CC BY

Providing Sustenance for Everyone- Substitutes for Organic Agriculture

Dr. Ram Bajaj[1]*

[1] *RNB Global University-Bikaner

***Corresponding Author:** Dr. Ram Bajaj
*RNB Global University-Bikaner

Abstract
Agriculture stands as the primary source of employment across the nation, employing a significant portion of the population. Nearly 43 percent of India's land is dedicated to agricultural endeavors, sustaining livelihoods for approximately two-thirds of its people. Historically, prior to Independence, India grappled with consistent food shortages. Following Independence, the country pursued a path of rapid agricultural modernization, yielding substantial benefits. However, the pace of agricultural advancement is now displaying signs of stagnation, presenting challenges such as food security, profitability, sustainability, and the distressing issue of farmer suicides.
In recent decades, there has been a forceful push towards post-modern agricultural practices, particularly organic farming, which is portrayed as superior to conventional methods and as the solution to India's agricultural woes. This has fostered widespread beliefs among the public that organic crop production is paramount. Consequently, activists and public figures have fervently advocated for this approach. For instance, in 2010, the Government of Kerala formulated a policy aimed at transitioning annual crops, including grains, fruits, and vegetables, to organic farming within five years, and extending this initiative to perennial crops within ten years (GOK, 2010).

Introduction
It's important to recognize that prior to the rise of modern farming methods, which rely on pesticides and synthetic fertilizers, food supplies were constantly at risk due to climate and environmental fluctuations, as well as pest and disease outbreaks. Traditional agriculture often led to poverty, famines, and low yields, as seen in British India. Many environmentalists overlook these historical realities when evaluating the impact of modern agriculture. While fervent supporters argue that organic farming could now sufficiently feed the world, the real question is whether scientific evidence supports these claims circulating in society. As Bergström et al. (2008) noted, the principles of organic practices stem from natural philosophies rather than natural sciences. Nonetheless, numerous reports stress the need for significant changes in the global food system, emphasizing the importance of meeting the dual challenges of feeding a growing population with increasing demands for food, including highcalorie diets with meat products, while minimizing environmental impacts (e.g., Godfery et al., 2010; Foley et al., 2011).
It's crucial to reassess the virtues attributed to organic farming before advocating it as the sole or complementary policy option to feed the anticipated 8.5 billion people by 2030 or 9.7 billion by 2050. Definitions of organic agriculture typically entail alternative methods that reject synthetic fertilizers, pesticides, plant growth regulators, and livestock feed additives. The Codex Alimentarius Commission defines organic agriculture as a holistic production management system that promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices over off-farm inputs, considering that regional conditions require locally adapted systems. This is achieved by utilizing agronomic, biological, and mechanical methods whenever possible, instead of synthetic materials, to fulfill specific functions within the system (FAO, 2001).
Human activities have made agriculture the primary environmental threat by clearing tropical forests, cultivating marginal lands, and intensifying industrial farming in sensitive landscapes and watersheds. Whether employing conventional, organic, or hybrid systems, the world's food system faces three intertwined challenges: ensuring adequate food for the current seven billion people, doubling food production in the next 40 years, and accomplishing these goals while achieving true environmental sustainability (Foley et al., 2011; Foley, 2011).

Evolution of farming practices
Evolution occurs in all spheres of human activity. A cursory look into the evolution of farming is essential to understand the shape of future farming options.
About 10,000 years ago, before the dawn of agriculture, the hunting and gathering style of living supported some 5 million people in the world. When the pressure of population on their existing resources increased and the means of sustenance started decreasing quantitatively and qualitatively, human kind had to go in for settled agriculture. The first form of agriculture attempted by them could be put under the category of "do nothing farming" or "natural farming" as there were not much human involvement. Later, with the development of tools, they perfected the art of shifting cultivation or slash and burn to take care of the depletion of soil fertility. According to Boserup (1965), there were five stages of land intensification through which farm communities evolved over time: (1) forest fallow (20-25 years between crops), (2)

bush fallow (6-10 years), (3) short fallow (1-2 years), (4) annual cropping, and (5) multiple cropping. In course of time, they were forced to abandon shifting cultivation because of the difficulty to find new areas for cultivation. Meanwhile, they learned that by adding animal excreta and kitchen ashes, they could grow crops in the same field year after year. Thus, traditional organic farming was born. This style of traditional agriculture prevailed upto the end of 19th century.

Thomas Robert Malthus, who pioneered the overpopulation debate with his essay on population in 1798, believed it would be physically impossible for food production to increase faster than population. However, advances in science and technology after the 16th century and the industrial revolution had their effects in agriculture too. Boserup (1965) introduced the concept that technological change could mitigate the effect of population growth on food supply by facilitating increase in food production. As available land becomes scarce relative to labour, farmers adopt labour intensive techniques, which take advantage of increased labour land factor ratios.

Great changes happened in the beginning of 20th century. The invention of the gasoline internal combustion engine ushered in the era of the tractor. Research in plant breeding led to the commercialization of high yielding cultivars. Fertilizers and pesticides began to be used in a big way in farming. Thus, the era of modern agriculture began.

The two World Wars brought drastic changes in the world agricultural scenario. The change was most spectacular since the end of World War II. Nevertheless, in the late 1960s, many experts predicted imminent global famines in which millions would perish, especially in third world countries. William Paddock and Paul Paddock, the authors of "*Famine 1975*" predicted that by 1975 at least half of Indians would die because of famine and starvation and suggested that the world turn its attention away from this hopeless land (Paddock and Paddock, 1967). In 1968, Paul R. Ehrlich published "*The Population Bomb*", warning that the growth of human population threatened the viability of planetary life-support systems (Ehrlich, 1968). The book was a best seller, raised the general awareness of population and environmental issues, and influenced policies of many governments in the 1960s and 1970s.

