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The Transition from Green to Evergreen Revolution

MS Swaminathan* and PC Kesavan

MS Swaminathan Research Foundation, Chennai, India

***Corresponding Author:** MS Swaminathan, Founder Chairman, M S Swaminathan Research Foundation Third Cross Street, Taramani Institutional Area, Chennai, 600113, India.

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Abstract

In the nineteen sixties, dwarf and semi-dwarf varieties of wheat and rice with long panicles and responding favourably to exogenous inputs of inorganic chemical fertilizers registered dramatic increases in productivity (kg/ha.). While based on the yield consideration for the immediate present, it could be regarded as a Green Revolution, it was really an unsustainable exploitative agriculture over long periods of cultivation.

The Green Revolution/exploitative agriculture, as expected, started showing signs of yield fatigue since 1990s owing to depletion of biodiversity and freshwater, and degradation of soil health. Further, the Green Revolution which substantially built the food security at the national level did not provide food security at the individual household levels to hundreds of millions of rural women and men. This was because it did not reduce the famine of rural livelihoods and increase the access (i.e. purchasing power) to food. For these reasons, a 'systems approach' – based 'evergreen revolution' was developed. Its design provides for various forms of ecoagriculture to produce food for 'availability' and for harnessing ecotechnologies for sustainable management of resources and creation of market-driven on-farm and non-farm ecoenterprises to enhance 'access' to food at the individual household level of hundreds of millions of rural women and men.

The evergreen revolution in the resource-poor small and marginal farms integrates diverse agri-horticultural crops, fodder, farm animals and also capture and culture fisheries in the coastal villages. Further, such small and marginal farms could cultivate biofortified crops as to provide agri-horticultural remedies to nutritional maladies, and use dung to generate methane for cooking purposes. Consequently, no methane is emitted into the atmosphere, and when that is used as cooking gas in the rural households, it saves the women from the drudgery of cutting and collecting fuel wood on one hand, and the trees which sequester carbon on the other. All these aspects are discussed briefly in the paper.

Keywords: *Green Revolution; Exploitative Agriculture; Evergreen Revolution; Ecoagriculture; Ecotechnologies; Ecoenterprises*

Introduction

The Green Revolution of the 1960s would remain in the annals of the globe as the most positive achievement of humankind after the destructive world wars, the Holocaust, detonation of atomic bombs over Hiroshima and Nagasaki and the great Bengal famine of 1943-1944. To India, in particular, the backdrop of the Bengal famine did not augur well when it attained independence in August 1947. This led to the first Prime Minister of India Jawaharlal Nehru, declaring that"'everything else can wait, but not agriculture'. The task ahead of the agricultural scientists was immense, because the goal was to enhance the productivity in terms of *kg per hectare* rather than the total production by bringing more of forestland under cultivation. Increasing the area under irrigation was yet another approach to achieve more total production, and this also was done. There is certainly a limit to increasing land under cultivation and tapping all sources of irrigation. Further, the Indian agriculture is a '**gamble in the monsoon**'. The ideal approach was to increase the productivity (kg/ha) of

crops by making them more responsive to external inputs of inorganic mineral fertilizers commonly referred to as N,P,K (viz. nitrogen, phosphorus and potassium respectively). Inorganic nitrogen fertilizer was particularly important. Yet, it was not simple to saturate the soil with inorganic nitrogen fertilizers as the Indian varieties of wheat and rice (i.e. the two staple food crops) with their characteristic tall stalks (stem) and dense and long panicles lodged (i.e. fell back) under the increased weight of the grains. So, an appropriate plant type would be dwarf/semi-dwarf plants with panicles of normal length.

