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Review Paper

Towards Sustainability: A Plan to Minimize External Inputs and Maximize Outputs

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Abstract

Sustainable agriculture is the method of cultivating crops, rearing livestock and other organisms using the principles of ecology. It establishes a relation between various life forms and the environment surrounding them. A farmer can maximize his profits by minimizing the cost he incurs from external inputs. He can adopt various enterprises on the same farm. These units comprise of apiary with sunflower, dairy, fisheries, cereal with legume crop rotation, commercial crop with legume crop rotation, hydroponically cultivated strawberries, kitchen garden, biogas unit, rainwater harvesting structure, vermicomposting etc. The farm surrounded by forest trees will add to the security. This paper reveals such a plan where in the owner is satisfied of the food, feed and fiber needs, the environment's quality is enhanced and natural resources are preserved. This model makes the most efficient use of non-renewable resources and on-farm resources and integrates them in an efficient and sustainable manner. It also sustains the economic viability of the farmer and his enterprise.

Keywords: Sustainable agriculture, hydroponics, vermicomposting, rainwater harvesting, apiary, biogas plant.

Introduction

The word sustainable is derived from the Latin word "*sustinere"* implying permanence, meaning to keep in existence, or establishing long-term support. There has always been a difference between conventional and sustainable model of agriculture. The traditional practice of agriculture is basically an industrial development model which pictures farms as factories and depicts fields, plants, farmers and farm animals as production units.

Agriculture has come to draw the inputs which it uses from more distant sources, both spatially and sectorally, to derive an increasing proportion of its energy supplies from non-renewable sources, to depend upon a narrower genetic base and to have an increasing impact on the environment. This is particularly reflected in its heavy reliance on chemical fertilisers and pesticides, its dependence upon subsidies and price support and its external costs such as threats to other species, environmental pollution, habitat destruction and risks to human health and welfare.

Agriculture is sustainable when it is ecologically sound, economically viable, socially just, culturally appropriate and based on a holistic scientific approach. Low-External-Input and Sustainable Agriculture (LEISA) is agriculture which makes optimal use of locally available natural and human resources (such as soil, water, vegetation, local plants and animals, and human labour, knowledge and skill) and which is economically feasible, ecologically sound, culturally adapted and socially just. 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 present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable.

Sustainable agriculture is achieved only when the following three basic principles are followed: diversification, integration and synthesis. A complete farm which has a diversity of enterprises and works out to be one has strong characters that the enterprise units individually can not possess. The same set of components or parts may be rearranged spatially or sequentially resulting in a unique system or whole for each new arrangement. These individual units when rearranged and managed well by applying innovative technologies have the potential to enhance the productivity of the whole farm.

Why go for sustainability in agriculture?: There are three main points. First: farmers have realized that chemical farming alone cannot lead to sustainability. All the food is poisoned through our modern farming systems. Second: farmers find that the cost and quantum of inputs are rising day by day and so he cannot pay back his loans. Resulting in loss of lands by small and marginal farmers or allowing the land to remain fallow and migrating to the river belts for seasonal jobs, or to other states and countries for menial jobs in order to survive. Third: the export market is facing a problem as importers of food materials especially in European countries and the USA; find that our food contains too much pesticide. They insist that these are removed and that the food has to be safe for consumption. So the pressure to change is coming from the export market also. But most of all, farmers are interested in a sort of integrated farming system because chemical farming has become uneconomical now a days and grain yields have started declining.

A time was there when the country wanted more grain production. A whole lot of people were brainwashed. They were given fertilisers practically free of cost, or at heavily subsidised rates. But once the government stops subsidies on chemical inputs, farmers will have to stop using them or change over to some other way of farming. And we cannot ignore the fact that without water, chemical farming is impossible.

The objective of this paper is to bring out a plan which uses the byproducts and waste of one farm enterprise as an input for another farm enterprise and thus reduce the external inputs there by reducing the cost incurred by the farmer. Such a plan when executed and managed in a proper way will lead to sustainability in the long run. Also, such farms can generate huge profits and then invest into high tech agricultural/ horticultural practices like hydroponics, vertical farming, greenhouse cultivation etc.

Material and Methods

Sustainable agriculture systems are typically based on relatively smaller, profitable farms which use fewer off-farm inputs, integrate plant production and animal components, maintaining a higher biotic diversity, emphasizing on technologies that are appropriate to the production scale, and make the transition to renewable forms of energy.

In order to develop a plan for sustainable farming, a broad literature search was conducted from which ten overarching sustainable agriculture indicators were identified. Then parameters were identified and those which were the best measures for assessing a given indicator were selected. These parameters were used as a basis for developing assessment questions to measure performance. The plans, which also include a description of the indicator, farmer benefits of improving practices, descriptions of best practices, and references to additional resources, were reviewed by experts as well as by farmers.

The following describes the focus: Animal Welfare: This plan examines animal welfare from three perspectives: nutrition, living conditions, and herd health. Animal nutrition includes the type and quality of feed that are provided to the dairy cows; living conditions refers to the general comfort of the animal; and herd health refers to incidence of diseases. Using these three foci as a guide, this plan assesses management practices according to the following topic areas: herd nutrition, overall health, health of incoming/outgoing animals, milk quality, lactations, housing/handling areas, stalls, pasturing, milking equipment and parlor, and calf raising conditions.

