Mitigating Climate Change through Organic Agriculture*

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As a researcher from the mainstream agriculture system, I remain committed to eco-friendly and sustainable agriculture of relevance to smallholder farmers in developing countries. Experience suggests that only some "organic farmers" use most of the interventions listed in the section "Features of Cool Agriculture". Agricultural scientists would note that there is a lot of literature in formal journals in support of most of these interventions. Once the mainstream agriculture system studies the potential of these other interventions (uncritically assumed now as "unscientific"), it too would agree that such farming practices are low-cost, maximize use of local natural resources, are sustainable, scientifically sound and have potential to mitigate climate change.

Green Revolution (GR) technologies, supported by official policies, and fuelled by agro-chemicals, machinery and irrigation, are well known to have improved agricultural production and productivity. While these technologies greatly helped developing countries to address their food-security and food-sovereignty needs, farmers using these technologies have had to depend on external inputs which constitute the major cost of production for small-holder farmers who are a majority in most developing countries of the Semi-Arid Tropics. Also all small-holder farmers are challenged by shortage of cash resources and depend on family labour.

The manufacture/supply of the three major inputs of GR technologies – fertilizers, pesticides and irrigation – need fossil fuels and/or expensive energy and are in turn associated with serious environmental and/or health issues. The Intergovernmental Panel on Climate Change (IPCC) has conceded that agriculture (conventional, modern or GR) as practised today has negative environmental impacts including production of greenhouse gases (GHG). This agriculture accounts for about one-fifth of projected greenhouse effects, and produces about 50% and 70%, respectively, of overall methane and nitrous oxide emissions (www.gcrio.org/ipcc /techrepI/agriculture.html). These are more harmful greenhouse gases than carbon dioxide.

Climate change (CC) is a long-term change in the statistical distribution of weather patterns over periods of time that can range from decades to millions of years. It may be a change in the average weather conditions or a change in the distribution of weather events with respect to an average – for example, greater or fewer extreme weather events. Climate change may be limited to a specific region, or may occur across the whole planet. The United Nations Framework Convention on Climate Change defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." In the latter sense, climate change is synonymous with global warming.

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* Keynote address, 3rd Biennial Convention of the OFAI, 15-17 Dec. 2010, Anand, Gujarat.

Issues with modern agriculture in the climate change scenario:

- **It is energy intensive.** It is widely accepted by the agricultural research for development (AR4D) system.
- **It is water intensive.** It takes 1000 tonnes of water to produce one tonne of grain (Brown 2004); aquifers are severely depleted in major breadbaskets of the world. Indo-Gangetic plains – the rice-wheat bowl of India is already facing this threat.
- **It is seed/breed centric.** Seed, no doubt, is a basic necessity if we are to grow crops and is an important component of crop production. There are several other important practices (soil and water conservation, crop agronomy/husbandry, crop protection, etc.,) that would need to be followed before achieving good yields. The AR4D system appears to ignore their importance, and investments continue to be heavily skewed in favour of breeding new varieties/hybrids and genetically modified (GM) technologies. Unfortunately, there is a silent acceptance among scientists and farmers that local varieties are poor yielders and therefore we essentially need seeds of improved varieties/hybrids. This is not always true because, at times, breeders have themselves selected and reported local varieties as high yielders. But this fact is rarely acknowledged or applied. There is a definite role for private seed companies but they need to be regulated through farmer-centric policies. If these are not farmer-friendly and instead largely benefit the generators of the technology or seed, there is a danger of the latter pushing a technology or seed before it has been thoroughly tested. This seems true for instance with Genetically Modified (GM) seeds – Bt cotton, Bt-brinjal, roundup ready soybean. A recent news suggests failure of the GE soybean over large areas in Brazil (www.agrimoney.com/news/brazil-battles-spread-of-mad-soy-disease--2316.html). The planning commission report from Vidarbha and some other reports suggest that Bt cotton is highly susceptible to weather extremes like prolonged dry spells and high rains.
- **GR agriculture emits greenhouse gases.** Agriculture is estimated to contribute directly 11% of total greenhouse gas emissions (www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf, 16 Nov 2007) and it is largely because it uses technologies that are energy dependent and which require fossil fuels. Organic farming is largely dependent on solar energy.
- **Loss of croplands from unsustainable practices.** The world loses 20 m ha, or 1.3% croplands annually from soil erosion and salination (www.energybulletin.net/3834.html). Replacing lost croplands results in deforestation, which greatly accelerates global warming. Large areas in the different states of India are salt affected – classed as chemical degradation-salinization/alkalization and acidification (www.soeatlas.org), totaling about 17.45 million ha (ICAR 2010).
- **Productivity is falling.** Grain yields fell for four successive years. World reserves are at their lowest levels in 30 years. In India, responsiveness to agro-inputs has decreased over the years (Chand and Haque, 1998), particularly in the Indo-Gangetic plains, suggesting that modern agriculture – based on external inputs – is un-sustainable.
- **Mechanization, monocrops, commoditization and globalization.** Globalization of the food trade is destroying the livelihood of family farmers all over the world as corporations consolidate their control over the commodity market and the food supply chain [Oram 2006], and subsidized food surpluses are dumped from the rich countries in the North on poor countries in the South [www.i-sis.org.uk/isisnews.php]. The globalised food trade also wastes huge amounts of fossil fuels and spews extra tonnes of greenhouse gases into the atmosphere.
- **Global warming threatens food production.** An increase in the earth's average temperature of 1.9 to 11.5 °C within this century has been predicted for the different regions of the world. Fall of 10% yield of rice for every degree C rise in night temperature is likely (Peng et al. 2004).

