio in future energy platter. Biofuel development in India centres mainly around the cultivation and processing of Jatropha plant seeds which are very rich in oil (40%). Jatropha oil has been used in India for several decades as biodiesel for the diesel fuel requirements of remote rural and forest communities; jatropha oil can be used directly after extraction (i.e. without refining) in diesel generators and engines. As well, increased Jatropha oil production delivers economic benefits to India on the macroeconomic or national level as it reduces the nation's fossil fuel import bill for diesel production (the main transportation fuel used in the country); minimizing the expenditure of India's foreign-currency reserves for fuel allowing

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India to increase its growing foreign currency reserves (which can be better spent on capital expenditures for industrial inputs and production). And since Jatropha oil is carbon-neutral, large-scale production will improve the country's carbon emissions profile. Finally, since no food producing farmland is required for producing this biofuel (unlike corn or sugar cane ethanol, or palm oil diesel), it is considered the most politically and morally acceptable choice among India's current biofuel options; it has no known negative impact on the production of the massive amounts grains and other vital agriculture goods India produces to meet the food requirements of its massive population (circa 1.1 Billion people as of 2008). Other biofuels which displace food crops from viable agricultural land such as corn ethanol or palm biodiesel have caused serious price increases for basic food grains and edible oils in other countries.

India's total biodiesel requirement is projected to grow to 3.6 Million Metric Tons in 2011-12, with the positive performance of the domestic automobile industry. The Government is currently implementing an ethanol-blending program and considering initiatives in the form of mandates for biodiesel. On 12 September 2008, the Indian Government announced its 'National Biofuel Policy'. It aims to meet 20% of India's diesel demand with fuel derived from plants. That will mean setting aside 140,000 square kilometres of land. Presently fuel yielding plants cover less than 5,000 square kilometres.

## 4. Biogas

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Organic waste such as dead plant and animal material, animal dung, and kitchen waste can be converted into a gaseous fuel called biogas. Biogas originates from biogenic material and is a type of biofuel.

Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, sewage, municipal waste, green waste, plant material, and crops. Biogas comprises primarily methane ($CH_4$) and carbon dioxide ($CO_2$) and may have small amounts of hydrogen sulphide ($H_2S$), moisture and siloxanes. The gases methane, hydrogen, and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel. Biogas can be used as a fuel in any country for any heating purpose, such as cooking. It can also be used in anaerobic digesters where it is typically used in a gas engine to convert the energy in the gas into electricity and heat. Biogas can be compressed, much like natural gas, and used to power motor vehicles.

Biogas qualifies on the merits that this technology utilizes organic agricultural waste and converts it to fuel and fertilizer. Direct impacts of biogas are fuel-wood, agriculture residue, livestock manure, and kerosene savings. Increases in soil fertility and crop production have also been observed. Biogas also solves the problem of indoor air pollution and improves household or communal sanitation. India's biogas potential is estimated to be 12 million biogas plants (MNRE, 2008).

## 5. Micro & Small Hydropower

The integration of off-grid mini and micro hydropower with agriculture, especially in scattered communities, is crucial. Observations have been that energy tariff of hydropower schemes decline with increment in load factor of the power plant. In such relation, agricultural power inputs will assume the dual role of sustaining revenue of power structures and increasing productivity of agriculture.

In this system of power generation, the potential of the water falling under gravitational force is utilized to rotate a turbine which again is coupled to a Generator, leading to generation of electricity. India is one of the pioneering countries in establishing hydro-electric power plants. The power plants at Darjeeling and Shimsha (Shivanasamudra) were established in 1898 and 1902 respectively and are among the first in Asia.

India is endowed with economically exploitable and viable hydro potential assessed to be about

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84,000 MW at 60% load factor. In addition, 6780 MW in terms of installed capacity from Small, Mini, and Micro Hydel schemes have been assessed. Also, 56 sites for pumped storage schemes with an aggregate installed capacity of 94,000 MW have been identified. It is the most widely used form of renewable energy. India is blessed with immense amount of hydro-electric potential and ranks 5th in terms of exploitable hydro-potential on global scenario. The present installed capacity as on 30-06-2011 is approximately 37,367.4 MW which is 21.53% of total Electricity Generation in India. The public sector has a predominant share of 97% in this sector. National Hydroelectric Power Corporation (NHPC), Northeast Electric Power Company (NEEPCO), Satluj jal vidyut nigam (SJVNL), Tehri Hydro Development Corporation, NTPC-Hydro are a few public sector companies engaged in development of Hydroelectric Power in India.

### 6. Biomass

Agriculture residues and wastes are converted to electric and thermal energy through processes like combustion, gasification, and cogeneration. Biomass technologies compliment mainstream crop production and reduce or completely replace consumption of traditional fuel. India has been promoting biomass gasifier technologies in its rural areas, to utilize surplus biomass resources such as rice husk, crop stalks, small wood chips, and other agro-residues. The goal was to produce electricity for villages with power plants of up to 2 MW capacities. During 2011, India installed 25 rice husk based gasifier systems for distributed power generation in 70 remote villages of Bihar. In addition, gasifier systems are being installed at 60 rice mills in India. During the year, biomass gasifier projects of 1.20 MW in Gujarat and 0.5 MW in Tamil Nadu were successfully installed. India estimates biomass availability of 600 million tons from agriculture and forest residue corresponding to 16,000 MW and 5000 MW from sugarcane bagasse (MNRE, 2008).