Biodiversity: The Convention on Biological Diversity defines biological diversity in terms of genetic, species, and ecosystem diversity. While all three measures are necessary for providing a complete understanding of the level of biodiversity in a given area, biodiversity at the genetic and species level is complex and difficult to measure at the farm level. Therefore, then I worked to identify proxy measures for assessing genetic and species biodiversity on a farm through ‘ecosystem’ measures. The plan focuses on the ‘ecosystem’ level measures of biodiversity, which provide more general indications of a farmer’s conservation and biodiversity protection practices. Specifically, questions for this plan center around: genetic diversity of crops, natural area conservation, management of riparian areas, pasture management, crop field management, adjacent area management, and the use of GMOs.

Community Health: Decisions made on the farm have effects on the local community. Similarly, the support received from the community can significantly impact a farmer’s job satisfaction. Farm labor also plays an important role in the maintenance of a healthy community. Ensuring the health and safety of the employees is an important social concern leading to the advent of worker safety programs and standards. Other areas of importance include fair wages and compliance with child labor laws. Given these concerns, this plan focuses on the two main topics: community relations and protection of labor supply. Questions within the plan to assess these topics focus on: community involvement, protection of the labor supply, child labor, base wage, and worker health and safety.

Energy: Agricultural production systems are energy intensive (includes agriculture production, processing, distribution, refrigeration, etc.). This plan focuses on two parameters: energy conservation measures and renewable energy technologies.

Farm Financials: Farm Financials refer to a farmer’s financial performance as well as his or her quality of life. Financial performance is measured in terms of profitability, efficiency, debt load, and other factors. Once farmers understand their financial position, the expectation is that they can create appropriate business plans for managing or growing their operations. Appropriate business management also affects a farmer’s work-life balance and overall quality of life. Quality of life is not only influenced by personal wealth, but also by a farmer’s ability to spend time with family, friends or helping the community.

Nutrient Management: Nutrients, such as nitrogen, phosphorus, potassium, calcium, magnesium and sulfur, are necessary for plant and animal growth and are therefore an integral part of any agricultural system, including dairy. At the same time, excess levels of the nutrients nitrogen and phosphorus can be detrimental to environmental health, particularly water quality.

Adopting best practices for nutrient management is important to preventing leaching or runoff of nutrients to ground and surface waters. Because healthy farm systems normally recycle nutrients via soil, crops, cows and manure, the focus of this plan is on managing nutrient imports, such as purchased feed and fertilizer, which serve as additions to these natural processes and often are the cause of nutrient buildup on a farm. Proper nutrient management in this plan is assessed through the following parameters: nutrient management and record keeping, manure application rate, commercial fertilizer application rate, manure and fertilizer application timing and techniques, and use of phosphorus supplements.

Soil Health: The essence of soil health is its ability to perform these functions simultaneously. Under current production methods, soil health and its corresponding contribution to farm production is under threat due to erosion, soil compaction, and overuse. These factors can contribute to water and air pollution, added costs for farmers and degraded crop yields. This module focuses on best management practices to maximize soil quality and health. Specific parameters to assess soil health include: soil organic matter, use of cover crops and vegetative areas, crop rotation, tillage practices, and soil conservation/erosion protection and soil quality monitoring.

This paper is drafted after going through various success stories in North Karnataka. A list of progressive farmers was made and then these units were studied in depth and the feasibility of their innovativeness was tracked for two consecutive years (2011-13). The various enterprises were examined for different features giving insights of economic, social and ecological perspectives. Various plans were drafted and the most feasible and profitable one was selected. The sustainability of the plan was studied and then the plan was concluded. The plan is evaluated based on cost effectiveness, land holdings, response to climate change, suitability, feasibility and labour requirement.

Suppose that the land is divided in a pattern such that the slope is on one side of the rectangular plot. Starting from a corner, at the higher slope edge, the plot can be divided into sub plots comprising of various agri-enterprises. The plot is depicted in figure 1.

Land shaping involves creating a pond by constructing a slope. The pond can be created at the centre too (figure 2). The top 10-15 cm of topsoil (fertile) from the pond and areas that will form the raised beds is scraped off and piled up to one side. The pond's subsoil is used to build the raised beds. Spread the topsoil over the surface of the newly formed beds. The pond covers about 20% of the land area, in the centre of the plot. It is about 2.5 m deep – not too deep, or there are chances of getting salty. The rainwater is stored in the pond, which is vital for domestic use and irrigation during the dry winter and summer seasons. It is used to keep fish and ducks throughout the year.

