

GLOBAL ENVIRONMENTAL AND ECONOMIC CONCERNS IN MODERN AGRICULTURE: ALTERNATE FARMING SOLUTIONS FOR RESOURCE CONSERVATION

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Abstract: *This paper reviews information on the significance of alternate agriculture today and analyses its procedural benefits in view of the recognized adverse long-term impacts of traditional farming procedures on environment. The promotion of organic farming both for crops and animals in recent times has gained momentum in tune with the global focus on sustainability. Organic technologies prove beneficial on counts like augmenting soil organic matter and nitrogen, reduction in fossil energy inputs and conservation of soil moisture and water resources. Ecological balance is maintained through use of cultural, biological pest controls and use of lesser toxic sprays. In the opinion of experts, developing countries where inexpensive labor is available constitute a fertile ground for penetration of organic farming as a viable venture and its labor-intensive nature ensures employment too. Its thrust on natural conditions, natural growth, natural varieties and optimal integration of crop and animal farming prove nature friendly not to forget its array of ecosystem services. Its long term beneficial feature of sustainability both environment and economic offsets its short-term costs. The paper endorses this practice of alternate agriculture as a sustainable solution to current farming problems and associated environmental and economic woes.*

Keywords: Global, Environmental, Economic, Agriculture, Resource Conservation

Introduction

The pace at which natural resources are dwindling necessitates immediate attention and determination to adopt a resource efficient economy regime for ensuring climate security, food security and health of our future generations. Only when our aim for resources is minimizing of usage and maximizing of recycling process, will we be able to leave food for our posterity that never gets exhausted. Towards this the pressing issue is to make our production or agricultural process sustainable. Sustainable agriculture incorporates three main objectives of environmental health, economic profitability, social and economic equity. According to the Food and Agriculture Organization (FAO, 2007), sustainable agriculture “is the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of environment and conserving natural resources”. Organic farming practices considered as a sustainable option are believed to augment soil stability, organic matter and show resilience to climatic variations. It is known to enrich biodiversity to the tune of almost 30 percent as against traditional farming leading to flow of ecosystem services ranging from pollination and nutrient recycling to purifying water and air. In terms of demography agriculture is the largest economic sector and significantly influences the socioeconomic structure of India. The performance of the agricultural sector influences the growth of the Indian economy. The share of this sector in GDP has witnessed a declining trend, but it still plays an important part on account of its employment potential. Agriculture furnishes raw materials for agro based industries. Unfortunately, rising costs of cultivation and uncertain output prices have rendered unsustainability to modern agriculture system and pose serious economic threats for our farmers specifically the small-scale ones. Adoption of alternate forms of agricultural practice becomes an imperative. To aggravate matters India suffers from poor productivity of soil because of low content of organic matter. The efficiency of the organic inputs in the promotion of productivity is dependent on the organic contents of the soil. It is reported that soil under organic farming conditions had lower bulk density, higher water

holding capacity, higher microbial biomass carbon and nitrogen and higher soil respiration activities compared to the conventional farms, Charyulu & Biswas (2010). Organic agriculture can be a boon towards resourceful use and recycling of essential nutrient elements, which otherwise are limited. Organic farming due to non-application of synthetic fertilizers and pesticides makes use of lesser energy. Lower stocking densities and lower feed concentrates further result in better energy balances. It thus can be seen as a solution to both the environmental and economic challenges that grip modern agriculture. A comprehensive in-depth analysis of the procedures involved and ensuing advantages in comparison to traditional agriculture is presented below.