The **International Assessment of Agricultural Knowledge, Science and Technology (AKST) for Development (IAASTD)** governed under an intergovernmental governance structure brought out a global agricultural synthesis report (www.agassessment.org/index.cfm?Page= About_IAASTD&ItemID=2) on the state of agriculture in the world. The World Bank initiated the assessment (Feldman et al. 2010) and the UNO (United Nations Organization) supported the activity which took over five years to complete. The assessment was highly consultative and interactive in nature and all significant stakeholders were represented. The output comprised the

main global report, 5 sub-global reports and a brief executive report. The 95 page main report (www.agassessment.org/reports/IAASTD/EN/Agriculture at a Crossroads_Synthesis Report (English).pdf) captures the complexity and diversity of agriculture worldwide and is titled "Agriculture at a Crossroads" indicating obvious problems with the agriculture widely practiced today. Production of the different reports involved 474 scientists drawn from 85 countries: 187 of these were from three countries – USA (92), France (53) and UK (42). Reading through the main report one may note a tacit support for the different procedures of ecological agriculture. At the time of release of the report in April 2008 in Johannesburg, a large number of countries, including India, were a signatory to the report while three countries (Australia, Canada, USA) opposed it. It should be noted that if the world starts following ecological agriculture, this would adversely affect the business of agro-chemicals and GM crops. Much of the formal AR4D system that seems to function under the control of developed countries through the 16 international centers of the CGIAR (Consultative Group on International Agricultural Research) strongly supports crops production procedures such as "integrated pest-management" (IPM) and "integrated nutrient management" (INM). Both appear to provide a science-based cover to continue the use of agro-chemicals in the world, particularly in the developing countries.

The AR4D system is top-down and not bottom-up: farmers/users are not included effectively in needs assessment, research agenda and prioritization, be it national (at least in India) or international. The first Global Conference on Agricultural Research for Development (GCARD) 2010 (such conferences are expected to be regular features) was held in Montpellier, France from 28-31 March 2010. GCARD was organized by the Global Forum on Agricultural Research (GFAR) in collaboration with the Consortium and the Independent Science and Partnership Council of the Consultative Group on International Agricultural Research (CGIAR controls/manages 16 international centers like ICRISAT in India) and Agropolis International (in France). It was an important global activity to determine the future of AR4D in the world. The 16 centers of the CGIAR are presently busy in finalizing their respective research agendas. From the participation in the e-conference and whatever I have read coming out of the international centers on revising their research agenda, I remain doubtful that anything greatly in favour of smallholder farmers of the developing world and in favour of eco-friendly sustainable agriculture that would help mitigation of the "Climate Change" crisis will be done by them.

Organic Farming is "Cool Farming". Organic farming is not simply doing agriculture without agro-chemicals; it involves a holistic system of farming which optimizes productivity in a sustainable manner. The different procedures/interventions used in organic farming to meet crop nutrient and crop protection needs result in less emissions of greenhouse gases, require less cash resources, help in carbon sequestration and overall make farming more resilient to vagaries of weather and thus help mitigate climate change. Mulching with plant biomass has been noted/reported to reduce soil surface temperature by about 2 to 5 °C. More in favour of this farming can be read in the papers of Rupela 2008 and Rupela et al. 2006.