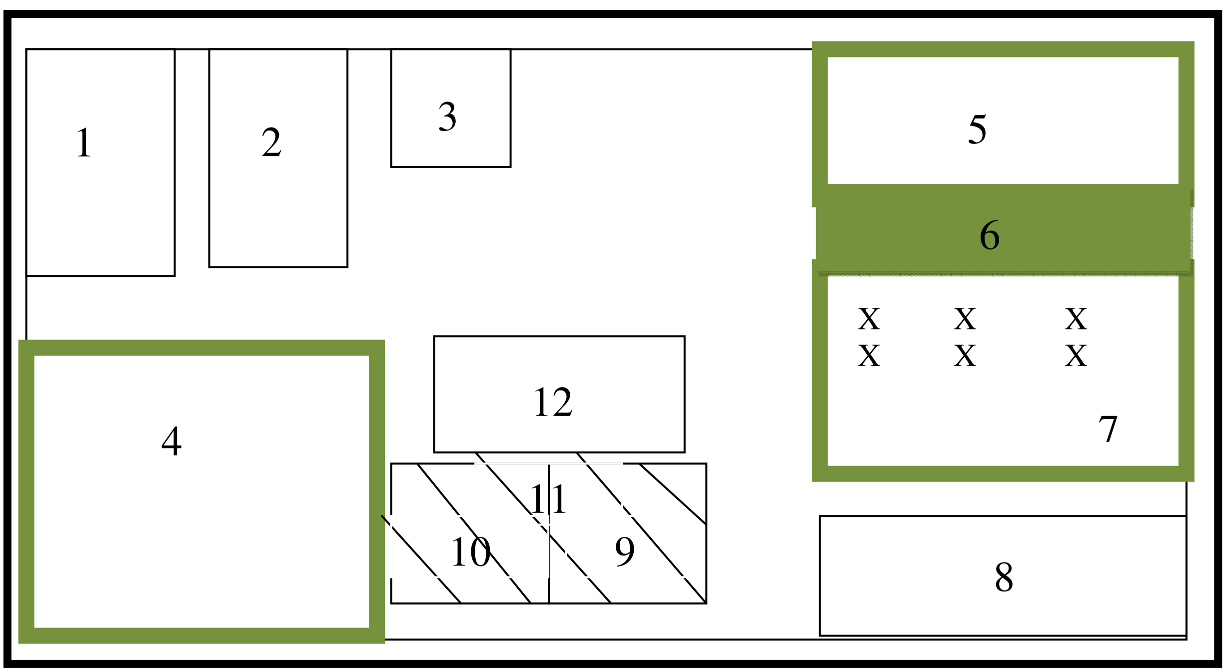

Figure-1

Plot of the field with various enterprises linked with each other to provide sustainability. 1 = low cost greenhouse, 2 = cattle shed, 3 = innovative biogas plant, 4 = commercial crop, 5 = cereal + pulse crop rotation, 6 = fodder grass, 7 = sunflower/ niger + apiculture, 8 = kitchen garden (vegetables), 9 = vermicompost pit, 10 = fish pond, 11 = coccinia thatch, 12 = house with roof acting as mushroom garden. Other components like coconut trees, timber trees, fruit trees etc can be distributed accordingly