Soil Productivity - Conservation Tillage

Agricultural land or soil is known to suffer due to both water erosion and wind erosion which in turn influences the productivity. Soil is threatened by a number of anthropogenic factors such as erosion which means loss of topsoil and humus, nutrient depletion, surface sealing, salinization meaning presence of huge amounts of sodium, magnesium and calcium, contaminants and compaction. Eroded soils can be responsible for 15-30 percent lower crop yields as compared to uneroded soils (Langdale et al., 1992). In organic agriculture adopting of methods like mulching, planting cover crops and intercropping ensures maintenance of soil cover all through the year. Direct mulching is also done with crop residues after ensuring that the mulch is fungus free. The practice of ploughing followed rigorously in conventional farming worsens erosion more so when the soil remains uncovered for longer periods and when it is low in organic content which impacts the soil's structural stability. Organic farming procedures adopt conservation tillage method which usually consists of direct seeding and fertilizing into the previous crop stubble either no till or minimum tillage before seeding, which conserves surface residues and disturbs the seedbed soil very mildly. Lesser tillage prevents compaction of soil and unnecessary oxidation of soil organic matter. Conservation tillage is known to be effective in reducing runoff and erosion irrespective of climatic, soil, and cropping conditions. Crop residues contain impact of rain and coupled with a rough soil surface, increase infiltration, decrease runoff and sedimentation. Conservation tillage though may not be sufficient in satisfactory control of erosion especially in cases when crop residues are limited and or slopes are steep, BD Guide (2005).

Water Conservation

Organic farming operations are known to improve water quality and water holding capacity thus aiding in water conservation. It facilitates preservation and restoration of water quality, enriching biodiversity in aquatic habitats. Organic operations are a strict no to the use of synthetic pesticides which in turn protects water bodies from pesticide pollution. Though, manure and slurry do cause some water pollution. Crop varieties with varied root structures to a greater extent enhance the structure of soil which consequently betters water infiltration process. Increased humus content, for instance, allows the soil to absorb more water during periods of heavy rainfall, reducing the runoff of surface water and soil erosion (Zeiger & Fohrer, 2009). Increased holding capacity enables soil to provide plants the required water intake in climatic variations or say drought like conditions. Contouring crop rows reduces soil erosion and excess sedimentation of waterways while helping to retain moisture in the field, as per BD guide (2005).

Resourceful Management of Phosphorus, Potassium and other Nutrients

Organic farming contributes to sustainable phosphorus and potassium levels by reducing nutrient inputs and outputs, replenishing stocks of these nutrients through crop rotation, and recycling of manure to complete nutrient cycles. These vital elements are naturally found in rock and soil, where they are transferred across the food chain from plants to animals and humans who intake them either directly through plants as primary consumers or indirectly by consuming meat or as secondary consumers. They can then be recycled through the application of animal manure and human sewage on the land as fertilizer. Today however there is a growing dependence on mined phosphate and potassium to produce mineral fertilizers (Ashley, Cordell & Mavinic, 2011). These elements are crucial for plant growth and maintaining fertility, productivity and hence the overall economic viability of a farm. Though there are many issues relating to their use like their loss from soils or continuous decline of rock phosphate resource. Poor phosphorus management has a serious negative environmental impact on water quality leading to the eutrophication of aquatic environments (Sharpley, Richard & Kleinman, 2001).

There is growing evidence to reinforce that organic farming responds best to the necessity of more efficient use of potassium and phosphorus. Traditional farming is dependent on large quantities of these elements in the form of mineral fertilizer to replace lost nutrients and increase productivity. Organic farming offers respite here as it limits external inputs and focuses on recycling of on farm nutrients. Organic farming observes practices that increase phosphorus inputs, phosphorus recycling and reduce phosphorus losses. Synthetic phosphorus fertilizers are derived from chemically modified rock phosphates, IFOAM (2011). Organic agriculture emphasizes on organic matter constituted by a complex combination of nutrients that maintains soil fertility. Organic matter is a good source of many nutrients and improves soil structure, with 95 percent of soil nitrogen to be found in organic matter as per the IFOAM (2011) resource book. Humus used in organic farming offers no nutrition though it is essential towards maintaining fairly good soil structure and ensuring nutrient availability to plants. Possibilities of a heavy nutrient deficiency are much lesser in organic agriculture as compared to traditional agriculture which even if sets in can be rectified through use of natural fertilizers like rock phosphate for potassium, magnesium rock for fulfilling magnesium requirements or mineral potassium towards meeting potassium deficiency. Other fertilizing options available in organic farming include guano, seaweed, bio degradable food by products, feed, oilseed, textile processing, wood and forestry products, and peat. Green manure or cover crops may not remove or provide phosphorus as it is absorbed by the plant, but the same is returned to the soil later till the time of plant harvest. Green manure could be leguminous crops like clover, alfalfa, beans, peas, ground nuts etc. towards increasing the nitrogen content of the soil. These plants engaging in a symbiotic relation with bacteria trap the air nitrogen and fix it in their cells while directly releasing some of it in the soil, IFOAM (2011). Green manure plantation between growing seasons is known to provide enough nitrogen to the soil. They bring in atmospheric nitrogen through fixation, which constitutes for about 70 percent of the total nitrogen fixed. As an example, clover when used as a winter cover crop can provide nitrogen sufficient for a wheat maize soya rotation not requiring addition of fertilizers.

