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A REVIEW :

Environmental degradation and agricultural sustainability

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SUMMARY : Environmental degradation means degradation or deterioration of the environment as a result of degradation of soil, water and air resources, destruction of habitats and ecosystems, etc. Our activities in agriculture have led to a decline in soil quality at several places. The anthropogenic activities in agriculture have also led to climate change, in the form of rising temperatures, unusual rainfall, drought and other havocs which impact food availability for not only today but also tomorrow. In order to achieve the desired yields to meet the needs of ever growing population; ensure food and nutritional security to all, Indian agriculture should move towards wide adoption of mix of technologies like biotechnology, precision farming, magnetic agriculture, vertical farming, micro irrigation systems, nanotechnology, etc, which help in enhancing yield without disturbing the soil health, arrest environmental degradation and achieve agricultural sustainability.

KEY WORDS :
Biotechnology, Micro irrigation, Vertical farming, Biofertilizers, Magnetic agriculture, Nanotechnology, Precision farming

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BACKGROUND AND OBJECTIVES

According to the Brundtland Report, released by the United Nations in 1987, "Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

– The concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and

– The concept of limitations of the environment to meet present and future needs."

Sustainable agriculture integrates three main goals, environmental health, economic profitability, and social equity. These are also known as three pillars of sustainability and have been defined by a variety of philosophies, policies and practices, from the vision of farmers and consumers. Perspectives and approaches are very diverse.

Environmental health :

Sustainable agricultural practices seek avoidance of synthetic fertilizers and pesticides in favor of less harmful, natural alternatives. The purpose is to address natural resource depletion, soil quality management, pollution and emission management, waste management, and energy and resource use among others.

Economic profitability :

The economic aspect of sustainability concerns the viability of farmers to continue managing environmental health. The question to ask for is, ‘can this continue in long run too?” Will he get market access for his sustainably grown produce? Will it turn out to be cost effective? Will he be able to manage profits?

Social factors :

This is the last pillar of late added to the factors affecting sustainability. Social pillar of sustainable agriculture focuses on addressing issues such as poverty, income inequality, farmer wages, and addressing basic human rights such as access to health care, clean water, sanitation, education, justice (how the farm labour is treated), etc. There is a need to address these issues and make our farming community feel empowered, for a socially empowered person is able to take timely and right decisions.

Does sustainable mean organic? :

When we started growing crops, we did it organically, and with the increasing demand for food, we shifted to cultivating hybrids (yielding higher produce), which required high dose fertilizers and pesticides, and water. Green revolution is what all of us are aware of, but what did it cost to us? We are self reliant in foodgrains, but when we talk sustainability, did the idea of green revolution prove sustainable in long run? If yes, then why are we again emphasizing on growing organic produce, not just in India, but the world over.

Question arises if organic farming is sustainable? Does sustainable agriculture mean organic agriculture? There is no argument on that the two are closely related terms. The dispute, however is on the exact nature of this relationship. For some, two are synonymous, and for others, equating them is misleading as reported by Rigbey and Caceres (2001). Lampkin’s (1994) widely accepted definition of organic farming states that the aim of organic farming is to develop environmentally sustainable production systems, which maximize crop, livestock and human nutrition. Lampkin further said that the sustainability lies in the heart of organic farming. Henning *et al* (1991) looked organic farming the same as sustainable agriculture. York (1991) went on to saying that, “sustainable is just a polite word for organic farming”.

Rigbey and Caceres (2001), quoted Pretty’s (1995) argument that although organic agriculture is generally a form of sustainable agriculture, it can also have negative environmental effect. These include the leaching of nitrates from field under legumes, the volatilization of ammonia from livestock waste, and the accumulation of heavy metals in soil following the application of Bordeaux mixture. The author duo also highlighted studies covering organic by neglect (that nothing has been put in plant) approach, that has never proved sustainable. This organic by neglect approach has been responsible for destruction of soil fertility by low input, chemical free unsustainable practices. The authors concluded the discussion that focusing on particular tools or inputs in the identification of sustainable agricultural systems is insufficient. Lampkin and Measures (1995) concluded that, “the term sustainable is used in its widest sense, to encompass not just conservation of non-renewable resources, but also issues of environmental, economic and social sustainability.”

Above discussion concludes that just organic is not sustainable and there is no one tool or input to achieve sustainability in agriculture. A mix of technologies that leads to environmental, economic and social sustainability is required for overall sustainable agricultural development, so that we continue to address the issues of climate change and food and nutritional security. This paper highlights certain innovative technologies which have emerged sustainable in the long run, and also address the three pillars of sustainability.