The different interventions listed below in the section "Features of Cool Agriculture" would indicate that most of these are taught to students of agriculture as part of the current curriculum along with the use of fertilizers and synthetic pesticides. But over the years, vested interests, dominated or guided by market forces, have only promoted external input based agriculture. And slowly but surely, even the national research system has become part of this group by default or by design and rarely generates or promotes farmers' empowering agro-technologies and policies. All this is being done using the wrong yard stick of "yield of a given crop in a given season" instead of the yardsticks of "farmers' net profits" and/or "yield from per unit land per year." Though indirectly and unknowingly farmers are also a party to this development: most of them over the years have chosen to adopt agro-chemicals increasingly because of their convenience in use and short term and visible benefits and have stopped or minimized use of other interventions listed here which are labor intensive. It should be noted that the AR4D system in India does not proactively promote these interventions despite their demonstrated potential to replace agrochemicals and to reduce the need of irrigation as well.

Questions about organic farming

The agricultural research system, be it national of international, questions organic farming in many ways – its scientific soundness, its alleged association with low-yields, its up-scalability, its ability to feed the growing population, etc. There is data from long-term experiments on large plots (Harwood 1984, www.rodaleinstitute.org, www.fibl.org/en/switzerland.html) and from India (Rupela et al. 2006) which suggests that crop yield in treatment plots receiving low-cost biointensive inputs was more or comparable to those receiving the recommended level of chemical fertilizers and pesticides.

Agricultural scientists question the scientific soundness of organic farming due to their limited exposure to it and/or their unwillingness to open themselves to forms and methods of agriculture that are beyond what is being taught/practised in agricultural universities and research institutions. Agriculture as followed over centuries in pre-British India was a non-polluting system. Historical records tell us that this agriculture was also high yielding (www.dharampal.net, and www.cpsindia.org/tav.html): yields of several crops were at least on par with – if not higher than – those harvested in the recent past with the help of inputs like agrochemicals. Scientists and research institutions need to understand farmers' needs and develop farmer-friendly and farmer-empowering agro-technologies. Even today, the organic farms of successful farmers (those following eco-friendly agriculture and having good livelihoods and net profits from their production system) are at least as equally – if not more – productive as conventional farms. If doubtful, agricultural scientists need to visit these farms and verify these facts. Addresses and phone numbers of several farmers are in the "Organic Farming Source Book" (Alvares 2009). Continuous denial of the fact that yields from organic farming are comparable will not help the agricultural research for development system. At least for this purpose, scientists need to generate data on large plots or from farmers' fields and not from small research plots if they are to prove their point. Up-scaling is important and one can devise strategies and equipment for this purpose provided there is a will. If an organic farm is as productive as a conventional farm, there can be no threat to the food security of India.

There are a few but definite examples that some states in India are listening to the experience of successful innovative farmers. Non-agro-chemical based farming has been demonstrated to be a poverty alleviation tool in Andhra Pradesh (www.serp-ncsa.com). Unfortunately these examples are centred around a few honest NGOs, upright bureaucrats and/or officers involved in development programs who are trying their best to help the farming communities in their areas despite the fact that much of the agricultural development system around them is not only unsupportive but obstructive in various ways. And in a democratic system like ours it is indeed difficult for them to go beyond a certain point.

Cool agriculture for mitigating global warming

Ideally we need an agriculture that can feed the world, mitigate climate change and let everyone thrive in good health and wealth. Can there be such an agriculture? Dr. Mae-Wan Ho of the Institute of Science in Society (ISIS) based in UK has said that it is not only possible, but that it already exists in developing countries (www.i-sis.org.uk/CROARFS.php). Its model was first dreamt and conceived by Prof. George Chan (a Chinese, born in Mauritius, educated at London University, specializing in environmental engineering, working in several developed and developing countries including China and USA). His model is called Dream Farm I (see Figure 1). It meets all the energy needs of a farming unit. The model integrates production of diverse crops with fishery, poultry, livestock, mushroom and energy production with biogas, and is based on organic principles.