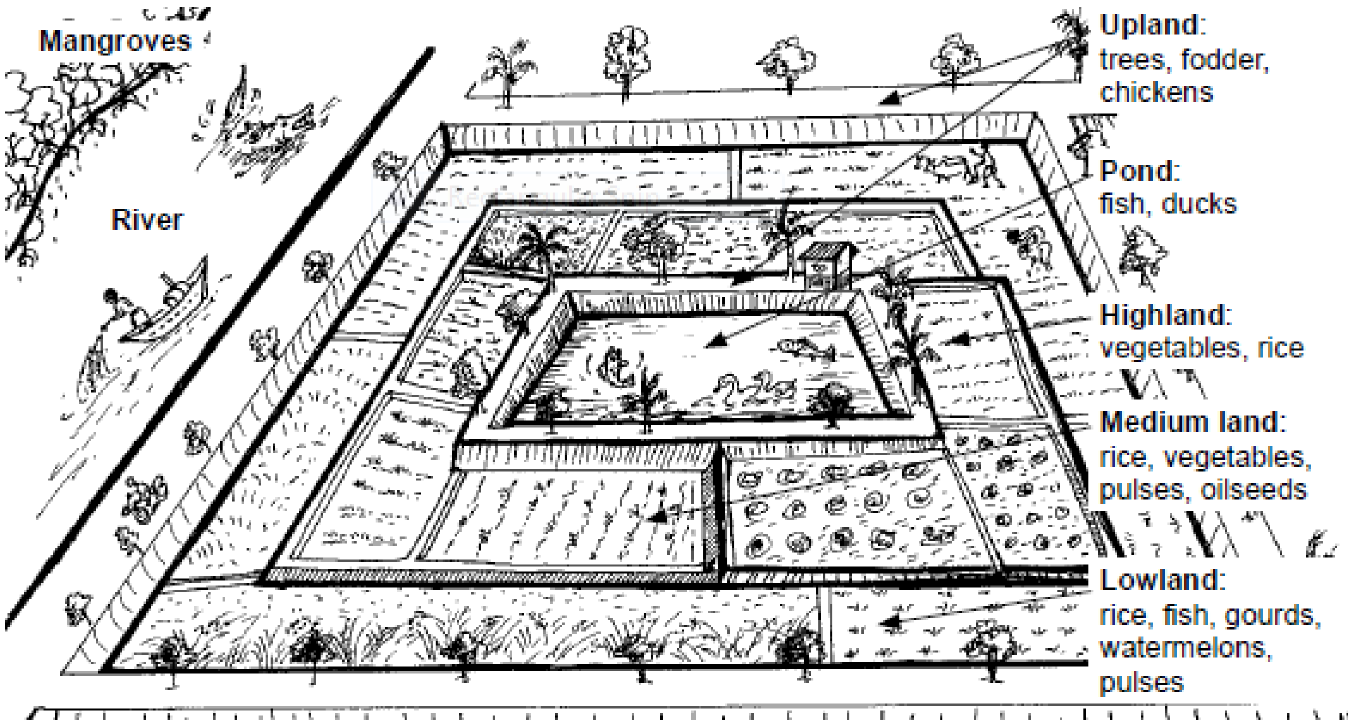

Figure-2
Pond at the centre after land shaping

The upland beds are about 70-75 cm high. These cover 5–8% of our land. They are built around the pond and plot borders. Fruit trees such as coconut, guava, mango, and papaya, ladies' finger and other rainy season vegetables, fodder crops such as *Leucaena* (*subabul*) can be grown on these. The chicken house and trees for timber are also grown there. The highland beds are about 55-60 cm high, and are located wherever is convenient. They cover about 30–35% of the plot. They are used for vegetables in the rainy season and winter, and quick-maturing high-yielding rice varieties. The medium land is about 30 cm high. It is also in broader beds in convenient locations, covering another 30–35% of the plot. It is generally used for medium-duration, high-yielding varieties, pulses and oilseeds. The lowland covers the remaining 10% of the land, and is left as it is. It is used for long duration traditional rice varieties, rice–fish culture, and (in the summer) gourds, sunflower watermelons and quick-growing pulses.

The following are the components included in the main plot:

Biogas plant: A compact biogas plant (from Appropriate Rural Technology Institute, Pune) which uses waste food rather than dung/manure as feedstock, to supply biogas for cooking can be established in the farm. Dr. Anand Karve (President of ARTI) has developed a compact biogas system which uses sugary/starchy feedstock (spoilt grain , waste grain flour, misshapen or overripe fruit, non-edible seeds, fruits and rhizomes, kitchen waste, green leaves, leftover food, etc). Just 2 kg of such feedstock produces about 500 g of methane, and the reaction is completed with 24 hours. The conventional biogas systems, using cattle dung, sewerage, etc. use about 40 kg feedstock to produce the same quantity of methane, and require about 40 days completing the reaction. Thus, from the point of view of conversion of feedstock into methane, the system is 20 times as efficient as the conventional system, and from the point of view of reaction time, it is 40 times as efficient. Thus, overall, the new system is 800 times as efficient as the conventional biogas system. The current practice of using low calorie inputs like cattle dung, distillery effluent, municipal solid waste, or sewerage, makes methane generation in conventional biogas plants highly inefficient. Through this compact system, it has been demonstrated that by using feedstock having high calorific and nutritive value to microbes, the efficiency of methane generation can be increased by several orders of magnitude. Operating the system on this simple tenet also brings in many more advantages over the conventional systems: As a result of the higher efficiency, the size and cost of the new system are also lower. While the conventional biogas system occupies about 4 cubic meters of space, the compact biogas system is about as large as a domestic refrigerator. It is an extremely user friendly system, because it requires daily only a couple of kg feedstock, and the disposal of daily just 5 litres of effluent slurry.

The design is not very complex and can be fabricated using locally available materials. In general the following parts would need to be obtained locally: i. 1000 Ltr and 750 Ltr plastic tanks. If not available then cement and brick tanks can be constructed. ii. PVC pipes of various diameters, commonly used in plumbing. iii. Biogas cook stove (This would generally be available in countries where the biogas technology has been promoted by the governments).

Table-1 represents the differences between this compact biogas system and the conventional biogas system.

Table-1
Differences between the compact biogas system and the conventional biogas system

	Conventional	Compact
Amount of required feedstock	40 kg + 40 lit water	1-1.5 kg + 15 lit water
Nature of required feedstock	Dung	Any starchy material
Amount and Nature of slurry to be disposed of	80 lit, sludge	15 lit, watery
Reaction Time for full utilization of feedstock	40 days	48-72 hours
Standard size for household	4000 lit	1000-1500 lit
Capital Investment per unit including stove	INR 20,000	INR 10,000
Running Expenses per meal	INR 25	0 to INR 5

The small amount of solid residue produced by the biogas plant makes a good fertiliser.