In 1943, an international campaign for increased food production was launched with the establishment of a joint undertaking, "Cooperative Wheat Research and Production Programme" in NW Mexico (the precursor to CIMMYT, the International Maize and Wheat Research Centre). Norman E. Borlaug headed the project, and in due course, it was replicated in many third world countries, especially India and Pakistan where it was a huge success and millions did not die in massive famines as the prophets of doom predicted. The dramatic increases in cereal-grain yields in many developing countries beginning in the late 1960s averted a great catastrophe as they predicted. This phenomenal increase in food grain production became a movement in the developing countries, later came to be known as "Green Revolution**"** after its inadvertent use by William Gaud, Director, United States Agency for International Development (USAID). In 1968, at a small meeting in Washington, Gaud said, "For the last five years, we've had more people starving and hungry. But something has happened. Pakistan is self-sufficient in wheat and rice, and India is moving towards it. It wasn't a red, bloody revolution as predicted. It was a green revolution". Many experts, however, felt that it was an unfortunate term because in no real sense was it a revolution at all (Tribe, 1994). In fact, its brilliant success depended on using scientific advances, which had already been made elsewhere in breeding and agronomy of wheat and rice, and then adapting them to conditions in Central America and Asia. In fact, green revolution has solved the immediate problem of feeding the ever-increasing population. This kind of modern farming methods came to be called 'green revolution style agriculture'.

A brief history of alternate farming systems While the hunting and gathering style of living evolved to the present form of modern farming, alternate farming systems also began to surface by the turn of the 20th century. Alternative agriculture, a term usually used by postmodernists, generally refers to agricultural practices that are different from those used in conventional agriculture. Natural farming, organic farming, biodynamic farming, permaculture, Homa farming, etc. are considered as different forms of alternate agriculture. It must be noted that 'alternate agriculture' does not specifically imply the concept of 'sustainable agriculture', which is a modern ecologically based approach to raise crops and animals.

Probably, biodynamic agriculture by Rudolf Steiner (1861-1925) was the first comprehensive alternate farming system, the apparent beginning of which was a series of lectures he presented in 1924 (Steiner, 1958). It is the oldest, most radical, alternative, rule- based organic agricultural system. However, mainstream agriculture dismissed it as occult because of its belief in cosmic forces and use of cow horn, viscera, and urinary bladder of stag and other weird practices (Kirchmann, 1994). Steiner's practices influenced Sir Albert Howard (1873-1947), a British botanist who worked as an agricultural adviser in India from 1905 to 1924. Although he was critical of many of Steiner's occult practices, he found merit in his biological practices, especially composting. He perfected the Indore method of composting.

Howard returned to England in 1931, and after his return, he documented traditional Indian farming practices. His research and further development of these methods is recorded in his famous book, *An Agricultural Testament* (Howard, 1940). Sir Albert Howard is often considered as the founder and pioneer of the organic movement. He put forth what he called the "Law of Return", which called for recycling of all organic waste materials including sewage and sludge back to farmland.

In 1939, influenced by Howard's work, Lady Eve Balfour of England launched the famous Haughley Experiment. Four years later, she published a book, *The Living Soil*, based on the initial findings. It led to the formation of a key international organic promotion group, the Soil Association. In fact, the present form of organic farming was developed from the philosophical views of Rudolph Steiner, Sir Albert Howard and Lady Eve Balfour.

Although Howard is considered as the father of organic agriculture, he did not coin the term "organic". The coinage of the term organic farming is usually credited to Lord Northbourne, in his book, Look to the Land , wherein he described a holistic, ecologically balanced approach to farming (Northbourne, 1940). In 1942, J.I. Rodale in the USA began publishing '*Organic Farming and Gardening'* magazine with Howard as the associate editor. The book "*Pay Dirt :*

Farming and Gardening with Composts" by Rodale with an introduction by Howard summarized organic farming concepts (Rodale, 1949).
Technological advances during World War II accelerated post-war innovation in all aspects of agriculture, resulting in big advances in mechanization, large-scale irrigation, and use of fertilizers and pesticides. A range of new pesticides appeared, for example: DDT, which had been used to control disease-carrying insects around troops, became a general insecticide, launching the era of widespread pesticide use. In 1962, Rachel Carson, a prominent scientist and naturalist, published *Silent Spring*, chronicling the effects of DDT and other pesticides on the environment (Carson, 1962). It was a truly significant event in the history of organics. The book and its author are often credited with launching the worldwide environmental movement and many post modernist philosophies in agriculture.
In Japan, Masanobu Fukuoka developed a radical no-till organic method, now known as 'natural farming'**.** In 1975, Fukuoka released his first book, "*One Straw Revolution".* In the early 1970's, Bill Mollison and David Holmgren, two Australians, started to develop ideas that they hoped could be used to create stable agricultural systems or permanent agriculture. A design approach called 'permaculture' was the result, and in 1978 , it was first made public with the publication of *Permaculture One* (Mollison and Holmgren,1978).
Some other variants of organic farming such as 'Rishi Krishi', 'Homa farming', and 'Homeaopathic farming' are also in vogue (Chhonkar and Dwivedi, 2004). Some related concepts with sustainability of resources as a main concern although not fully organic are 'biological farming', 'low external input sustainable agriculture' (LEISA), 'low input sustainable agriculture' (LISA), and 'sustainable agriculture'.
Many prominent intellectuals are arguing for 'alternate' sciences and 'alternate' farming methods such as organic farming, questioning the very basic content and methodology of science. This perspective also has numerous sympathizers among the environmentalist and feminist movements. Their criticism of modern farming is mainly because of its '*reductionism'*. Reductionism is most often used to describe the idea that all phenomena or processes can be broken into smaller and smaller parts and assuming that the whole can be understood in this way. The idea of reductionism was first introduced by Descartes (hence, sometimes also referred as *Cartesian reductionism*). According to this view, the world is like a machine, its pieces like clockwork mechanisms, and that themachine could be understood by taking its pieces apart, studying them, and then putting them back together to see the larger picture.
Reductionist thinking and methods are the bases for many of the well-developed areas of modern science. Reductionism seeks the explanation of the whole by eliminating the need for postulating extra forces, for example, consciousness, vital force, etc. over and above the relationships between the building blocks that can be experimentally tested (Nanda, 1997; 2004). Probably because of a fundamental misunderstanding of how science actually works, many critics among feminists, environmentalists, and anti-imperialist movements have developed a condemnation of reductionism (e.g., Shiva, 1988; 1991). Deep ecologists and ecofeminists see reductionism as opening the way to merciless exploitation of nature.
A certain degree of reductionism is essential to agricultural science, otherwise, it would be impossible to determine significant versus not significant measurements. The denial of reductionist ideas is often called 'holism'; the idea that things can have properties as a whole that are not explainable from the properties of their parts. However, most of the claims of supporters of "holism" are unsubstantiated. Many people who are opposed to science use the words "reductionism" and "reductionist" too often to condemn whatever they dislike most about modern science. This is not true and patently unfair. Science needs both reductionism and holism. For certain things, scientists approach them in a holistic way. Watershed management is an area where we should go for both reductionist and holistic approaches. We approach watershed management holistically in a multidisciplinary platform, but when going for individual components we also employ some amount of reductionism.
The International Federation of Organic Agriculture Movements (IFOAM) was formed in 1972 with its base at Versailles, France. In the 1980s, around the world, various farming and consumer groups began seriously pressuring for government regulation of organic production. This led to legislation and certification standards being enacted through the 1990s and to date.
As discussed earlier, until humans started farming some 10,000 years ago, they were food gatherers and hunters. Farming passed through many evolutionary stages necessitated mainly by population growth as shifting cultivation, primitive organic farming, modern farming, and lately green revolution style agriculture. A reverse evolution in farming is ruled out. Whatever be the next form of farming, it must be able to face three major challenges; the immediate problem of feeding the present population; the long-term problem of meeting future food needs; and preventing the deterioration of the natural resources that agriculture depends on.
These challenges are not simple. For example, every year, world farmers have to feed about 90 million more people. Remember one–sixth of this new addition to population is from India! As discussed earlier, it is obvious that organic farming in its present form cannot meet these challenges. At the same time, the present form of input intensive agriculture cannot go on as such because of the sustainability issues involved. The moot point is whether the evolution in farming practices will ultimately take a postmodern organic farming route or a modern sustainable farming route to ensure food for all in the future.