Weed Control

To control weeds between cropping seasons, no till systems apply cover crops in place of the otherwise both water and soil polluting herbicides. Also cover crops grown with the purpose of covering the bare ground fix nitrogen into the soil decreasing the requirement for synthetic fertilizers. These crops are usually grown in orchards and plantations where the gestation period of tree crops is long. Growing winter cover crops brings about green browse, erosion control and wildlife cover as per the BD guide (2005). Cover crops displace invasive weeds too. Because herbicides are not used for weed control, cover crop options are not restricted by herbicide carryover. Crop cover, however face the challenge of sandy soils and warm climates quickly burning up organic matter or cover crop residues. Most vegetable crops leave little residue which remains a challenge for organic horticulture. Besides cover crops, weed control is carried out through initiatives such as crop diversification or grazing of livestock. Crop rotation implies cultivation of different crops on the same piece of land every year at different time periods. Rotating crops serve to interrupt pest host cycle and draw natural enemies of agricultural pests. In organic farming frequent mechanical soil cultivation used for weeding and complex crop rotations are known to decrease inoculum concentrations. More stable cell walls in the plant tissue because of lower fertilization levels decrease chances of fungal infections, BD guide (2005). For controlling weeds organic farmers also use techniques like flame weeding which does not affect the soil temperature adversely. It is also used to kill some infected crops in order to prevent the spread of infestations.

Emphasis on Natural Pest Control Techniques

The thrust of organic farming is prevention and not cure. It lays premium on preventive aspects and takes recourse to natural pesticides only when left with no other choice. Bio control mechanisms like using releases of predaceous, parasitic insects to reduce pest populations are adopted, (SEBI, 2010). Natural pesticides degrade fast and thus leave no residues in food stuff. Botanicals are preferred over synthetic pesticides as they break down fast into common natural compounds, synthetic substances on the other hand continue to persist in the environment. Ecological balance can be maintained through use of cultural and biological pest controls and use of lesser toxic pest sprays in event of any need. Pest control is carried through cultural methods or practices like application of sustainable crop rotations, biodiversity maintenance, maintenance of

optimum crop health and making use of resistant varieties. Certain insect species are attracted towards certain species of flowering plants and these insects control pests too in nearby growing vegetable crops. Pyrethrin's for example are natural insecticides produced by some chrysanthemum plant species. They are very less poisonous for mammals as they quickly break into inactive forms and are easily removed from the body during excretion. Though pyrethrin's (SEBI, 2010) are toxic for aquatic life, there are fewer chances of water bodies getting contaminated due to their extremely low pesticide movement rating as they bind to the soil tightly and degrade quickly in sunlight both at the soil surface and in water.