Cattle Shed and Other Farm Animals: Some area of the farm should be dedicated to a hygienic cattle shed where in milch and drought animals are sheltered. Milch animals can be used for the household purposes and if the number of cows is high, the milk obtained can be sold. The birds grow by feeding on kitchen waste, generate some revenue, It also takes care of the nutritional needs of the farmer. We have been seing the poultry sector focusing more on rearing of commercial poultry birds like broilers for meat and eggs, resulting in almost extinction of many indigenous species of poultry. One such breed is the Giriraj fowl breed that is native of Karnataka. These are red brown in colour and mainly reared for meat purpose. These birds are robust and are known to tolerate extreme climates. They are easy to rear and there is no need for any special attention for them. They thrive well in a minimal management system. They are good scavengers. Hence the feed cost gets reduced. They can generally be housed in large bamboo baskets as well as inside store rooms. Both the cockerels and hens grow fast and the hens start laying eggs from sixth month of age. In a year a single hen can lay 80-120 eggs. The birds fetch a good price in the market. A four month bird is sold for Rs. 600-800 and a one year old bird above Rs. 600 (other desi variety fetch Rs. 100-150). The eggs are also sold at a good price. The farmer will be able to get an income of Rs. 80, 000 - 90,000 a year. Goats can be reared for mutton purpose. And the manure of all these farm animals can be used as an input for other enterprises.

Apiary in Sunflower/Niger Crop: Sunflower is a cross-pollinated crop. The pollen of the plant cannot fertilize ovary of same plant. Pollen source should be from different plant. Hence, honey bee's acts as important agents for pollination in sunflower. In sunflower, yield increases by 32-48 per cent due to bee pollination. It improves quality and quantity of seeds. Oil content also increases by 6.5 per cent in seeds. To achieve this it requires five strong C. *indica* colonies or three *A. mellifera* colonies. After Sunflower is harvested the bees survive on Niger and till the Niger crop comes to flowering stage, it thrives on cotton. And hence three crops, apart from other fruit trees and flowering crops, are benefited.

Roof Mushroom Cultivation: Mushrooms are a rich source of nutrition and come under health foods. They have less fat content in comparison to the protein and carbohydrate content. The fat consists mainly of unsaturated fatty acids such as linoleic acid. Mushrooms are the perfect food for maintaining a healthy heart and cardiovascular system. Mushrooms are increasingly gaining acceptance in different cuisines and in ever day consumption. Also, current trend of consumption depicts the opportunity that lies in the area of exporting mushroom. White button mushroom and oyster mushroom are the two most commonly grown species of mushroom in India. Production of white button mushroom is seasonal in India. Apart from other factors, the system requires humidity, a temperature for spawn or vegetative growth (Spawn run) of 22-28^{0}C, for reproductive phase or fruit body formation temperature should be 15-18^{0}C, relative humidity must be 85-95% and ventilation is needed. Steaming at 100^{0}C (pasteurization) is also needed in order to reduce contamination. Oyster mushroom requires a temperature of 20-30^{o}C, both for its vegetative growth (spawn run) and reproductive phase, i.e. for formation of fruit bodies. The suitable cultivation period at high altitude - 1100-1500 meters above mean sea level is March to October, mid altitude – 600 - 1100 meters above MSL is February to May and September to November and at low altitude - below 600 meters above MSL is October to March. Mushrooms are harvested in flushes. About 2-3 flushes may be harvested from a single cube. The yield of the first harvest is high and then gradually lowers, giving a total yield of 1.5 kg to 2 kg of fresh mushroom from one cube. Then the cube is discarded and can be used as manure in the field.

Operational Costs:

Cost of substrates (straws etc)/year:	Rs. 7,000
Cost of plastic bags for packing products/year:	Rs. 1,500
Cost of Spawns/year:	Rs. 6,000
Miscellaneous costs (Chemicals etc.):	Rs. 1,500
Total Cost:	Rs. 16,000

First Generation Spawns in glass glucose bottles: FGS x 25 Cycles = 200 FGS @ Rs. 70/- = Rs. 14,000
Tissue Culture in Glass Test Tubes = 3 Beds X 20 cultivators = 60 Beds x 14 days per cycles
308 second generation spawns in polypropylene pouches (104 Tissue Culture yearly x Rs. 100/- = Rs. 10,400
Polypropylene bags @ Rs. 250 x 26 cycles = Rs. 6,500
Cost of 2800 Kg. Jowar/Wheat grains required for culturing 26 cycles @ Rs. 10/- per Kg.
Cost of other chemical components & miscellaneous expenses.

Fishery: The water stored in the pond can be used to rear fishes which have a great market potential. The study showed that the cost of cultivation came out to be Rs. 15,000 and the income generated was Rs. 30,000, which is double the money invested.