Organic farming vs. Conventional farming
It is important to distinguish between the general notions on organic farming and conventional farming. In organic agriculture, practices followed are quite distinct from those of "conventional" modern agriculture. An organic farming

system excludes the use of synthetic inputs such as synthetic fertilizers, pesticides, veterinary drugs, livestock feed additives, growth regulators, genetically modified organisms, preservatives, food additives and irradiation. In contrast to conventional agriculture, organic agriculture consciously avoids trying to maximize the yield per unit area.
Organic agriculture systems and products are not always certified and such products are referred to as "non-certified organic products". All over the world, four different streams of organic production can be identified.

Certified organic production: This is consumer or market-driven organic agriculture. Products are clearly identified through certification and labelling. Consumers take a conscious decision on how their food is produced, processed, handled and marketed.

Service-driven production. In certain countries, for example, in the European Union, subsidies for organic agriculture are available to generate environmental goods and services, such as reducing groundwater pollution or creating a more biologically diverse landscape.

Farmer-driven organic agriculture. Some farmers, especially those who are supporters of Western ideologies like deep ecology or ecofeminism, believe that conventional agriculture is unsustainable and prefer to practise alternate methods of production. The primary aim is not markets, but if there is a surplus, sold without a price distinction as it is not certified.

Organic by default**:** In general, these are traditional systems, as was the case with resource poor farmers in third world countries. They may not be using synthetic fertilizers and pesticides as they are ignorant about them or are without the necessary resources. In Kerala, most of the small farmers are organic mainly because of the small size of the farm. In India, it is estimated that 65 percent of farmers are organic by default.
According to Trewavas (2001), only two principles distinguished organic farming from other farming methods. In organic agriculture, soluble mineral inputs are prohibited and synthetic pesticides are rejected in favour of natural pesticides. Conventional farmers apply chemical fertilizers in addition to organic manures to maintain soil fertility, and use plant protection chemicals such as insecticides, fungicides and herbicides to protect crops from pests, diseases and weeds. On the contrary, organic farmers use only natural manures. Non- chemical agents such as insect predators, mating disruption, and traps are used to protect crops from pests and disease. Weeds are managed through crop rotation, tillage, hand weeding, cover crops, mulches, flame weeding and other management methods. As a last resort, organic farmers may apply certain non-synthetic pesticides.
The meat, dairy products and eggs that organic farmers produce are from animals that are fed on organic feed and allowed access to the outdoors. Unlike conventionally raised livestock, organic livestock must be kept in living conditions that accommodate the natural behavior of the animals. For example, ruminants (including cows, sheep and goats) must have access to pasture. Although they may be vaccinated against disease, organic livestock and poultry may not be given antibiotics, hormones or medications in the absence of illness. Instead, livestock diseases and parasites are controlled largely through preventive measures such as rotational grazing, balanced diet, sanitary housing and stress reduction.
Organic and conventional food must meet the same quality and safety standards. As organic farming and marketing entered the 1970s, it began to develop as an industry. Therefore, a clearer definition was needed to distinguish its products from conventional agriculture. In many countries, organic farming is defined by formal standards regulating production methods. The International Federation of Organic Agriculture Movements (IFOAM) prescribes IFOAM basic standards. In the 1980s, many national governments began to formulate organic production guidelines and a trend towards legislation of standards began. In 2000, under the National Programme for Organic Production (NPOP), Government of India released the National Standards for Organic Products (NSOP) (GOI, 2005). Products sold or labelled as 'organic', thereafter, need to be inspected and certified by a nationally accredited certification agency. A trademark, "India Organic", will be granted on the basis of compliance with the National Standards for Organic Production.
One early goal of the organic movement was to encourage consumption of locally grown food. However, with the publication of certification standards for the production of organic food, this goal has been diverted to the sidelines. Now, a large percentage of certified organic food is coming from corporate farmers. Organic food in the US and European countries is such a lucrative business that it has been almost completely taken over by big multinational food corporations. For example, big companies like Kraft and Wal-Mart are getting involved in producing and marketing a host of organic foods and groceries. Big players in the food industry is likely to drive down the price of the more expensive organic products compared to conventionally produced items. In India too, many multinationals are jumping into the bandwagon for the production of "organic foods".
Carrying capacity of earthThe most important innovative technologies that have contributed to past increases in yield have been: (1) improved cultivars able to grow vigorously, resist pathogens, and respond to fertilizers without lodging; (2) the application of fertilizers and particularly the availability of affordable nitrogen fertilizer; (3) the development of chemicals to control weeds, pests, and diseases; and (4) improved irrigation systems, especially in rice-producing countries and for some previously rainfed crops. The consequence of these innovations has been that yields of many crops, especially the major cereal crops maize, rice, and wheat, have increased substantially over the last half century (Evans, 1993; 1998).
The implications of yield increases due to changes in farming must be examined from the perspective of human population growth as well. For example, the increases in food production allowed many people, who would otherwise have starved,