Based on my exposure to innovations and literature on organic farming in India (much of the literature is in local languages and I do not have access to it) and interactions with a limited number of organic farmers (about 6 lakh registered farms), I am convinced that components of cool agriculture are in use in India but need to be integrated and enhanced. A large number of farmers are listed in "The Organic Farming Source Book" (Alvares 2009) and several are innovators of farming practices that help sustain productivity without agro-chemicals. Also, many innovations, including practices of pest management, are on www.sristi.org. A good number of these innovations in crop production practices are in no way less important than the research output from the formal agriculture research system and would strongly feed into the overall integrated scheme of Prof. Chan in Figure 1. Growing trees on cropped land noted in village Bajwada (Dewas, Madhya Pradesh); integration of poultry/fishery/livestock with crops in village Hiatpura (Maachhiwada, Ludhiana, Punjab); soil and water conservation of relevance to big and small farms in village Dorli (Yavatmal, Mahrashtra); polycrops in Chikodi (Belgaum, Karnataka); biogas as a locally manufactured fuel (using cattle and human excrements) in village Malegaon (Khandwa, Madhya Pradesh): these are only a few of the interventions in use. Most innovations are small-farm friendly and are therefore readily acceptable to the 80% farmers of India (own <1.4 to 2.4 ha, as per 1991 census, Chadha et al. 2004). The challenge to us all is to set-up a working model of a dream farm that harnesses all features of not only cool agriculture but cool development.

Two important innovations in large areas have been applied in India in the past decade. Both will go a long way in mitigating climate change through agriculture: a) producing rice using the System of Rice Intensification (SRI, see www.sri-india.net for more information) already evaluated/used by about 9 lakh farmers in about 350 districts of

India. SRI does not depend on flooding, uses less fertilizers (some organic farmers have grown rice without agro-chemicals) and most practitioners have indeed reported increased yields; b) innovated by an NGO (see www.csa-india.org) and scaled up by the government of Andhra Pradesh (www.serp-ncsa.com), Non-Pesticidal Management (NPM) of crops was reported to be practised by at least 3 lakh farmers, on about 6.2 lakh ha in 2008/09. Both the innovations offer important entry points before a farmer may go fully organic.

Features of "Cool Agriculture"

It is important to have living and healthy soils rich in agriculturally beneficial microorganisms for high productivity without agro-chemicals. It may take a couple of years and a series of interventions before such soils get formed and result in harvesting high yields without agro-chemicals. A list of the needed interventions/practices are listed/discussed below: (All farmers are urged to go through these to examine if they practise them on their farms. If not, it is recommended that they start practising from now onwards.)

- **Contour based cropping.** Helps soil and water conservation. Its use on undulating and sloppy land is crucial/essential for high yield.
- **Rainwater harvesting.** Rainfall on a given field should remain there and not be allowed to erode bunds and enter other fields. It is feasible to capture every drop and make it enter the local soil, using low-cost structures, farming practices and following contour-based cropping.
- **Trees (including fruit trees) on cropped land.** Trees can exist with crops when planted in alleys (5 feet wide single rows) 50-60 feet apart and maintained differently from what is recommended in the kind of "horticulture" promoted presently. These alleys serve as ecological niches, like a live hedge; they can host plants of different utility, including plant species identified by entomologists to shelter/promote predators and parasites of insect-pests.
  The canopies of trees on cropped land can be managed by programmed lopping so that they occupy a limited area (five feet wide rows) leaving much of the field for annual crops. Their loppings are a great source of crop nutrients for the annual crops of the same field (Rupela et al. 2006b) and they still produce some fruit. The root systems of trees access nutrients from much deeper depths (often one meter and beyond) while most annual crops largely explore the top 30-45 cm.
- **Crop diversity on a given field.** A given field should always have poly- instead of mono-crops. This enhances biodiversity and greatly helps manage insect-pests.
- **Minimum tillage.** Tillage influences the physical, chemical and biological properties of soils. Conventional tillage increases soil erosion, decreases surface residues, decreases the amount of organic matter over time. Reduced or minimum tillage has been reported to enhance soil quality while maintaining yields (Blaise and Ravindran 2003, Mehla et al. 2000). Organic farmers have to innovate to manage weeds as the mainstream system has developed the concept with use of chemical herbicides.
- **Recycling of crop residues and excrement of animals.** All biomass (from plants and animals) when recycled through surface mulch, enhances soil organic matter – a store-house of all the 33+ elements a crop needs for good growth. Animal excrements are best used in fermented form. Excess, if available may be composted/vermicomposted.
- **Surface mulch and not incorporation of biomass.** Mulching allows harnessing of the fullest value of plant biomass and obviates the need for composting/FYM. The population of naturally occurring local earthworms increases substantially with this practice. There should be no need to use expensive vermicompost. Mulching also lowers soil temperature.
- **Cowdung-based ferments.** Cowdung and farmers' innovations and/or traditional knowledge products such as 'Amritpaani', Jeevamrut' and 'Panchagavya' are known to contain agriculturally beneficial microorganisms and will reduce/obviate the need to depend on market-based bio-products (Rupela et al. 2006a). The dung of a single cow may be enough to meet the needs of one ha area if fermented as advised.
- **Biodiversity.** Use of practices such as 'Aurogreen crops' or 'Shatra crops' are likely to enhance above ground and below-ground biodiversity (researchable topics). Such practices are likely to minimize pest problems.
- **Weed management.** Weeds can be an issue but can certainly be managed without herbicides. Some weeds have great value, e.g., Bathua (*Chenopodium* sp.) – a common vegetable in Punjab/Haryana – which is rich in magnesium/iron and has medicinal value. Like Bathua, some other weeds make good