Early Indian work in the 1950s at the Central Rice Research Institute (CRRI), Cuttack, India, involved making crosses between short '*japonica*' rice varieties and the tall *indica* rice varieties. The goal was to make the tall Indian rice varieties shorter and more robust to withstand the weight of the heavy panicles of plants grown in soils enriched with about 100 kg N_2 per hectare. This led to the development of a few varieties of rice like Mashuri and ADT-27 more responsive than pure *indica* rices to exogenous inputs of inorganic nitrogen fertilizers. Hence, it is reasonable to view that seeds of '*Green Revolution*' were first sown in the fields of CRRI, Cuttack, India. What then followed in the wheat fields of the Indian Agricultural Research Institute, New Delhi, became remarkable for at least two reasons. One is that dwarf and semi-dwarf wheats with dwarfing genes from Norin-10 wheat (Japan) were highly fertilizer-responsive and they broke the 'yield-ceiling' of Indian wheat varieties. Consequently the then image of India as 'begging bowl' changed to 'bread basket'. The second reason is that the Green Revolution silenced the doomsayers who wrote that the famine of food and consequent hunger in India would never be solved and that a vast section of humanity would perish in hunger. In this regard, references are made to the two books, "*The population bomb*", by Ehrlich [1] and "*Famine 1975: America's Decision: who will survive*" by William and Paul Paddock [2]. A serious question in the mind of one of us (MSS) who was deeply associated with late Norman Borlaug in ushering in the India's Green Revolution was whether the Green Revolution type of agriculture, which indeed was 'exploitative agriculture' could be sustainable over long periods of time. Convinced that it would not be sustainable, and should only be used to get some 'breathing space', Swaminathan [3] emphasized this point in his Chairman's Address to the Agricultural Section of the 55th Indian Science Congress Session held in January 1968 in Varanasi, India. What he then said is reproduced below, since it is still valid.

"Intensive cultivation of land without conservation of soil fertility and soil structure would lead ultimately to the springing up of deserts. Irrigation without arrangements for drainage would result in soils getting alkaline or saline. Indiscriminate use of pesticides, fungicides and herbicides could cause adverse changes in biological balance as well as lead to an increase in the incidence of cancer and other diseases, through the toxic residues present in the grains or other edible parts. Unscientific tapping of underground water would lead to the rapid exhaustion of this wonderful capital resource left to us through ages of natural farming. The rapid replacement of numerous locally adapted varieties with one or two high-yielding strains in large contiguous areas would result in the spread of serious diseases capable of wiping out entire crops, as happened prior to the Irish potato famine of 1845 and the Bengal rice famine of 1943. Therefore, the initiation of exploitative agriculture without a proper understanding of the various consequences of every one of the changes introduced into traditional agriculture and without first building up a proper scientific and training base to sustain it, may only lead us into an era of agricultural disaster in the long run, rather than to an era of agricultural prosperity [3]. Further, what was described as exploitative agriculture [3] was, however, referred to as 'Green Revolution' by William Gaud of the US Agency for International Development. More than four decades later, Bourne [4] wrote, "*The Green Revolution Borlaug started had nothing to do with the eco-friendly green label in vogue today*". In the following year, Dhillon., et al. [5] demonstrated with the help of a wealth of data that the productivity of wheat and rice in Punjab had been clearly plateauing since 1996-1997 through 2007-2008. Yet another disconcerting aspect of the Green Revolution was that it did not ensure food security at the household level to hundreds of millions of resource-poor small and marginal farming, fishing and landless families. The paradox, "*mountains of grains on one hand and millions of hungry people on the other*" aptly described the factual position. The Green Revolution provided only enhanced availability of food at the national level, but was not designed to fight the '**famine of rural livelihoods**' in order to enhance '*access*' (i.e. purchasing power) to food. Attention was also not given to the provision of clean drinking water, so essential to avoid gastric diseases and retain the ingested food for '*absorption*' or utilization in the body. These are the primary considerations which led to MSS to develop a '*systems approach'* – based '**evergreen revolution**' in order to achieve productivity in perpetuity without ecological and social harm. The systems approach involves concurrent attention to all the ecological foundations of sustainable

agriculture, such as soil structure and soil health, freshwater, biodiversity, renewable energy and climate. The basic principles, design and goals of the 'evergreen revolution' are described in several publications by Swaminathan [6-11]. Kesavan and Swaminathan [12-16] have elaborated as to how the evergreen revolution would be able to fight both the 'famines of food and rural livelihoods' in an ecofriendly and socially 'inclusive' manner. They have also shown [14] that evergreen revolution which has all the elements of sustainable rural development could be integrated with disaster preparedness to reduce loss of lives and livelihoods following a major natural disaster. With particular reference to hydro-meteorological extreme events (e.g. cyclones, floods, droughts etc), sustainable rural development greatly enhances the resilience or the coping capacity of the vulnerable rural communities.