Innovative technologies to achieve agricultural sustainability :

Biotechnology:

Biotechnology can help mitigate environment pollution. The scientists are developing/have developed disease and drought-resistant crop varieties through genetic engineering. Use of biotechnology in conservation of biodiversity, improving soil fertility through nitrogen fixing, use of genetic engineering and manipulations are some of the biotechnological methods of minimizing environment degradation. Biotechnology could also be used for reclamation of toxic waste sites.

According to James (2014), the International Service for the acquisition of agri biotech applications (ISAAA), data for 1996-2013 showed that “biotech crops contributed to food security, sustainability and climate change by: increasing crop production valued at US$133.3 billion; providing a better environment, by saving ~500 million kg a.i. of pesticides in 1996-2012; in 2013 alone reducing CO_2 emissions by 28 billion kg (as it operates on no/less ploughing), equivalent to taking 12.4 million cars off the road for one year; conserving biodiversity in the period 1996-2013 by saving 132 million hectares of land; and helped alleviate poverty by helping 16.5 million small farmers, and their families totaling >65 million people, who are some of the poorest people in the world."

A study by Thomson in 2007 on the role of biotechnology in agricultural sustainability in Sub Saharan Africa revealed that continuing traditional agricultural practices, the Sub-Saharan Africa could fall short of 90 Mt cereals by 2025, and biotechnological intervention can help reverse it. Insect-resistant varieties of maize and cotton suitable for the subcontinent have been identified as already having a significant impact. Virus-resistant crops, especially maize resistant to African endemic maize streak virus and cassava resistant to African cassava mosaic virus, are under development. Field trials of herbicide resistant maize were successful and drought tolerant varieties could be extremely helpful for the region.

In India, introduction of Bt cotton in 2002 resulted in steep decline in insecticide usage on *Helicoverpa armigera* from 71% in 2001 to just 3% in 2011. According to (CIBRC, 2012), the percentage of cotton insecticides to the total pesticides market in India registered a steep decline from 33% in 2001 to 11% in 2011. However, the total pesticides market in India witnessed boom during the same period. According to Choudhary and Gaur (2015) cotton yield increased from less than 300 kg lint per hectare (in pre Bt cotton period) to 500 kg lint per hectare, within ten years of the adoption of Bt cotton. Many scholars claim biotechnology as a major contributor in this success. On the other hand, there are also controversies over the Bt cotton in different sections of society. Those should not be overlooked by the scientific community and consistent research and improvement is required.

Bio Fertilizers and biopesticides- A biotech tool for soil sustainability and environmental protection (Plant Growth Promoting Rhizobacteria, PGPR):

Biofertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth promoting substances. A few widely used bio-fertilizers are: *Rhizobium*, *Azotobacter, Azospirillum*, Azolla, Anabaena, etc. (Vyas *et al*., 2008). Through the use of biofertilizers, healthy plants can be grown while enhancing the sustainability and the health of soil (Singh and Vyas, 2015).

Benefits of biofertilizers:

– Bio-fertilizers are cost effective and increase yield of crops

– They can replace the use of chemical fertilizers by 25%

– Enhance soil productivity by restoring natural soil fertility

– Stimulate plant growth

– Provide protection against some soil borne diseases

Mishra and Dash (2014) studied the rejuvenation of biofertilizers for sustainable agriculture economic development (SAED) in comparison to chemical fertilizers on sugarcane. The study was conducted by comparing the application of Azolla as a biofertilizer in green manure and dual crop with chemical fertilizer in Balasore district of Odisha. The author duo found that the yield, the number of tillers, plant height, profit to farmers, and the benefit to cost ratio of azolla were higher than chemical fertilizer, proving that rejuvenating biofertilizers would lead to better sustainable economic development for the farmers and their country.

Oliveira *et al.* (2015) studied effects of biofertilizers produced from rocks and organic matter, enriched by diazotrophic bacteria inoculation on growth and yield of sugarcane located in the Brazilian northeastern, and suggested NPK biofertilizers as potential alternative for mineral fertilizers. Though biofertlizer technology is a low cost, eco-friendly technology, but the understanding of this technology and its handling by skilled personals, is very important. Use of improper, less efficient strains for production, will not yield desirable results.

Precision farming and integrated approaches:

Precision farming is about the application of technologies and agronomic principles to manage temporal and spatial variability associated with all aspects of agricultural production for the purpose of improving crop performance and environmental quality. It is strictly based on high precision positioning system (GPS), automated steering systems, geomapping, sensors and remote sensing, integrated electronic communications, and variable rate technology. The precision farming is more popular in the West; however, there is lack of knowledge about it among Indian farmers, and the practice needs to be spread through better extension services.