vegetables (see www.ddsindia.com/www/default.asp for a list). Also, if one weed is rich in iron, others can be sources of other minerals. Weeds are plants that are least studied by the agricultural research system.

- **Canopy management.** The yield of some horticultural crops (both fruits and vegetables) can be increased by targeted pruning. Relevant procedures have been innovated/developed by farmers.
- **Root treatment of trees.** Procedures developed by a farmer have been reported to enhance growth of feeder roots of a tree, resulting in yield increases. The method has been observed to rejuvenate old fruit trees.
- **Botanicals/biopesticides for managing pests.** Most successful organic farmers do not use these bio-inputs. But it has been noted that their use would greatly help beginners (Rupela 2008) until the natural enemies of the pests are in place, which may take 2-3 years.
- **Compost, farmyard manure (FYM).** Compost is reported to be rich in agriculturally beneficial microorganisms. The value of compost be judged not by its concentration of NPK but by the concentration and diversity of enzymes and plant growth factors and the presence in them of diverse beneficial microorganisms. Huge quantities of compost, vermicompost and FYM are not essential for harvesting high yields without agro-chemicals. Indeed crop nutrient needs can be met by using loppings (as surface mulch) of trees (mix of fast and slow-growing trees of economic value, e.g., fruit trees and not necessarily 'gliricidia') grown on boundaries and alleys of the same field in which the crops are raised.
- **Ash application.** Ash contains all the elements a plant/crop needs for growth. The unstable and volatile elements like sulphur get lost during burning. Ash is a cheap source of about 30 elements (some in available form) widely disrespected by most farmers.

The following is submitted for consideration of all concerned to further strengthen "cool agriculture" as described above:

- **Local production and consumption.** Production of healthy food and its local consumption should be given priority over its export to other areas within or outside India. Yes, there are many aware citizens who are ready to pay more and some farmers are already getting benefitted. Farmers like Subhash Sharma of Yavatmal (phone: 09422869620) are happy to sell their crops at prices prevailing in local markets because their cost of production is lower than neighbouring conventional farmers.
- **Unity is strength.** Today there are different names – natural farming, eco-farming and BD agriculture etc. – for organic farming or cool agriculture. For a scientist like me the different versions of organic farming have broad similarities. Originators/innovators of a given version need not spend their energies in arguing the strengths and weaknesses of each other's method of farming. They must not forget that their real challenge comes from the promoters of modern agriculture based on external inputs.
- **Seed and planting materials.** Having one's own seed and planting material not only reduces the cost of production but such seeds can be accessed at will. The Rural Seed Bank concept innovated by some NGOs (www.ddsindia.com/www/default.asp; www.csa-india.org) has been found to help farmers. Great, if each village could initiate its own seed bank. Some innovative farmers have been reported to develop varieties of several crops and even help fellow farmers by providing seed. This system will greatly help in arresting the loss of valuable local food crops like millets and their germplasm. Several traditional grains have been found to be more nutritious than the ones promoted by government programs through the public distribution system.
- **Funds are essential to scale-up.** There are several government programs/funds aimed at different aspects of rural development. For example, the recently initiated 'Mahila Kisan Sakshtikaran Pariyojana (MKSP) under the Ministry of Rural Development should attract many. Farmers' groups and NGOs can access such funds for promoting organic farming in innovative ways.
- **Data generation.** Documentation of the experiences of successful farms and comparing neighborhood conventional farms is important. This should help generate comparative data to help policy makers to listen to this form of eco-friendly agriculture and help them decide on investing more heavily in this direction.
- **Producer company concept.** In addition to the problems of agro-technology indicated above, it is important to note that the agri-business environment – through policies, investment, regulatory mechanisms, etc – is biased towards large entrepreneurs. Farmers should become entrepreneurs and have stakes in their