### 7. Bio Transgenics

The use of bio transgenics (BT) also referred to as Genetically Modified Organisms (GMO) has been growing at 45% per annum in developing countries which now account for 39% of 103 million hectares planted worldwide. Mostly in India and China, 9.2 million farmers planted Bacillus thuringiensis (Bt) cotton on 7.3 million hectares in 2006.

Recent developments like modified high yield oil seeds verities can trigger rapid spread of transgenic crops. Risks as lateral transfer of genes and pollution of natural gene pool, dominance of multinational companies through Intellectual Property Rights clauses, reduction in arable land, production decline, and loss of bio diversity are associated with bio transgenics. The costs of monitoring and regulatory mechanisms are yet other hurdles for transferring benefits to smallholder farmers. However increased and consistent yield, reduced pesticide costs, and reduced post harvest loss along with opportunities like drought resistant crops and nutritional quality enhanced crops open avenues for efficient and sustainable agriculture.

### 8. Organic Farming

Organic farming is the form of agriculture that relies on techniques such as crop rotation, green manure, compost and biological pest control. Organic farming uses fertilizers and pesticides but excludes or strictly limits the use of manufactured (synthetic) fertilizers, pesticides (which include herbicides, insecticides and fungicides), plant growth regulators such as hormones, livestock antibiotics, food additives, genetically modified organisms, human sewage sludge, and nano-materials.

International Federation of Organic Agriculture Movements (IFOAM) defines the overarching goal of organic farming as:

"*Organic agriculture is a production system that sustains the health of soils,* ecosystems *and people. It relies*

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*on ecological processes,* biodiversity *and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.*"

Organic and biodynamic farming systems have soils of higher biological, physical, and in many cases chemical quality than that of conventional counterparts. When productivity in terms of inputs applied and outputs obtained and social costs of conventional farming are accounted organic alternative has also been found to be economically competitive.

National Planning Commission of India in 2000 recognised organic farming as a thrust area. National Programme for Organic Production was launched subsequently with National Steering Committee's approval on national standards, accreditation criteria for accrediting inspection and certification agencies, accreditation procedures, and inspection and certification procedures. Consolidating organic standards, certification/ regulatory mechanisms, technology packages, and market network can support organic farming and therefore sustainable agriculture.

**9. Integrated Pest Management (IPM)**

Integrated pest management (IPM) is an ecological approach to agricultural pest control that integrates pesticides/herbicides into a management system incorporating a range of practices for economic control of a pest. In IPM, one attempt to prevent infestation, to observe patterns of infestation when they occur, and to intervene (without poisons) when one deems necessary. For their leadership in developing and spreading IPM worldwide, Perry Adkisson and Ray F. Smith received the 1997 World Food Prize.

Identifying IPM as a knowledge intensive approach dichotomous to conventional chemical intensive approach best serves the purpose of this research. IPM, especially through initiative like Farmer Field School programs, where farmers are envisaged experts with their expertise emanating from routine hits and trials, interactions, and trainings, have both empowered farmers and maintained agricultural and environmental balance.

In India most of IPM activities are funded from the government budget. This along with reasons like extant extension systems and federal decision-making structure barricaded successful implementation of IPM with FFS approach. In India alone, several bio-pesticides (Trichoderma viridi, Bacillus thurengiensis BT, NPV, GV, etc), botanical pesticides (neem), bio-control agents (Trichogramma, Cryptolaemus, Chrysoperla, etc) are available to supplement IPM.

**10. The use of ICT for Facilitating Green Technology**

While information and communication technologies could add little direct value to agricultural yield, possibilities also are that they can be the centre of paradigm shifts. Since GT has emerged as a strong force to regulate climate change and build globally based, environmentally sustainable solutions, organisations are using ICT to reduce carbon emissions and develop and support business models with a green focus. This relationship is considered while ICT is recommended to serve as a green technology.

It is believed that the use of ICT improves energy efficiency in the economy, starting with buildings, lighting and the power grid. ICT enables economy a green behaviour. For example, the most advanced computer servers consume the same amount of energy as a standard light bulb; if widely used they could offer potential energy savings up to 70%. The European Commission presumes that real gains from green ICT will come from developing energy efficient ICT solutions that impact the other 98% of global emissions. The intention of elaborating ICT in the present Green Technology is with this intention.

Precision agriculture uses information and communication technologies (ICT) to cover the three aspects of production namely for data collection of information input through options as Global

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Issue : 3, Vol. : 4, Oct.-Nov.-Dec. (2017), Pages : 59-65 , ISSN 2348 – 3318


Positioning System (GPS) satellite data, grid soil sampling, yield monitoring, remote sensing, etc; for data analysis or processing through Geographic Information System (GIS) and decision technologies as process models, artificial intelligence systems, and expert systems; and for application of information by farmers. Adjustments in volume and timing of fertilizer and pesticide inputs and limited input leakage to environment are expected in precision agriculture. ICT can also be useful in knowledge intensive farm management as IPM.

**Conclusion:**

India has great potential of Hydro Power, Biogas, Biomass, Bio-fuel, Solar Energy etc to develop rural area sustainably adopting green technologies. India has to take up Renewable Power Generation Technologies much more aggressively to meet its power needs and most of these technologies get integrated with the Rural Development and the Sustainable Growth of India using Green Path, reducing our dependence on Imported Fossil Fuels. Food production using Organic Farming ensures not only healthy human generation but a pollution free environment also by keeping soil and water pest & pollution free. Thus, application of Green Technologies in rural India has enough potential to achieve sustainable development and poverty eradication on a scale and at a significant speed.

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