There are successful case studies from India, in favor of precision farming. Tamil Nadu precision farming project (TNPFP) was a Tamil Nadu State sponsored project. It was implemented at Dharmapuri and Krishnagiri districts of Tamil Nadu (Both districts suffered from water scarcity and farmers in the region followed traditional agricultural practices) in an area of 400 ha with a total budget of 7.20 lakhs for a period of three years (2004-05 to 2006-07). TNPFP tailored inputs – water, fertilizer and pesticides – in a measured form to match verifying growth stage of each crop on the field. TNPFP adopted a location specific, field specific and crop specific approach. The objective was optimization of inputs use to facilitate optimal output resulting in saving of valuable resources like water and energy. Around 400 ha was planted with 23 kinds of crops over three years a 60 % increase in yield and 90 % increase in marketable quality, was recorded. The yield of tomatoes increased from 50 ton to 150 ton per hectare, three times under precision farming. Similar results were observed in other crops too (Table 1).

Nanotechnology:

According to the US Environmental Protection Agency, nanotechnology is the science of understanding and control of matter at dimensions of roughly 1–100 nm, where unique physical properties make novel applications possible. The use of nanotechnology in agriculture, through nano-fertilizers, nano-pesticides, etc. is to raise production rates and yield, increase resource use efficiency, and minimize waste production. At nanoscale, the application of inputs is slow, targeted and efficient. Nano-pesticides application is similar to that of nano-fertilizers; slow, stable, and targeted delivery of active pesticide ingredient. It may result in low requirement of active ingredients. According to White (2013), nanosensors can be used to detect pathogens, as well as monitor local, micro, and nano-conditions in the field (temperature, water availability, humidity, nutrient status, pesticide levels, etc.).

Magnetic technology in agriculture:

Magnetic technology has the immense potential to increase the agricultural productivity multifold (Singh and Vyas, 2015). The magnetic treatment of seeds enhances seed qualities and its germination properties. Experiments show that magnetic treatment of seeds reduces spending on sowing material by 30-50%, reduces vegetative period, and increases harvest significantly, in some cases by 100% or more.

Ali *et al.* (2014) suggested that magnetic treatment of water restructures the water molecules into very small clusters which have hexagonal structure. Restructuring makes water easily enter the passageways in plant and animal cell membranes. Authors further suggested that, "toxic agents cannot enter the magnetic water (MW) structure, making MW a bio-friendly compound." Therefore, magnetic treatment of water increases the productivity of water, making it more effective for agriculture purpose. This could be a solution for the water problem in agriculture, making it more sustainable.

Micro irrigation systems:

Slow and regular application of water directly to the root zone of plants through a network of economically designed plastic pipes and low discharge emitters is called

Table 1 : Comparative statement on cost of cultivation of annual horticultural crops under conventional and precision farming system (Average of three years from 2004-05 to 2006-07)

	Cost of cultivation (Rs./ha)		Yield (MT/ha)		Increase	Net income (Rs.) at the lowest prices		Market price
Crops	Conven	Preci	Conven	Preci	(%)	Conven	Preci	range (Rs./kg)
Tomato	61000	99800	50	150	200.00	39000 (@Rs.2/kg)	275200 (@Rs.2.5/kg)	2 – 30
Chilli	46000	68000	22	35	59.09	64000 (@Rs.5/kg)	142000 (@Rs.6/kg)	5 – 15
Paprika	49000	72000	37	60	62.16	136000 (@Rs.5/kg)	288000 (@Rs.6 /kg)	5 – 20
Capsicum	49000	72000	18	25	39.00	95000 (@Rs.8/kg)	153000 (@Rs.9/kg)	8 – 25
Brinjal	50000	82000	60	150	150.00	70000 (@Rs.2/kg)	293000 (@Rs.2.5/kg)	2 – 30

Source : Tamil Nadu Agricultural University, and Tamil Nadu Agricultural University- Precision Farming Project

Note : Conven: Conventional Farming System, Preci: Precision Farming System micro irrigation. The research carried by Varma *et al* (2006) at the International water management institute (IWMI) suggests that one third of the world's population will face absolute water scarcity by 2025, and the worst hit regions will be in Asia, the Middle East and Sub Saharan Africa, home to largest number of poor in the world. While discussing the problem of water scarcity, Varma *et al*. (2006) also highlighted the need and importance of microirrigation technologies. The micro irrigation technologies have the ability to use water more efficiently in irrigated agriculture. The author trio says, "These technologies can improve productivity; raise incomes through crop yields and outputs; and enhance food security of households." Several developed countries which have water scarce regions have been using micro irrigation technologies in agriculture.