Vermicompost: The term "organic" does not explicitly refer to the type of inputs used. Rather, it refers to the concept of the farm as an organism. Nutrient management is the key to this: organic farming employs crop rotation, green manuring, water management, recycling of residues etc to ensure that available nutrients are used on the farm itself to grow crops as well as raise livestock. Conventional practices tend to ignore or waste these resources, and use artificial replacements instead: they depend on artificial fertilizer rather than depending on manure/compost. How much agricultural waste could be recycled in this way? Estimates vary widely, but the amount is really remarkable: something like 1,800 million tons of dung, 800 million tons of compost and 400 million tons of crop residues per year. These "wastes" are rich in nutrients: well-rotted farmyard manure, for example, contains 0.5% nitrogen (N), 0.2% phosphorus (P_2O_5) and 0.5% potassium (K_2O). Most of these valuable resources are wasted and used in improper ways. For example, even if only one-third of the 1,800 million tons of dung were used as manure, it would be equivalent to 2.90 million tons of nitrogen, 2.75 million tons of P_2O_5 and 1.89 million tons of K_2O. Even the crop residues have the potential to supply 7.3 million tons of NPK. According to an estimate, a quarter of the nutrient needs of Indian agriculture can be met by using various organic sources. Vermicompost (compost made by earthworms) is nutrient rich. It contains 1.5% nitrogen, 0.5% phosphorus and 0.8% potassium along with micronutrients. Vermicompost can act as the single source of all nutrients that the crop needs. It also contains 10% organic carbon, and continuous applications increase the soil's organic matter content significantly. Earthworms can convert about 1,000 tons of organic waste (moist) into 300 tons of rich vermicompost (dry). They eat any type of organic matter and consume their own weight of residue every day, converting it into worm casts, which is again rich in nutrients. In about two months, one kg of earthworms (1000–1250 worms) can give us 10 kg of casts. Vermi-wash can be used as an input for the farm enterprises.

Creeper of Coccinia: Trail Coccinia creeper over the fish pond and the vermicompost pit. This will provide shade and act as a thatched roof along with providing extra income to the farmer. It acts as a good source of nectar for the honey bees too.

Legumes and Green Manure: Green manuring is the traditional method employed to improve fertility of the soil and supply part of the crop's nutrient needs. A green manure is a crop (usually a nitrogen-fixing legume) that is grown in a field, then cut and incorporated into the soil, or left of the surface to decompose. A green manure plant (40–50 day old) can supply up to 80–100 kg of N/ha. So, if (say) the following crop can use just half of this nitrogen, the green manure is equivalent to 50–60 kg/ha of nitrogen fertilizer. Potential green manures include cowpea (*Vigna unguiculata*), sesbania (*Sesbania aculeata, dhaincha, dhunchi*), sunnhemp (*Crotalaria juncea*), mungbean (*Vigna radiata*), cluster bean (*Cyamopsis tetragonoloba, guar*), berseem clover (*Trifolium alexandrinum*) etc. Leguminous green manures fix large atmospheric nitrogen.

Field Crops, Fodder Grass and Fruit Trees: Field crops with a diverse range of oilseeds like groundnut, soybean etc., cereals like sorghum, rice, wheat etc., and cash crops like cotton, sugarcane etc. can be grown in the plots allotted to these. Several fodder grasses can be grown on the bunds and can be harvested periodically. Coconut palms can be grown at the border along with some fast growing timber trees. These act as wind barriers and live fence for the farm. Other fruit trees like mango, sapota, papaya etc. can be planted so as to get additional benefits.

Kitchen Garden: A small kitchen garden is a must in order to fetch vegetables for household purposes and when bumper production is seen, it can be sold out too. Vegetables like radish, egg plant, curry leaves, leafy vegetables and trailing vegetables are some profitable enterprises.

Future Projects: By generating huge profits, the farmer can invest in establishing a low cost greenhouse (on utilizing the subsidies) where in gerbera and strawberries can be grown using hydroponics and vertical farming principles. This can add to the benefits and lead to higher income. The produce from such an enterprise can be exported and thus the farmer can gain a good hold over the market.

The byproducts of all these enterprises mentioned above can be used as an input for the rest of the enterprises. Dealing with each component and then comparing the estimated cost of individual enterprise with that of the combined enterprise can help us know the real difference.

A Progressive Farmer's Case Study: District: Byadagi, Haveri in Karnataka.
Major farming systems: Maize, Cotton, Minor millets, Sorghum, Groundnut, Sunflower, Soybean, Green gram, Horticulture crops, Animal husbandry, Integrated farming system, Agri-silivi-horti-pasture etc.

Agro-climatic zone: Northern Transitional Zone (Zone 8) with the following characteristics: Total geographical area of 4.85 lakh ha. with cultivated area of 3.86 lakh ha., of which 72,000 ha is irrigated (13.5%). Receives on an average 702 mm of rainfall annually mainly during June to October. The rainfall received with two peaks (July and September). Land holding pattern of the district is < 1 ha (32,719), 1-2 ha (60,095), 2-4 ha (48,885), 2-10 ha (19,613) and > 10 ha (2,649). Soil type: Red soil (2.53 lakh ha) and medium to deep black soil (1.33 lakh ha). Lies approximately about 750 meters above sea level with a temperature range of 18˚C - 37˚C and an annual rainfall of 864.0mm.

Profile of the Progressive Farmer:
Name and address: Sri. Hemanna Barangi, Hireanaji “At post”, Byadgi Taluk, Haveri
Phone number: +91 966 386 1958
Age (as on June 30, 2013): 43 years
Education: Illiterate
Landholding: 1 acre 10 gunta
Farming experience: 7 years

Crops/livestock/other enterprises and techniques adopted : Maize, horse gram, coccinia, cluster bean, chilli, ridge guard, chrysanthemum, rose, drumstick, papaya, egg plant, mango, coconut, lemon, insulin plant, azolla, fishery, two cows, two ducks, apiary, vermicompost, vermin-wash, biogas plant, rainwater harvesting.