to survive and to have children. Food security achieved in many countries helped to increase life expectancy by over 10 years over the last five decades. The world population was 3.0 billion in 1960, and it doubled to 6.0 billion in 1999; in October, 2011 it crossed 7.0 billion. The implications are obvious. From one perspective, the green revolution or modern farming has been humane; it has kept people from starving. However, from another perspective, it has been inhumane and cruel! While humane in the short term, it has only aggravated the long-term suffering, in that it has allowed more people (about 3 billion within a period of 39 years!) to live and have children than would have otherwise been the case. According to this cruel view, it would be wrong to increase food supply in the developing world; let the nature do the work of restraining the human population as in the case of other species!

The above argument is based on the notion that modern farming artificially boosted the 'carrying capacity (K)' of earth through unsustainable agricultural practices, which provided short-term relief. Carrying capacity refers to the number of individuals that can be supported without degrading the natural, cultural, and social environment; that is, without reducing the ability of the environment to sustain the desired quality of life over the long term. This perspective is referred to as "life boat ethics". The latter term was first used by Garrett Hardin, a renowned American human ecology Professor, in his 1974 essay "Living on a Lifeboat" (Hardin, 1974). His earlier essay, "The Tragedy of the Commons" first appeared in

Science (Hardin, 1968), is also very famous. Hardin argues that if a lifeboat's carrying capacity is exceeded, everyone dies. What policies should the people on board adopt towards people wanting to board? According to Hardin, helping the drowning people threatens the people onboard. Moreover, it is not going to aid the drowning in the end. For example, if the lifeboat has a capacity of 50 people and that there are now 40 people on board, is it possible to allow anymore individual to board the boat? Suppose there are 100 people in the water. If all are allowed to board, everybody would be drowned. There is a possibility to let 10 aboard, but the choice is difficult. Further, it is not proper to fill all berths as a safety factor in case of possible emergencies.

The movement called bioregionalism emerged in the 1970's is also based on the concept of carrying capacity to counter the overexploitation of earth through practices such as green revolution style agriculture (Berg and Dasmann, 1977). According to the perspective of bioregionalism, each region or country should support only as large a population as its own resource base will allow. Further, it argues that food aids are even more problematic, if they result from agricultural practices in the donor nations that are likely to be unsustainable, for example, intensive modern farming.

Most organisms can do little to change the carrying capacity of their environments, but humans can! If food is not available in a region, we can purchase it from another region by paying cash or kind. The historical pattern of human population growth shows the effect of breakthroughs that essentially allowed increases in K. Intensive agriculture coupled with technological advances increased the effective carrying capacity of earth for humans.

A nation's land has a limited capacity to support a population and in most of the developing countries, the carrying capacity of the land has already exceeded. In short, the proponents of lifeboat ethics and bioregionalism argue that each region of the world should support only as many people, as it is able to, that is, without food subsidies or technical aid! For example, USA supports just 30 million or 5.0 percent of global population with almost

percent of world's land area, well within the natural carrying capacity. At the same time, India has only 2.4 percent of world's geographical area, but we have about 17 percent of world's human population, 15 percent of world's cattle, 46 per cent of world's buffaloes, and 17 percent of world's goats. We are feeding this population by artificially boosting the carrying capacity with the help of green revolution and white revolution!

In India, the population was 23.8 crores in 1901. It increased to 43.9 crores in 1961 (almost double within a period of 60 years) and 102.7 crores in 2001 (about two and half times increase within a period of 40 years). According to 2011 Census, it is 121 crores. This indicates that the rate of population growth in the later forty years was something phenomenal. Still, we were able to tide over the crisis with the help of green revolution and white revolution; which effectively increased the carrying capacity.

Organic food and the widespread notions

There are many claims and widespread notions about organic agriculture, which are for the most part unscientific and unrealistic. The validity of these notions has been discussed in detail by Chhonkar (2003), Chhonkar and Dwivedi (2004), Trewavas (2004), and Bergström *et al.*, (2008). Some of these widespread beliefs are:

Organic farming can ensure food security by sustaining higher yields Organic food tastes better and is of superior quality.

Organic food is healthier because it does not contain synthetic pesticide traces.

Organic farming is environmentally better than the other forms, and is free from chemicals.

Organic farming improves soil fertility and chemical fertilizers deteriorate it.

Organic farming sustains higher yields.

Enough organics are available to replace chemical fertilisers.

Food security and organic agriculture

A general opinion in society is that conversion to organic crop production is followed by little or no yield reduction and that organic crop production is capable of feeding the world. In fact, some researchers claim that the solution for famine in Africa is large-scale organic agriculture (Pretty *et al.*, 2003). Scientists warn that, if organic farming is going to be adopted on a wider scale, per-hectare agricultural productivity will decline sharply. It is established that organic yields are lower than conventional farm yields, but the extent depends on the crop (Leake, 1999; 2000). Compared to conventional crops, the yields of organic wheat, beans and peas were 60-70 percent and that of organic oats were 85 percent. Maeder *et al*. (2002) reported the results of 20-year long-term experiment in which they compared conventional, organic and biodynamic agriculture. Compared to conventional farming, there was 20 percent yield reduction (winter wheat, potato, clover) in organic and biodynamic farming. However, input of fertilizer and energy was reduced by 34 to 53 percent and pesticide input by 97 percent.

According to Halberg *et al.* (2006), in areas with intensive high-input agriculture, conversion to organic farming will most often lead to a reduction in crop yields per ha by 20- 45 per cent in crop rotations integrated with leguminous forage crops. However, in many areas with low input agricultural systems as farmers have little access to use chemical fertiliser and pesticides, yields may increase when agroecological principles are introduced. This is the case with vast rainfed farming tracts of India where more than 65 percent farmers are oraganic by default.