Structure and Outcomes of the Evergreen Revolution

'Evergreen revolution' does not deal only with cultivation of crops as does the Green Revolution. In other words, it is not commodity-centric. Besides various forms of ecoagriculture [12], the evergreen revolution includes sustainable management of natural resources and development of *on-farm and non-farm* livelihoods using ecotechnologies within a 'biovillage' paradigm and knowledge empowerment of the rural people through modern information and communication technology (ICT) based Village Knowledge Centres [13,15,16].

With regard to ecoagriculture, the emphasis is on 'organic agriculture' and 'green agriculture'. The organic agriculture as defined by the International Federation of Organic Agriculture Movements (IFOAM) relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of chemical inputs with adverse effects. A more flexible system is the Green Agriculture which permits the use of chemical inputs within the schedules of integrated pest management (IPM), integrated nutrient management (INM) and natural resource management systems.

Various modifications of the organic agriculture, such as '*Effective Microorganisms (EM) agriculture', 'one-straw revolution*' (system of natural farming without ploughing, chemical fertilizers, weeding and chemical pesticides and herbicides) and 'white agriculture' (system of agriculture based on substantial use of microorganisms, particularly fungi) have been described by Kesavan and Swaminathan [12,15]. None of these involves the use of chemical fertilizers and chemical pesticides.

The evergreen revolution, most importantly, integrates farm animals with eco-fisheries/eco-aquaculture (in the coastal villages) for dung, urine, draught power, milk and meat. Dung is used to produce methane by anaerobic fermentation (pyrolysis) and the methane is used as cooking gas. Used in this manner, methane is not released as a potent greenhouse gas, and furthermore, with the provision of methane as a cooking gas, the rural women do not have to fell the trees as fuel wood or walk long distances to gather biomass for fuel. Emission of greenhouse gases (GHGs) due to cutting down of trees is also arrested, a step in the direction of mitigation.

Recommended for resource-poor small and marginal farms, the evergreen revolution provides multiple sources of income from cereal and cash crops, eggs, milk and meat and also provides renewable energy. The year 2014 was declared the 'International Year of Family Farming'. Writing an editorial in *Science* on 'Zero hunger' Swaminathan [17] suggested that family farming characterized by diversified crops can be harnessed to support nutrition sensitive agriculture. Just following this, Kesavan and Swaminathan [18] elaborated as to how the evergreen revolution with several elements of family farming could cultivate crops identified for their specific nutrient content in order to provide agricultural remedies to nutritional maladies in different agro-ecological regions. Within the framework of evergreen revolution, a farming system to leverage agriculture for nutritional outcomes, called "*farming system for nutrition*" (Swaminathan and his co-workers [19] would help to integrate food security (i.e. under nutrition due to inadequate intake of food) with nutrition security (i.e. addressing the hidden hunger caused by the deficiency of vitamin A, vitamin B, zinc, iron, iodine etc. The other unique features of the evergreen revolution, not envisaged in the Green Revolution, is the skill and knowledge empowerment of hundreds of millions of resource-poor small and marginal farmers. The purpose is to enable them to create and manage *on-farm* and *non-farm* rural livelihoods to generate income and thus, to enhance '*access*' to food. The skill empowerment is imparted to the rural women and men through a pedagogic method of '**learning by doing**' that was called 'techniracy' by Swaminathan [20]. The technologies used in the rural areas both for sustainable management of natural resources and creation of *on-farm* and *non-farm* livelihoods are called the '*ecotechnologies*' which are the resultant of blending frontier technologies (e.g. space, modern information and communication, nuclear, nano-, modern biotechnology etc) with traditional knowledge and ecological prudence of the rural and tribal people, especially the women.

The ecotechnologies have a *pro-nature, pro-poor, pro-women* and *pro-employment* orientation. What this means is that technologies are designed to have ecological, social as well as gender orientations. It is known that subsistence farming over centuries in thousands of villages in India has not been adequately productive to leave marketable surplus beyond the household requirement of food grains, pulses, oilseeds etc. The bulk of India's poor are among these subsistence farmers. And about 60 percent of India's population lives in about 638,000 villages. In the early design of the evergreen revolution, and the setting up of the M.S. Swaminathan Research Foundation in 1988, the Founder-Chairman (M.S. Swaminathan) focused on revitalizing the largely indolent villages with subsistence farming into vibrant agri-business-oriented villages. So, he came up with the concept of 'biovillages' (bios = living) which are the centres where 'ecotechnologies' are harnessed for sustainable management of locally-available natural resources, and also to develop one or more ecotechnology driven on-farm and non-farm ecoenterprises with market linkages for income generation. Groups of 10-15 women only or women plus men organize themselves into self-help groups (SHGs) who are then given training, capacity and initial requirement of resources etc., to adopt one or more of several ecoenterprises. The SHGs also require the power of scale to succeed in their ventures. In the globalized trade, the policies and preferences are in favour of '*mass production*' than '*production by masses*'. However, India's milk production is an example of how 'production by masses' has made India the world leader in the production of milk in the world (138 million tons in 2014 -15) and provides directly and indirectly livelihoods for about 18 million rural people of which women constitute nearly 70 percent. On the other hand, factory/corporate industrial farming in milk production would have displaced about 50-60 percent of the rural women and men from dairy-related livelihoods. USA is a good example.