Natural Biodiversity Conservation

The invaluable role of biodiversity is widely accepted in that it cleanses air, water, soil and supports many soil functions like nutrient recycling, provides pollination services resulting in propagation of crops. Biodiversity however is constantly jeopardized by anthropogenic factors. As for agriculture, intensification or higher use of inputs and higher stocking densities as is the case with conventional agriculture is the predominant cause. Other factors include application of synthetic fertilizers and pesticides, abandoning of land, climate change, invasive alien species and overgrazing (SEBI, 2010). There is lack of scientific evidence on effect of genetically modified organisms on health and environment. Organic agriculture adopts a precautionary stance and hence application of genetically modified organisms has no place in organic farming. It banks mainly on natural biodiversity. However, with increasing use of genetically modified organisms in conventional agriculture and their pollen transmission in the environment, organic agriculture or product eventually is bound to face the challenge of remaining completely free of them. Protecting sensitive habitats from degradation or putting them to other uses like agriculture is crucial to biodiversity conservation or conservation of native species. Restoring degraded riverside habitats with native species and adapted ecosystems benefits biodiversity along with advantages like water purification, flood protection and groundwater recharge according to BD Guide (2005). Bengtsson et al. (2005) analyzed the effects of organic farming on species richness and abundance and found that organic farming usually increases species richness, having on average 30 percent higher species richness than conventional farming systems. Birds, insects and plants usually showed an increased species richness in organic farming systems. Both long term and short-term researches have increasingly proved that more species thrive in organic farmlands due to its features of crop rotation, leaving of buffer strips, nonuse of synthetic pesticides and growing of best adapted or area specific breeds which practices provide an edge over conventional farming.

Organic farming simultaneously promotes biodiversity and is dependent on biodiversity as well in all its levels of gene, species and ecosystem, BD Guide (2005). Genetically speaking conventional and adapted breeds are taken recourse to as they are more disease resistant and more climatic stress resilient. As for species, diversity is the adopted rule as variety plant animal combinations bring about optimal nutrient and energy cycling. For ecosystem level benefits, management of natural zones within and surrounding organic fields and lack of chemicals naturally enhance suitability of wild life habitats. More use of underutilized species as in rotation crops towards building soil fertility arrests agro biodiversity erosion, paving way for an enhanced gene pool. Arrangements offering food and shelter and absence of pesticide bring newer flora and fauna species permanent as well as migratory and organic system friendly organisms like pollinators and pest predators closer to the organic fields. Organic structures provide appropriate habitats for pollinators, insect predators, birds and bats which play their own purposeful parts. Invasive species are ruled out from the farm through fully composted material, clean soil amendments, mulches and clean tractor tools. Invasive weeds are replaced with native perennial grasses and forbs to control erosion and to attract pollinator, predatory, and parasitic insects. Nectar and pollen producing native plant like hedgerows attract beneficial insect pollinators, predators, and parasites, BD guide (2005). Flowering strips of alyssum interspersed with vegetable crops serve to bring pollinator, predator and parasitic insects drawn for nectar, BD guide (2005). New invasive weeds are prevented from settling down in organic operations. Sheep and goats may be left to graze. Grazing is in tune with habitat needs, including reproduction and migration of native species and other wildlife.

Beavers play a critical role in biodiversity and many native species are dependent on them to create the favorable habitat associated with their ponds. Building of natural dams by beavers

helps control flood severity and facilitates recharging in aquifers. Safe foraging and roosting cover for birds can be ensured by planting wildlife food crops and sheltered resting areas for mammals during cold winters need to be created. Crop rotations can be planned such that some fields always provide food or crop leftovers, water, and cover for priority and other wildlife. Making rice fields flood in off season draws waterfowl and shorebirds, which feed on leftover grain and freshly hatched aquatic invertebrates suggests the BD guide (2005). The birds trample the rice straw and their excreta facilitates breaking down of the crop stubble doing away with the environmental hazardous practice of burning and applying fertilizer at later stages. In traditional farming organic matter is wasted when farmers burn crop residues. Needless to mention that stubble burning constitutes a burning problem in our country each year for the amount of air pollution it causes. In organic farming organic matter is fed to the soils through methods like mulching. In combined traditional farming systems, the livestock manure deposited in the sheds or stables is usually not returned to the cultivated fields and left to decompose.