Productivity is an important issue to the acceptance of organic agriculture. The carrying capacity of organic agriculture is estimated at 3 to 4 billion, well below the present world population of 7 billion and more than 9.3 billion projected for 2050 (Buringh and van Heemst, 1979; Smil, 2001). These estimates are based on the performance of organic agriculture systems as practiced before the widespread use of inorganic fertilizers and when the world population was around 1 billion by the beginning of 1800.

Kirchmann *et al*., (2008) suggested that the following factors as responsible for lower yields in organic systems than in conventional: (1) Low nutrient input (2) low nutrient use efficiency; (3) high weed abundance; (4) limited possibilities to improve low native soil fertility in resource-poor areas; and (5) poor control of pests and diseases.

A recent study published in *Nature* concludes that crop yields from organic farming are generally 34 percent lower than conventional agriculture (Seufert *et al.,* 2012). This is more relevant for cereals, which are staples of the human diet. Nevertheless, the yield gap is much less significant for certain crops and under certain growing conditions, for which, organic farming may be applicable. When the best management practices are used for organic crops, overall yields are just 13 per cent lower than conventional levels. The study, which represents a comprehensive analysis of the current scientific literature on organic-to- conventional yield comparisons, aims to shed more light on the debate over organic versus conventional farming.

The study by Seufert *et al.,* (2012) indicates that organically fertilized systems might require higher nitrogen inputs to achieve high yields, as organic nitrogen is less readily available to crops. In some cases, organic farmers may therefore benefit by making limited use of chemical fertilizers instead of relying only on manure to supply nitrogen to their crops. They conclude that to achieve sustainable food security many different techniques are needed, including organic, conventional, and possible 'hybrid' systems to produce more food at affordable prices, ensure livelihoods to farmers, and reduce the environmental costs of agriculture. It is hoped that we can create a truly sustainable food system by combining organic and conventional practices that maximizes food production and social goods at the same time minimizes adverse impact on the environment.

A paper on organic farming from Michigan State University by Badgley *et al*.(2007) is misleading. They claimed that organic methods could produce enough food to sustain the current human population, and even a larger population without increasing the agricultural land base. This claim is simply not convincing, as there are many flaws. For example, they labeled as 'organic, 49 yield ratios from the 'System of Rice Intensification', which is not organic. The paper reports the favorable yields of specific organic crops from reviewed papers, while omitting the unfavorable yields of other crops. Many of the studies cited by Badgley *et al*. (2007) are from organic activists with a clear agenda in reporting only high organic yields. Moreover, non-favorable study results from organic research groups were entirely omitted. They say that organic farming can obtain ample nitrogen by growing off- season green-manure crops to replace the inorganic synthetic nitrogen fertilizer that is currently responsible for roughly half of global crop production. However, the green-manure strategy, if implemented worldwide, threatens a major cropland expansion due to lower per hectare yields and the ensuing loss of wildlife habitat and biodiversity. According to Connor (2008), the authors have failed to realize that any significant increase in organic agriculture from its current small base of world agricultural area (0.3%) will increase competition for limited organic nutrients. Crop yields and cropped areas will fall as an increasing proportion of land is devoted to biological regeneration of fertility.

The fact is organic agriculture alone cannot feed the world, because there is substantial scientific evidence that crop yields are considerably lower in organic systems. The above review suggests that long-term yield reduction could be as much as 30-40 percent compared with the corresponding conventional crops. Therefore, to obtain equivalent yields in organic systems, significantly more land would be needed for agricultural crops. However, according to recent assessments, such land is not available in the world. It is worthwhile to mention that most good agricultural soils are already under cultivation and that additional crop production would have to encroach sensitive ecosystems like forests or areas with a high risk of erosion or other degraded lands.

Food quality

There is no scientific evidence to suggest that organic food is more nutritious or safer than conventional food. It is true that organic food is less likely to contain pesticide residues than conventional food. However, according to experts, if the traces of pesticides are within the limits, they are not going to pose any problems.

Many taste assessments of organic and conventional foods have shown that the public cannot easily distinguish organic from conventional foods in terms of taste (Hansen, 1981; Basker, 1992). As Chhonkar and Dwivedi (2004) suggested, the better taste of organically grown food is of psychological nature and could be attributed to 'placebo effect'. This could be easily proved by conducting 'single blind' or 'double blind' organoleptic tests. Anybody can design and do this kind of tests. Trewavas (2004) reviewed the reports of five studies conducted on the nutrient composition of organic and conventional food and found that there were no significant differences between the two foods.

Environmental impacts

The argument that organic farming is environmentally better is also a debatable issue (Nature, 2004). There is general agreement on some benefits; organic products are not likely to contain synthetic fertilizers or pesticide residues. On the other hand, organic methods have a greater environmental impact on smaller scales. For example, methane emissions from organic farms are likely to be higher per unit of food production. Studies are leas definitive about the environmental impact of farm runoff through which nitrate and phosphates leach into streams, rivers, and lakes. Although several studies have suggested that organic methods would reduce nitrate leaching, according to an assessment of literature sponsored by the British Government (Nature, 2004), this is not fully correct. Nitrate is the main product of decomposition of organic manures. It is continuously released from organic matter undergoing decomposition. Since nitrate release is not synchronized with either crop demand or its uptake, it tends to accumulate in excessive amounts in soil and cause environmental pollution. This could be observed in heavily manured plots. With reference to phosphorus run off there are not much definite studies.

Plant nutrients

After reviewing several long-term fertilizer experiments, Stewart *et al.* (2005) reiterated the commonly cited generalization that at least 30-50 percent of crop yield is attributable to commercial fertilizer inputs. The Broadbalk experiments started by Laws and Gilbert in 1843 (Rothamsted , England) where winter wheat was grown continuously on land with only organic manure and with inorganic manures, N fertilizer with P and K was responsible for 62 to 66 percent of wheat yield compared with P and K alone.