Reinders (2006), Vice President, International Commission on Irrigation and Drainage (ICID), South Africa, elaborated the advantages and disadvantages of microirrigation as follows:

Advantages of micro-irrigation :

a) Sophisticated technology, b) Maximum production per mega litre of water, c) Increased crop yields and profits, d) Improved quality of production, e) Less fertilizer and weed control costs, f) Environmentally responsible, with reduced leaching and run-off , g) Labour saving, h) Application of small amounts of water more frequent.

Disadvantages of micro-irrigation :

a) Expensive, b) Needs managerial skills, c) Waste: The plastic tubing and "tapes" generally last 3-8 seasons before being replaced, e) Clogging, f) Plant performance: Studies indicate that many plants grow better when leaves are wetted as well.

Knowing the advantages, to save water and promote sustainable agriculture, the Indian government has promoted these technologies and has also introduced subsidies to encourage their use, yet the biggest challenges come from small farmers, who are short of cash, lack a knowhow and have limited access to adequate credit facilities. Furthermore, the installation proves uneconomical on small farms. Despite this, several farmers in the states like Rajasthan, Gujarat, Andhra Pradesh, and Maharashtra have willingly adopted micro irrigation technologies for efficient water use in agricultural systems. By the end of 2013, about 6 million hectare area was under micro irrigation systems in India (Table 2). The need is to expand it more. A technical manual on the micro irrigation systems has been released by Consultative Group on International Agricultural Research (CGIAR) Challenge Program on WATER and FOOD and International Development Enterprises and is available.

Table 2 : Statewise area covered under micro irrigation system in India (Till Dec., 2013)

States	Net irrigated area (000 ha)	Area under micro irrigation
Uttar Pradesh	13386	30.50
Madhya Pradesh	7140	298.41
Rajasthan	6661	1225.31
Andhra Pradesh	5034	815.68
Gujarat	4233	599.72
Punjab	4070	36.96
Karnataka	3490	663.46
Maharashtra	3256	961.03
Bihar	3030	107.58
West Bengal	2955	150.84
Tamil Nadu	2912	267.97
Haryana	2887	542.43
Other States	4547	357
Total	63,601.00	6056.49

Source : Directorate of Economics and Statistics-2013 [5]

Vertical farming:

The United Nations predicts that around 86 per cent will live in cities by 2050. So the production centers must be in cities rather hundreds of kilometers away, if we want to get the product at reasonable prices. Transportation from farther located production centers to these cities not only makes the product costlier, it also results in more emissions and so more damage to the environment. Furthermore, the world population is going to rise to 9 billion by 2050 (from current 6 billion). According to Despommeir (2011), an ecologist at Columbia University in New York City, an estimated 10^9 hectares of new land (about 20% more land than is represented by the country of Brazil) will be needed to grow enough food to feed them, if traditional farming practices continue as they are practiced today. He suggested that food should be grown year-round in high-rise urban buildings and he has termed it as, "Vertical farming". This is what Despommier called the future of farming, in an era where we aspire achieving agricultural sustainability.

It is often seen that the crops are cultivated on farms several kilometers away from consumption centers and these farms have become low yielding due to over utilization of inputs in certain pockets of the world. Furthermore, it has also been observed that the recurrence of droughts and diseases in certain regions have made the fields less yielding in nature. In such a scenario, countries might want to grow food on vertical farms, near to the cities, reducing transportation cost, contributing positively to the environment, reducing wastages (during handling and transportation) and using minimal inputs.

Highlights of vertical farming (VF):

– The production could be harvested all the year round. The yield could be 2-3 times higher than open space (field) farming, as VF optimizes space utilization

– No weather-related crop loss.

– All VF food is grown organically: no herbicides, pesticides, or fertilizers.

– The runoff water can be recycled

– No use of heavy mechanical devices like tractors, plows etc, reduces carbon footprint

– Abandoned urban properties could be turned into food production centers

– VF could reduce physical conflicts resulting from battles to control limited resources.

– Not only crops, but poultry, fisheries etc can also be grown on same vertical farm, creating a diversified farming system

In 2012, the world's first commercial vertical farm was opened in Singapore, developed by Sky Greens Farms, and is three stories high. They currently have over 100 towers that stand at nine meters tall. The concept has gathered attention of locals and governments alike all over the world.