Air Pollution in Conventional Farming

Burning of rice stubble by farmers on lakhs of acres of land after kharif harvest is a substantial source of air pollution in our country. Aiyar (2016) proposes an environment friendly way of converting stubble into goat fodder. Aiyar (2016) suggests that burning stubble destroys a useful raw material, causes respiratory diseases and worsens the greenhouse gas emissions. Earlier rice used to be manually harvested. But today to avoid labor costs as well as shortage combine harvesters are used which leave about 12-15 inches of stubble as against only few inches when done manually. In yesteryears farmers allowed shepherds to graze sheep on the stubble. Unfortunately, today's farmers are in a rush to clear the fields and plant a rabi crop within two weeks of the kharif harvest. Transporting stubble too proves expensive for farmers who conveniently burn the stubble. Aiyar (2016) focuses on approaches like zero till farming, sowing wheat seeds without removing the stubble. Cattle, sheep, goats all with four stage stomachs can easily digest rice and wheat straw. Straw can also be treated with urea, alkalis or molasses for improving digestibility and calorific value. Forest grazing has the demerit of thwarting regeneration and Aiyar (2016) mentions that the energy animals spend in grazing uses up to one third of their calorie intake. He suggests stall feeding as answer to this which method makes animals produce more milk and meat due to lesser calorie losses.

Livestock Husbandry and Nutrient Recycling

Feeding of livestock proves not to be an expensive affair in organic farming. Crop residues offer fodder to livestock. Livestock thus has a significant role to play in organic agriculture as animal manure provides nutrients to crops. According to BD guide (2005) rotation to perennial forage rests soil after intensive annual crop production. And animal grazing activity controls weeds and diseases in crops. Nutrient recycling course can be illustrated through the example of pig husbandry. Pigs by themselves do not produce phosphorus on their own. They excrete the surplus or unassimilated phosphorus from their phosphorus enriched feed. When pigs were fed with farm grown food and their excrement is returned as fertilizer to the soil to the same farm, phosphorus concentrates can never reach out of proportion levels. However, the situation is not the same when pigs are grown in industrial environments with lack of connectivity between crop and animal production. Maintaining optimum stocking rates is essential in order to ensure a balance among animal and crop production. Organic farming totally disregards the idea of making any genetic changes so as to ensure a sustainable production of pigs. Cattle and other farm animals serve as nutrient sources for organic farmers. Farm animals concentrate nutrients in a form that is easier to spread in the farm. Animals collect nutrients from pastures while grazing which they process, assimilate and concentrate the undigested parts in feces which are spread on to the crop fields. This nutrient transfer on the part of farm animals facilitates maintenance of biological soil fertility and stabilization of soil structure. Applying compost which encourages disease suppressive qualities of soils and mulch with crop and other crop residues from the farm raises soil fertility and structure. Unsustainable agricultural practices lead to loss of organic matter in soil and are detriment to the extent that no application of mineral fertilizers can offset. Two negative factors come into play here low cation exchange capacity of the soils implying lesser nutrient retention and limited availability of other nutrients say micronutrients, BD Guide (2005).

Thrust on Natural Conditions, Natural Growth and Animal Welfare

Organic farming practices are animal friendly as they give paramount importance to maintaining the health and wellbeing of animals by focusing on balanced organic nutrition; stress free living conditions and resistant breed selection for diseases, parasites, and infections, BD guide (2005). Preventive strategies like regular exercise, free access to pasture, open air runs, and adequate grazing rotations reinforce the natural immune mechanisms of animals. Preventive use of chemically synthesized medicines and antibiotics is prohibited as routine drug intakes enervate the immune system and may cause antibiotic resistance. Natural and complementary therapies including homeopathy, Ayurveda and acupuncture are applied in event of animal disease. Keeping the environment as natural as possible facilitates a stress-free setting for livestock which in turn boosts their immunity. Sand bath for chickens aids in ridding them of parasites. Exercises and access to sunlight curbs the risk of skeletal disease and fertility problems. Rotating the grazing pastures promotes natural immunity in animal young ones as they receive a steady exposure to both harmless and pathogenic microorganisms. Natural environment also takes care of self-medicating mechanisms when animals on reflex cure some of their diseases by in taking non-nutrient substances which heal that particular ailment. Crops grown organically are never pressurized during the process of growing implying that their growth is slower in comparison to non-organic crops nevertheless resulting in higher quality yields. The same principle applies to animal products. Growth of animals in conventional farming usually is hastened by adding certain hormones to their feeds. This in turn increases the weight of meat produced per calorie of food intake mainly due to more retention of water in the flesh. The producer fetches more profits as price is not calorie but weight determined. Organic standards address the issue of animal stress during transport by keeping it to the minimum possible levels. Better productivity scores of animals in conventional farming is achieved only at the cost of health and wellbeing of animals. In traditional farming the thrust is on high productivity at the lowest possible price whereas in organic farming ensuring the breeds robustness and disease resistance ability are paramount. Growth rate in organic farming encompasses animal longevity, health, and adaptability. Animals may thus take long to reach adult hood; their productive life however is longer than conventionally brought up animals.