At present, there is a gap of nearly 10 million tonnes between annual addition and removal of nutrients by crops which are met by mining nutrients from soil. A negative balance of about 8 million tonnes of NPK is foreseen in 2020, even if we continue to use chemical fertilizers, maintaining present growth rates of production and consumption. The most optimistic estimates at present, show that only about 25-30 per cent nutrient needs of Indian agriculture can be met by utilizing various organic sources, which include agriculture wastes, and livestock manures. However, if we take Kerala, availability of on-farm manures is a major problem. Cattle population is declining at an alarming rate in Kerala. In 1996, cattle population in Kerala was 33.96 lakhs and buffaloes 1.65 lakhs. In 2007, their numbers have shrunk to 17.4 lakhs and 0.58 lakhs respectively (GOK, 2011). Organic matter status of soils is affected mainly because of the non-addition of organic manures.

Will organic farming completely take over from conventional food production? It has been estimated that without the production of artificial nitrogen fertilizer, the carrying capacity of the world's fertile land will support only about 60 per cent of the current population of 7 billion people. As the world's population approaches an estimated 9.3 billion by the year 2050, our dependence on artificial fertilizer will almost certainly become even greater.

Organic farming and plant protection

Plant protection against the ravages of pests, diseases and weeds is an important issue in any modern high production system. The exclusion of pesticides for plant protection poses greater risk of yield losses. The options available under organic production systems are very few and crop specific. Often, they are very slow and the success rate depends on the prevailing weather conditions leading to low to moderate effectiveness even in the recommended crops and situations. Thus, they limit the realization of full potential of crop yields. Any sudden outbreak of insect pests or plant disease can completely destroy the crops, unless requisite chemical pesticides are used.

Food for all: The challenges ahead

It is a known fact that 70.8 percent of earth is covered by water and land occupies only 29.2 percent. Total area of earth's land surface is estimated to be 13 billion ha. Out of this, forests occupy 32 percent; grasslands 27 percent; and urban settlements 9 percent (Pimental and Pimental, 2008). Deserts, snow covered lands, and wetlands occupy another 21 percent, which cannot be used for agriculture or forests. What remains is just 11 percent or 1.43 billion ha, which is fit for arable farming. Normally, each individual requires 0.5 ha land for the food he/she requires (Pimental and Pimental, 2008).

Constraints on resources

Considering the constraints on land, de Vries (2001) concluded that a person requires 0.05 to 0.5 ha land depending upon the intensity of farming. The problem is per capita availability of land is decreasing at an alarming rate. The per capita availability of agricultural land decreased from 0.5 ha in 1960 to 0.21 ha in 2011. The present population growth percentage is 1.2. In other words, the world population may double within next 58 years, and the availability of land may still go down to 0.11ha (Pimentel and Pimentel, 2008). If all the couples of the world decide to have only two children, still it takes about 70 years to stabilize world population at 13 billion. A major problem of population growth is large scale conversion of agricultural land for other purposes. Urban encroachment on agricultural land also increases the pressure on remaining lands. Each person requires land for housing, transpiration, industry, commerce, leisure, education and religious needs. It is estimated that the per capita requirement of land for this needs is

0.025ha (Young, 1998). On this account, annual loss of 0.1 percent agricultural land is predicted. Agricultural land can become degraded completely and irreversibly by various other processes too including soil erosion, nutrient mining, salinization, and pollution. A global average of 0.5 percent loss of agricultural land per year is estimated. Considering all these changes, it is estimated that every year, 1 million arable lands are permanently lost.

It is widely recognized that, globally, only a small proportion of future increases in crop production will come from the cultivation of new land (about 20%) with the majority coming from intensification through increased yield (67%) and higher cropping intensity (12%) (Gregory *et al.*, 2002; Bruinsma, 2003). This means that per capita arable land area will continue to decrease while average cereal yield will need to increase by about 25 per cent from 3.23 Mg/ha in 2005/07 to 4.34 Mg/ha in 2030 (Smith *et al.*, 2010; Bruinsma, 2009).

Population growth rate in India is 1.7 percent. That means, within 41 years, Indian population may double (Pimental and Pimental, 2008). In India, for the past so many years the net cultivated area hovers around 14.1 million ha. This may reduce to 10 million ha within the next 30-40 years because of urbanization and non-agricultural uses. The present per capita availability of land is only 0.12 ha. Imagine the plight of agriculture, if population doubles within 41 years; per capita arable land would be only 0.049, which is below the threshold of intensive agriculture, 0.05 ha.

If we consider the case of Kerala, the problem is still acute. In Kerala, net cultivated area is 20.7 lakh ha. The population according to 2011 Census was 3.34 crores, which means that the present per capita availability of land is just 0.06ha. If we consider only the land occupied by food crops (10%), per capita land availability may drop to a miserable level!

Feeding more people would be easier if all the food we grew went into human hands. However, only 60 percent of the world's crops are meant for people; mostly cereals, followed by pulses, oil seeds, vegetables, and fruits. Another 35 percent is used for animal feed, and the final 5 percent goes for biofuels and other industrial products (Foley *et al.*, 2011). The use of food grains as feed and biofuel are on the increase, posing a major threat to the food security of the poor nations. Globally, there is an increase of 25 percent utilization of food grains for industrial purpose. In the USA alone, within the last five years, there was 2.5 times increase in utilization of maize for biofuel. Utilizing prime lands for the cultivation of other biofuel crops like sugarcane and jatropha will also affect food grain production.

Changes in food habits Changes in food habits are taking place rapidly especially with the rise in income and standard of living of the people. There will be a shift first from coarse grains to rice, and then from rice to wheat. More and more people may become non-vegetarians. An increased demand for maize and other coarse grains as animal feed is expected. In China, India and some other countries, there have been significant changes in the food consumption patterns with affluent families taking more of meat, milk and vegetables than cereals. Meat is the biggest issue here. Even with the most efficient meat and dairy systems, feeding crops to animals reduces the world's potential food supply. For producing one kilogram of lean meat, about 25-50 kg of grains is required (Nature, 2004).The consequent increased demand for grains as cattle and poultry feed has compounded the shortage. In Kerala in recent years, there is a quantum jump in the consumption of broiler chicken.

Climate change

Climatic changes such as flood and drought are other factors, which affect food supply. Global warming is bound to affect the grain output further. It is feared that global warming and consequent changes in climate may decrease the total agricultural production by 16 percent globally by 2020. In the developing countries, this may touch 20 percent and in developed countries, it will be only 6.0 percent.