Conclusion :

Monotonous practices in agriculture are a threat to agriculture and have failed to address the problem of food and nutritional security. They have also caused environmental degradation. Technical innovations discussed in this paper are not only sustainable, but are safe and have the capability to control damage due to environmental degradation, survive climate change, and also may reverse the effects of climate change in long run. These practices also raise the crop yields and improve their quality thereby addressing the problem of food and nutritional security. India must invest in these technologies to combat prevailing agricultural crisis that may appear huge in coming decade, if left unresolved. The careful adoption of these technologies will affect farming community. However, before adoption they should be analyzed for their social, environmental and economic implications.

REFERENCES

Ali, Y., Samaneh, R. and Kavakebian, F. (2014). Applications of magnetic water technology in farming and agriculture development: A review of recent advances. *Curr. World Environ.*, **9** (3). doi : http://dx.doi.org/10.12944/CWE.9.3.18.

Choudhary, B. and Gaur, K. (2015). Biotech cotton in India, 2002 to 2014. ISAAA Series of Biotech Crop Profiles. ISAAA: Ithaca, NY.

Despommeir, D. (2011). *The vertical farm: Feeding the world in the 21st century*, Picador publications, 336 pp.

Directorate of Economics and Statistics (2013). Lok Sabha Unstarred Question No. 1044, dated 20.03.2012

Henning, J., Beker, L. and Thomassin, P. (1991). Economic issues in organic agriculture. *Canadian J. Agric. Econ.*, **39**, 877-889.

James, Clive (2014). Global status of commercialized biotech/ GM Crops: 2014. ISAAA Brief No 49. ISAAA: Ithaca, NY.

Lampkin, N. (1994). Organic farming: Sustainable agriculture in practice. In: Lampkin, N., Padel, S. (Eds.). *The economics of organic farming: An international perspective*. CABI. Oxford.

Lampkin, N. and Measures, M. (1995). 1995/96 *Organic farm management handbook*. University of Wales Elm, Farm Research Centre, Aberystwyth.

Mishra, Pallavi and Dash, Debiprasad (2014). Rejuvenation of biofertilizer for sustainable agriculture and economic development. *Consilience: J. Sustain. Dev.*, **11**(1) : 41–61.

Oliveira, F.L.N., Stamford, N.P., Neto, D.S., Oliveira, E.C.A., Oliveira, W.S. and Carolina Etienne de Rosália e Silva Santos (2015). Effects of biofertilizers produced from rocks andorganic matter, enriched by diazotrophic bacteria inoculation on growth and yield of sugarcane. *Australian J. Crop Sci.*, **9** (6):504-508.

Pretty, J. (1995). *Regenerating agriculture. Policies and practice for sustainability and self reliance*, Earthscan, London.

Reinders, F.B. (2006). Micro-irrigation: World Overview on technology and utilization, Keynote address at the opening of the 7th International Micro-Irrigation Congress in Kuala Lumpur, Malaysia.

Rigbey, D. and Caceres, D. (2001). Organic farming and the sustainability of agricultural systems. *Agri. Systems*, pp. 21-40.

Singh, Ritambhara and Vyas, R.V. (2015). Innovative technologies and sustainable agricultural development. *Indian Res. J. Extn. Edu*., **15**(3): 66-71.

Thomson, Jennifer A. (2007). The role of biotechnology for agricultural sustainability in Africa, Philosophical Transaction of the Royal Society London B: Biological Sciences,Feb 27, 2008; 363(1492): 905–913.Published online Aug 30, 2007. Retrievedfrom http://rstb.royalsocietypublishing.org/content/363/1492/905.short, on April 1, 2016.

Varma, S., Verma, S. and Namara, Regassa E. (2006). Water policy briefing Paper (23), International Water Management Institute.

Vyas, R.V., Shelat, H.N., and Vora, M.S. (2008). Biofertilizers techniques for sustainable production of major crops for second green revolution in Gujarat – an overview. *Green Farming*, **1**, 68-72

White, Jason C. (2013). Nanotechnology use in agriculture: benefits and potential risks. Presented at the 2013 APHL Annual Meeting and 7th Government Environmental Laboratory Conference Raleigh, North Carolina.

York, Jr, E.T. (1991). Agricultural sustainability and its implications to the horticulture profession and the ability to meet global food needs. *Hort. Sci.*, **26**(10) : 1252-1256.

WELIOGRAPHY

CIBRC (2012). Central Insecticides Board and Registration Committee (CIBRC), Ministry of Agriculture, Government of India. http://cibrc.nic.in, accessed on May 26, 2017.

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