products exported beyond their fields. Amendment IX-A of the Companies Act 1956 of India allows farmers groups to set up community enterprise systems. This provision can be harnessed to implement the economic development needs of communities and to address issues of poverty and malnutrition. See www.ximb.ac.in/~navajyoti/index.htm for details on the concept and a model PC in the making.
All the protocols (see the section "Features of cool agriculture") of organic farming as listed/described here may find favor/support of agricultural scientists except say "Cowdung ferments", because these have not been studied/researched sufficiently. The present agricultural research for development (AR4D) system – national or international – is not farmers-centric. Instead it is agri-business centric. The farmer is only incidental. Their plight and poverty are used to justify more funds for research and development in favor of agro-technologies which make farmers depend more strongly on external inputs/advice. Most agro-technologies do help increase yield but make farmers depend on the market and also increase the cost of production. Farmers do not have any control on prices of their produce and distress sales are not uncommon. Profitability/livelihood sustainability of farmers has heavily eroded over the years. If farmers' suicides in India are any indicator, organic farming (cool farming) is an important part of the answer to distress in the farm sector. We have yet to hear of an organic farmer committing suicide. In the present agricultural development scenario farmers are suggested to become experimenters. To my knowledge/information, members of the Prayog Parivar (a network of farmer researchers initiated in mid 1960s by Prof. Sripad Dabholkar) are among the most innovative. Several are winners of state level awards in Maharashtra/Karnataka, including for producing the highest yield of a given crop. This has important lessons for others. This suggestion will be relevant even when the AR4D system becomes truly farmer- friendly.

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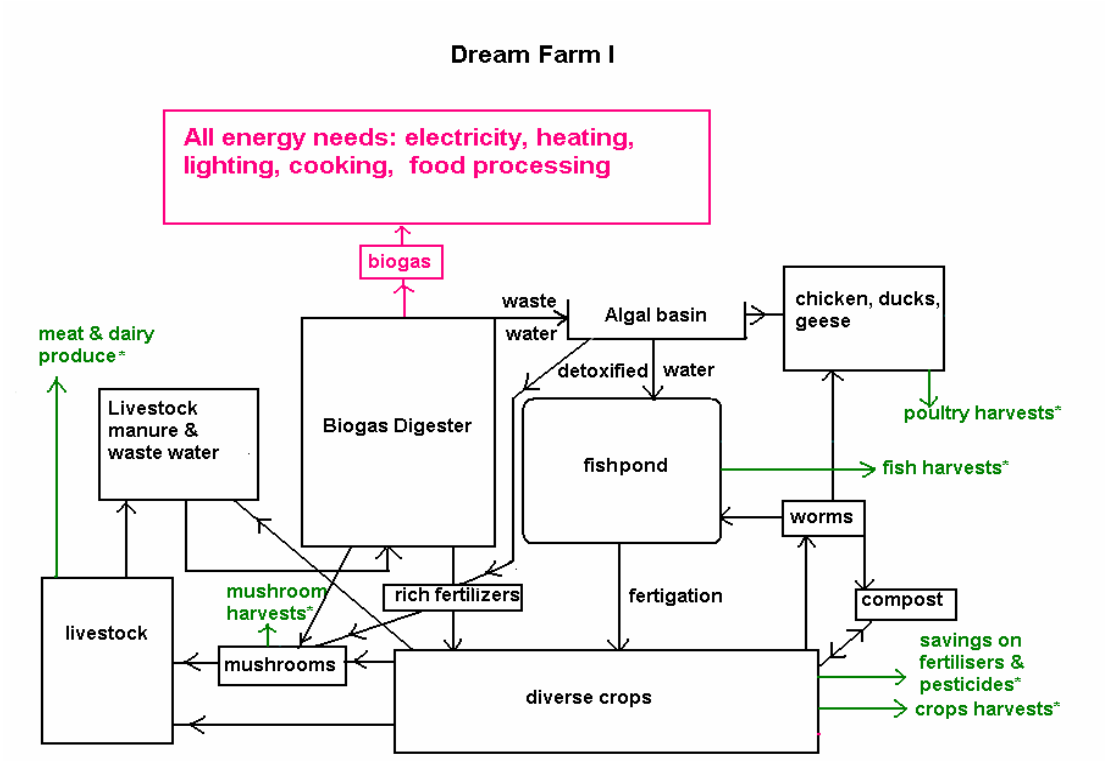

Figure 1. Model of a farm based on eco-friendly agriculture with processes to meet all its energy needs.