Slow down in crop productivity and the causes

Slow down in the productivity growth of major cereals, wheat and rice, especially in the intensively cultivated lowlands is apparent not only in India but throughout Asia (Pingali and Rosegrant, 2006). Slackening of infrastructure and research investment and reduced policy support partly explains the sluggish growth. According to Pingali and Rosegrant (2006), the slow down in rice and wheat productivity growth in Asia since the 1980's has been caused by two major factors: (1) world cereal price-induced factors, and (2) Intensification induced factors.

Declining prices have caused a direct shift of land out of rice cultivation or paved way for more profitable cropping alternatives. Declining world prices has also caused a slow down in investment in rice research and irrigation infrastructure. The most common intensification induced environmental consequences are: (1) the buildup of salinity and water logging; (2) the depletion or pollution of ground water resources; (3) formation of a hard pan due to subsoil compaction; (4) changes in soil nutrient status, nutrient deficiencies, and increased incidence of soil toxicities; and (5) increased pest build up, pest related yield losses and associated ecological consequences of increased and injudicious use of pesticides.

Pingali and Rosegrant (2006) suggest further that severe environmental degradation in intensified agriculture occurs mainly when incentives are incorrect, due to bad policy, or due to lack of knowledge of the underlying processes of degradation.

At the national level, several other issues also contributed to the stagnation in food production. For example, intensification of farming in the wheat belt of Punjab, Haryana and UP is showing signs of fatigue. Before Green Revolution, the prevailing cropping pattern was wheat-pulses/oilseeds. However, introduction of short duration wheat and rice enabled the farmers to go for wheat-rice rotation. This took a heavy toll on the environment in that this required heavy irrigation. In many parts of North India, ground water level has been receding due to over exploitation. The present advice being given by the Ministry of Agriculture is to revert to the old cropping systems involving pulses and oilseeds.

Compared to wheat, rice consumes more water to produce a kilogram of grains (virtual water for wheat is 1200L and for rice 2700L). Farmers are also abandoning cereal cultivation especially in regions like Punjab where more areas are brought under fruits and vegetables at the cost of cereals.

Hunger and poverty

Hunger and poverty are two great evils affecting humanity. However, hunger is not a natural condition of humans, but their actions are responsible for that. As populations increase and more people move from rural to urban areas, the task of reducing hunger will become even more difficult than it is today. Food is a basic need and every citizen of the country should have access to food, which provides minimum nutritional level. Currently, about 1.4 billion people live below the international poverty line, earning less than US $1.25 per day. According to FAO estimates, in the world, 1.02 billion people suffer from chronic poverty. More than 60 percent of chronically hungry people are women. Everyday, 25,000 people are dying of hunger and poverty or there are 9.0 million deaths every year. Out of these, 6.0 million are children under the age of five who die prematurely as a direct or indirect result of hunger (means 16,000 child deaths per day or 1 in every 5 seconds!).

Food wastage

Organic supporters point to the huge food wastage and excessive consumption in the developed countries which could, if more equitably distributed, make up for at least some of the current and predicted shortages. They argue that the problem is not producing enough food—the problem is getting the food that is already produced to the people who need it. This is partly true. About 30–40 percent of all food at every step of the food cycle is wasted (Giovannucci *et.al*., 2012). A good chunk of food produced in developing countries never makes it to market and consumers in rich countries waste as much food as the entire net food production of sub-Saharan Africa. Moreover, rich nations who produce more are not willing to spare their excess production, even if they empty them to seas. It is a fact that the world can produce more than enough food for everyone but human action is needed to ensure its fair distribution. Yet this is a political problem, and one that is very unlikely to be solved in the near future.

Access to food

Along with production, we should also focus on two vital areas, more access to food and more nutrition or healthy food. The key issue is to increase food security by ensuring that all households have real access to adequate food for all their members and do not risk losing such access. This means not only that the food must be available but also that people can afford to buy it. However, organic agriculture is bound to decrease productivity further. Enhancing the productivity of smallholder agriculture must be an important step to eradicate hunger in the years ahead. This indicates that organic farming, or for that matter, any 'alternate' farming system, may have contradictory perspectives in developed and developing countries. For the rich countries having limited population and surplus resources, a consumer can demand enough food of the highest possible quality to satisfy their fancies. The affluent countries can pay more for food produced by "organic" methods. Organic farming, therefore, would not be economically or socially viable in poorer countries.

The possible options

As discussed earlier, organic farming is not feasible as an alternative to conventional farming under the prevailing circumstances in India. Scientists and policy makers now recommend integration of conventional farming with organic farming. Such integration on sound scientific basis will be effective in addressing the problems of deficiencies of both macro and micronutrients, recycling of crop residues and farm wastes, rural and urban wastes, besides effectively meeting growing food demands of rising populations.

Organic farming should be considered for lesser endowed region of the country. It should be started with low volume high value crops like spices and medicinal aromatic crops. A holistic approach involving integrated nutrient management, integrated pest management, enhanced input use efficiency and adoption of region-specific promising cropping systems would be the best farming strategy for India. There will also be scope for practicing organic farming on case-to-case basis in traditional strongholds like hilly areas, rain fed and dry land farming system to cater to the demands of organic produces in urban areas who would pay premium prices for such commodities. Organic foods are a matter of choice of the individuals or enterprises. If somebody wants to go in for organic farming, primarily on commercial consideration or profits motive or to take advantage of the unusually higher prices of organic food, they are free to do so. In Kerala, traditional organic farming may prevail in certain areas where modern methods are consciously avoided, for example, Pokkali rice, scented rice, and medicinal plants. With a growing population and precarious food situation, India cannot afford to take risk with organic farming alone. According to a team of agricultural experts, the scientific basis for the success of organic farming to be the only alternative to modern farming is yet to be proved. In response to the organic policy document of the Kerala State Biodiversity Board, they favoured the need to develop modern sustainable farming systems integrating the best available options (TOKAU, 2008).