Impact on Nutritive Value of Foods

Reports suggest organic products to have lower levels of pesticides, veterinary drug residues and nitrate content. Organic plant based food products are generally found to contain higher amounts of antioxidants, vitamins, minerals etc. They usually contain a higher amount of beneficial, healthy secondary plant compounds which are phytochemicals produced by the plants like vitamins. Organically processed products lack hydrogenated fats and other harmful additives. Plants grown organically get enough time to synthesize their vital components. They involve their innate defense mechanisms fully to counter higher levels of pest pressure and in the process, end up producing a wide range of secondary plant compounds, BD Guide (2005). Further organic farmers opt for crop varieties or animal breeds based on their yield characteristics and resistance to disease and pests as well as adaptation to the local conditions. These local varieties may have a higher nutrient content as against new varieties with better yields.

Challenges and Scope

Organic agriculture as a sustainable agriculture practice is considered to have a lesser impact on the environment. Organic farming though leads to smaller yields in terms of production per unit area. Large scale application of organic farming calls for more land clearance and more extraction of water so as come at par with conventional farming yields. It is vital to contain the industrialization of organic agriculture as has been the case with conventional agriculture for the simple reason that industrialization proves expensive for climate change and deforestation. In terms of economic gains organic agriculture has the potential to create robust local economy, self-reliant economy, income security, increase returns, reduced cash investment and involves low risk. Nevertheless, the pace at which it is being applied is far beyond satisfaction owing to its own set of weaknesses. These range from initial productivity gaps in cultivation, labor intensive nature, expensive in comparison to conventional food, dearth of recognized output markets, government apathy, lack of appropriate organic inputs to little research and development inputs, complexities in certification process, dearth of necessary infrastructure. Organic farming proves more labor intensive than conventional farming. Its processes of compost and manure application and anti-soil erosion landscaping are labor intensive. This comes as a boon for developing countries like

ours where these practices are usually undertaken manually or with application of minimum technologies, all of which make use of a good amount of workforce thus rendering employment much needed for the developing world. In developing countries inexpensive labor is available forming a fertile ground for penetration of organic farming as a viable venture.

Conclusion

Given the state of India's soil, organic agriculture appears to be one potential solution which is certainly gaining ground though with a lesser momentum. According to Paul (2016), India has 6,50,000 organic producers, which is more than any other country. India also has 4 million hectares of land certified as organic wild culture, which is third in the world. Through organic agriculture, promotion of healthy biodiversity, enhanced soil formation is automatically achieved through the soil building processes of crop rotations, inter cropping, symbiotic associations, cover crops, organic fertilizers and very less tillage. Nutrient and energy cycling is increased and the soil retentive capacity is also increased offsetting for the nonuse of mineral fertilizers thus reducing soil erosion. The soil's vulnerability to factors causing erosion is reduced. Application of organic fertilizers like compost, animal manure, green manure, better water infiltration and increased nutrient retentive abilities all contribute to containing groundwater pollution to a lesser or greater extent. It also lessens the greenhouse effect and thus global warming as carbon is sequestered in the soil through operations like minimum tillage, applying crop residues to the soil, the use of cover crops and rotations, and enhanced integration of nitrogen fixing plants like legumes which in turn enhance yields. Organic farming is questioned for being less productive per area basis and that it needs more land for food production. But this perspective overlooks the broader perspective of long term benefits. When it comes to sustainability factor and conservation of natural resources, organic farming fares better on long term food security parameter. Organic products irrevocably cause less polluting agricultural systems compensating to some extent for hidden costs of agriculture to the environment in terms of degradation of natural resources. Environmental and economic advantages of organic agriculture can be summed up by stating organic agriculture due to its preventive and restorative predilection renders agricultural sustainability gradually though spread over a long time stretch.

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