Social recognition: Member of Savayava Krishi Parivar and received a Certificate for participating in the programme of “farmers to farmers” in Krshi Mela of 2007.
Family Composition:

Table-2
Family composition of the progressive farmer

Name	Relationship	Age	Education	Occupation
Bebakka	Wife	32	SSLC	House wife
Manjunatha	Son	18	Drop out	Agriculture
Kiran	Son	16	1st PUC	Student

Details of the Farm: i. Soil types: He owns 1 acre 6 guntas of land, whole of which is red soil, in this he cultivates maize, horse gram, coccinia, chilli, cluster bean, ridge guard, chrysanthemum, rose, drumstick, papaya, egg plant, mango, coconut, lemon and insulin plant. ii. Size of the farm. iii. Source of irrigation: His innovativeness is best highlighted by describing the way he has harnessed the rainwater according to the slope. The technique involves the storage of runoff water in a tank and a ditch which collects the rainwater and then using a pipe and pump water is utilized for fisheries as well as irrigating crops. iv. Livestock possession: The cow is fed with husk, green grasses and azolla. He is conscious of getting the animals, both mother and the calf, vaccinated. He has maintained the shed in a hygienic manner and also influences other villagers to adopt cleanliness and sanitation. v. Principal crops grown: Cereals: Maize, Pulse: Horsegram, Vegetables: Coccinia, cluster bean, ridge guard, drumstick, egg plant, chilli, Floriculture: Rose, chrysanthemum, Fruit crops: Papaya, mango, lemon, Plantation crops: Coconut, Medicinal plants: Insulin plant.

Table-3
Size of farm and its details

Title	Details
Total geographical area	1acre 10 gunta
Net cultivable area	1 acre 6 gunta
Total barren land	00
Area under forest	Border
Area under plantation crops	Border
Total Rainfed area	1 acre
Total Irrigated area	6 gunta
Single cropped area	1 acre
Double cropped area	00

Table-4
Size of farm and its details

Livestock	Number	Utility
Draught Animal	00	00
Milk Animal	01 (cow)	Milk, dung and urine
Dry Buffalo	00	00
Heifer	00	00
Calves	01	00
Goats/Sheep	00	00
Poultry birds	00	00
Any other	02 (ducks)	00

Description of innovation: Farmer is practicing agriculture in his land (1 acre) by growing crops like maize, horse gram, cluster bean etc from past 6 years. Available land of about 10 guntas, adjacent to his house, is utilized efficiently by using IFS concept. In which he is growing coconut and drumstick as border crops and rearing two cows along with four vermicompost pits (40’x8’). Earlier he had 20 giriraj birds. Vermicompost pits are provided with natural shade by growing three Coccinia plants in the vermicompost pit itself. Among the three one is grown at the centre and two on either sides of the vermicompost pits. Plants are placed in such a way that they can be easily detached while collecting the vermicompost and are replaced without harming the plant root system. With these three plants farmer is earning an amount of Rs. 500/- per week by selling 40-45 kg Coccinia. It gives continuous weekly income for 4 – 5 years without any additional expenditure and also adds one quintal of leaf as raw material for vermicompost. To train the Coccinia plants cement pillars are raised on the pits for which thatching is done with 2’’ width GI wire.

Problems faced by using asbestos and other thatching materials for shade. Asbestos sheets were not advantageous during windy days, temperature and aeration was not congenial for vermicompost production with the use of asbestos sheets, thatching material used other than asbestos sheets require frequent change and repair as they get mutilated and investment was more on thatching material.

Replication and Promotion: i. Horizontal spread of innovation and No. of farmers adopting: About 10 farmers from different villages like Biranakoppa, Siddapura, Hirehalli, Chikkerur have adopted the same technology and expressed satisfaction regarding adoption of the same. ii. Socio-economic implications: The innovation made by the farmer has improved his socio economic status with the help of publicity through University of Agricultural Sciences, Krishi Vigyana Kendra, State departments and mass media. The economic status of the farm family has been benefited by the additional income. iii. Income generated out of this innovation by the innovator: Farmer is earning approximately Rs. 500/- per week by selling coccinia which accounts to Rs. 8000-10000/- in a year in addition to the income earned through the sale of worms (Rs. 20,000 -25,000/- @ Rs. 200/- per kg) and vermicompost (Rs. 40,000-50,000/- @ Rs. 300/- per quintal). iv. Feedback from farmers and other agencies: Farmers who have adopted the technology are satisfied.

Results and Discussion

Annual Income of the Progressive Farmer: The waste from the cattle shed, twigs, leaves and other farm waste is used as a base material for the vermicomposting pit. The vermiwash is extracted and used as a spray/ drench in the flowering plot and kitchen garden. The vermicompost is used up by the farm enterprises and the rest is sold at the rate of Rs. 300/ quintal. Use of biofertilizers like *Azospirillum, Pseudomonas, Azatobacter* etc can help reduce the cost of cultivation by reducing the required dosage of NPK/ha for the crop. It also enhances the crop growth and thus increases the yield and overall quality of the produce. *Azolla* can be used as an enhancing feed for the milch animals and in case of paddy growing areas, it can be used as a nitrogen delivering fertilizer. Green manure crops can be incorporated in the field soil to reduce the external fertilizer dosage and to maintain the soil health.