Plucknett (1993) argues that the present food production in most countries is still below its potential. According to him, crop yields can be categorized into five; (1) the farm yields, which are being achieved by farmers at present; (2) the practical farm yields, which could be realized now, if farmers fully utilized known technologies; (3) the experimental station yields, which are higher again because they are produced under more controlled conditions than is usually possible on commercial farm ; (4) the record yields, which represent the highest levels of production yet recorded under field conditions on either farm or experimental stations; and (5) the theoretical yields, which are calculated based on the photosynthetic potential under specified environments and represent the highest limits of biological potential. Considerable gaps exist between each of these categories and the theoretical yields of most crops are often three or four times as large as present farm yields within the same environment. Food production in most countries is still below its maximum potential. All the categories of yield are increasing and in many countries, there is ample scope for this to continue. As basic scientific knowledge increases and technologies of genetic engineering and biotechnology improve, it is conceivable that the concept of maximum theoretical yields may be revised upwards (Tribe, 1994).

An international team of experts, has settled on five steps that, if pursued together, could raise by more than 100 percent the food available for human consumption globally, while significantly lessening greenhouse gas emissions, biodiversity losses, water use and water pollution (Foley *et al.,* 2011). According to them, five solutions, pursued together, can achieve these goals: (1) stop expanding agriculture's footprint (2) close the world's yield gaps (3) shift diets away from meat (4) use resources much more efficiently and (5) reduce food waste. To double global food production without expanding agriculture's footprint, we must significantly improve yields of existing farmlands. According to the authors, two options exist, boost the productivity of best farms by raising their yield ceiling through improved crop genetics and management, or improve the yields of the world's least productive farms by closing the yield gap between a farm's current yield and its higher potential yield.

Most agricultural scientists believe that there will be a gradual amalgamation of organic and conventional farming to produce a system appropriate to different situations – that employ the best aspects of each form of farming to allow adequate and sustainable food production with minimum disruption to the environment. This is the logic behind the evolution of sustainable agricultural systems and good agricultural practices (GAP).

Sustainable agriculture as a modern alternative

Sustainability is a general concept, relating to the continuity of environmental, economic, and social aspects of human society. 'Our Common Future', a 1987 report from the United Nations (Bruntland, 1987), defines 'sustainable development' as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (*Our Common Future* is the report made by the World Commission on Environment and Development in 1987. It is often called the

'Bruntland Report' after the chairperson of the commission, the then Prime Minister of Norway, Ms. Gro Harlem Bruntland). One of the main factors, which sustainable development must overcome is environmental degradation. The issue is closely tied to economic growth, and the need to find ways to expand the economy in the long term without using up natural resources for current growth. However, the concept of growth itself is a problem, as the resources of the earth are limited.

The Bruntland Report called for strategies to reinforce efforts to promote sustainable development. Prompted by the report, the UN Conference for Environment and Development in 1992 (*The Earth Summit*) became instrumental in the popularization of the concept of sustainable development. The Bruntland Commission put forth the most widely used definition of sustainable development, which contains two key concepts: The concept of "***needs***" and the idea of "***limitations*"** imposed by the state of technology and social organization on the environment's ability to meet present and future needs. When the "needs" are considered, priority should be given to the essential needs of the poor.

FAO's definition of sustainable agricultural development is as follows: Sustainable development is 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 human needs for the present and future generations. Such sustainable development (in the agriculture, forestry, and fishery sectors) conserves land, water, plant, and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable (FAO,1990).

Reganold *et al.* (1990) points out that just because a farm is organic or alternative, it may not be a sustainable one. For a farm to be sustainable, it must produce adequate mounts of high-quality food, protect its resources, and be both environmentally safe and profitable. Sustainable agricultural systems mean successful management of natural resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources. Most of the prevalent land use systems in the tropics are characterized by a rapid decline in productivity and high rates of soil and environmental degradation.

Sustainable agriculture integrates three main goals—environmental health, economic profitability, and social and economic equity. Sustainable practices are based on an understanding of ecological principles; and insuch systems, farmers find themselves working with the ecology of the system, rather than against it. However, any farming system that is going to be truly sustainable must be so in all these senses; a farmer cannot continue the farming business, if the farming operation is not economically viable, regardless of how fine it may be ecologically! Although increased attention is paid to organic components, particularly in soil fertility management and pest control, integration is the key in sustainable agriculture. Integrated nutrient management (INM), integrated pest management (IPM), integrated weed management systems (IWMS), integrated watershed management, and better land husbandry are some of such concepts.

Population growth and increased food consumption are placing unprecedented demands on agriculture and natural resources. To meet the world's future food security and sustainability needs, food production must grow substantially while, at the same time, agriculture's environmental footprint must shrink dramatically. Incredible progress in food production could be made by halting agricultural expansion, closing yield gaps on underperforming lands, increasing cropping efficiency, changing food habits, and reducing waste. These strategies, if implemented based on sustainable principles, could double food production while greatly reducing the environmental impacts of agriculture.

REFERNCES:

1. Badgley, C., Moghtader, J., Quintero, E., Zakem, E., Chappell, M. J., Avilés-Vázquez, K., Samulon, A., and Perfecto, I. 2007. Organic agriculture and the global food supply. Renewable Agric. Food Syst. 22: 86-108.
2. Basker, D. 1992. Comparison of taste quality between organically and conventionally grown fruits and vegetables. Am. J. Alt. Agric. 7: 129-136.
3. Berg, P. and Dasmann, R. 1977. Reinhabiting California. The Ecologist 7(10): 399-401.
4. Bergström, L., Kirchmann, H., Thorvaldsson, G. 2008. Widespread opinions about organic agriculture: Are they supported by scientific evidence? In: Kirchmann, H. and Bergström, L (eds.), Organic Crop Production–Ambitions and Limitations, Springer, Dordrecht, The Netherlands, pp. 1-13
5. Boserup, E. 1965. The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure. Aldine, Chicago, 124p.
6. Bruinsma, J. 2009. The Resource Outlook to 2050: by how much do land, water, and crop yields need to increase by 2050? In: FAO Expert Meeting on 'How to Feed the World in 2050', 24-26, June 2009 [On-line]: ftp://ftp.fao.org/docrep/fao/012/ak542e/ak542e06.pdf
7. Trewavas, A. 2001. Urban myths of organic farming. Nature 410: 409-410.
8. Trewavas, A. 2004. A critical assessment of organic farming and food assertions with particular respect to UK and the potential environmental benefits of no-till agriculture. Crop Prot. 23:757-781.