Knowledge empowerment is quite essential for sustainable and productive living today. Particularly, ever-green agriculture requires the support of biological software for marrying productivity and sustainability. The biological software includes bio-pesticides, bio-fertilizers, vermi culture etc. Hundreds of millions of resource-poor small and marginal farming, fishing and landless rural women and men are often in desperate need of relevant information to save their crops from an impending disease or pest attack, or their cows from a complicated, life-threatening delivery, market prices for their local produce, hospitals for emergency and scores of routine daily needs. In the case of marginal fishers venturing on sea in their country rafts, information on weather, sea wave heights, and fish shoals is very important both for successful operation and personal safety. So, modern information and communication technology-based village knowledge centres (VKCs) were set up in several villages. Young women who have passed the 8^{th} or 9^{th} class are given training in computer operation and use of different programmes and softwares. They become very adept in using internet for linking data seekers (i.e. rural people) with data holders (i.e. scientific institutions, state and central government establishments, media, non-governmental agencies). The VKCs designed by the MSSRF and managed by the local grass root institutions promote lab to lab, lab to land, land to lab and land to land interactions. Special attention is given to update information content on weather, crop and animal husbandry, market trends and prices, welfare schemes, education, employment, healthcare etc. The mobile phones have greatly facilitated the provision of information to far greater number of people instantaneously.

The ecoagriculture/family farming system which is an integral part of the evergreen revolution movement does not necessarily cultivate only the improved high-yielding varieties; instead, the bulk of the cultivation involves locally-adapted land races and indigenous varieties. Hence, it contributes to the conservation of the precious genes and gene pools on the one hand, and consumption and commerce on the other. Swaminathan [21] has proposed a continuum of conservation, cultivation, consumption and commerce (the 4Cs) as the pathway to link biodiversity conservation with food and nutrient security at the household level towards the goal of Biohappiness.

The evergreen revolution that encourages the cultivation of locally-adapted cultivars is innately more resilient to a variety of biotic and abiotic stresses induced by global warming induced climate change. Varied effects of climate change on the growth and productivity of crop plants have been discussed by Swaminathan and Kesavan [15] in detail elsewhere. Impact of climate change on agriculture has been discussed in detail elsewhere by Swaminathan and Kesavan [22].

Conclusions

a. The 'Green Revolution' that changed India's image as 'begging bowl' to 'bread basket' was commodity-centric, and it was not integrated with ecological and social dimensions of sustainable agriculture. Consequently, the productivity has been plateauing since the mid - 1990s.

b. The evergreen revolution, on the other hand, is based on a 'systems approach' with concurrent attention to all the ecological foundations (i.e. soil, freshwater, renewable energy, biodiversity, climate etc) of agriculture and socio-economic dimension of access to food and nutrition security.

c. With the principles of ecoagriculture, ecotechnologies based ecoenterprises of on-farm and non-farm livelihoods and renewable energy sources, the evergreen revolution is ideal for transforming the subsistence farming into vibrant agri-business enterprises.

d. As with family farming, the ecoagriculture of evergreen revolution is conducive to integrate food security with nutrition security in the nature of 'farming system for nutrition' (FSN) and provide agri-horticultural remedies to nutritional maladies in the different agro-climatic zones.

e. With its continuum of conservation, cultivation, consumption and commerce (4Cs), the evergreen revolution is the pathway to 'biohappiness', i.e. happiness arising from the sustainable and equitable conversion of biodiversity into jobs and incomes. Evergreen agriculture promotes the growth of biological software industries, which are environment-friendly and lend themselves to the "production by masses" pathway of job-led economic growth.

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