Crops like banana, sugarcane, potato, tapioca and others require more potassium. Almost 200 kg/ha of potassium is recommended for sugarcane. To meet this requirement farmers have to apply almost 330 kg of Muriate of Potash. This costs about Rs. 5,450. Fortunately Indian soils are naturally rich in potassium and there is a potash mobilizing bacterium to mobilize this native potassium so that the plant can absorb the nutrient and the readily available potassium in soil solution is just 2 per cent out of the total, the rest is locked up in soil minerals. Thus it is not readily available for the plant to absorb. The part which gets fixed in the clay minerals can be mobilized by the use of potash mobilizing bacterium.

Table 6 represents the difference in income obtained after including various sustainable practices of the farmers.

Table-5
Annual income of the farmer

Sl. No.	Enterprise	Yield	Rate (Rs./unit)	Expediture (Rs.)	Profit (Rs.)
1	Vermicompost	400qt	300/qt	1500	1,18,500
2	Rose	6 dz/bloom	60/dozen	250/month	1,100
3	Citrus saplings	500 grafts	20/graft	750	2,500
4	Coconut	250 nuts	20/nut	00	50,000
5	Drumstick	2 qt	2/stick	500	12,000
6	Honey	15kg	70/250gm	1000	2,800
7	Coccinia	100kg	12/kg	00	2,500
8	Papaya	300kg	25/kg	1000	6,000
9	Mango	Variable	200/dozen	00	4,000
10	Azolla	Variable	70/250gm	00	3,500
11	Earthworms	Variable	200/kg	00	25,000
12	Horse gram	3qt	25/kg	1000	6,000
13	Maize	4qt	2000/qt	3000	8,000
14	Fishery	Under obs.	Under obs	Under obs.	Under obs.
	Total profit				2,41,900

(Vermicompost yield - 350 - 450 kg vermicompost from 1.5 tons fresh herbs/pits in 100 days). His annual income ranges from Rs. 2, 00,000 to 2, 50,000 lakhs.

Table-6
Difference in income obtained after including various sustainable practices

Sl. No.	Practice Adopted	Cost of Cultivation (Rs.)	Income (Rs.)	Income Increased (Rs.)
1	Paddy SRI method + INM	37,500/ha	1,56,128/ha	1,18,628/ha
2	Coccinia trailing thatch	45,000/acre	11,25,000/acre	67,500/acre
3	Integrated Farming (fish + poultry + cow + agriculture + trees)	15,000 +10,000 +20,000 + 6,000	30,000 + 25,000 + 50,000 + 25,000	15,000 + 15,000 + 30,000 + 19,000
4	Paddy + green manure	11,500/acre	48,240/acre	36,740/acre

Conclusion

The desire for gaining an ecosystem where in all are engaged in sustainable agriculture is universal, yet agreement on how to progress towards this situation remains elusive. The urge for greater yields has landed farmers on a technologic treadmill of investing huge amount of inputs and decreasing profit margins. We should not forget the goal of the sustainable agriculture movement which is to create farming systems that mitigate or remove environmental harms associated with industrial agriculture. Sustainable agriculture leads to sustainable development. It recognizes that natural resources are finite. It acknowledges the limits on economic growth and it also encourages equity in resource allocation. Sustainable agriculture finally gives due consideration to long-term interests (e.g., biodiversity, preserving topsoil, and rural communities) rather than short-term interests such as profit only. Sustainable agriculture is also place specific. For example, a farming system that is sustainable in a high-rainfall area may not be sustainable in an arid and dry climate. Sustainable agriculture is always dynamic. It must evolve to respond to changes in its physical environment or its social context or economic context. Sustainable agriculture is holistic as takes a system-wide approach just to solve the farm management problems. It places farming within a social context and in general within the context of the entire food system. Sustainable agriculture is not just a package of prescribed methods. More important, it is a change in mindset whereby agriculture acknowledges its dependence on a finite natural resource base—including the finite quality of fossil fuel energy that is now a critical component of conventional farming systems. It also recognizes that farm management problems (weeds, insects, etc.) cannot be dealt with in isolation and hence, must be seen as part of a whole ecosystem whose balance must be maintained. It is true as according to Mandipa Roy et al in their work Pseudomonads: Potential Biocontrol agents of Rice Diseases those pseudomonads can control rice diseases[1].

Community landshaping is truly a good technique to increase production in case of individually owned plots. Shaping a larger area of land has to be done. Patience and a long-term view will be needed to adapt this approach successfully in order to get sustainability.

Large-scale conversion to organic agriculture would give rise to food shortage. But a balance of organic and inorganic farming can lead to sustainability. Organic manure is a renewable source of nutrient supply. A combination of lower input costs and favourable price premiums can successfully offset reduced yields and make the balanced farming practice more profitable. In this plan, pest and disease management is largely preventive than reactive.

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