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HANDBOOK ON AGROECOLOGY : FARMER'S MANUAL ON SUSTAINABLE PRACTICES

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HANDBOOK ON AGROECOLOGY : FARMER'S MANUAL ON SUSTAINABLE PRACTICES

FOCUS ON THE GLOBAL SOUTH

Handbook on Agroecology : Farmer's Manual on Sustainable Practices

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Content

Foreword

Agriculture has not just been a mere profession but a way of life in India. It is also the base for all other cultural forms. All the festivals in India, the system of food and folk art forms are based on agriculture. Agriculture was practiced by keeping a harmonious relationship with nature. The earth has always been our mother. She is worshipped before the first plow and after harvest. It is a beautiful relationship our ancestors felt with the sun, the moon, the earth and nature because of which they survived.

However, the green revolution technology introduced in the 1960's changed the whole scenario. Farmers were taught to look at mother earth from the perspective of yield and profit. She was reduced from a mother to just a means of production. Now, after fifty years of implementation of the Green Revolution, the most fertile land in India has become totally unproductive. Corporate controlled model of production has converted food into poison, destroyed soil fertility, contaminated water and resulted in destruction of forests. Commodification of natural resources and the rising cost of production without much return have not only driven hundreds of thousands of farmers out of agriculture, but also left them without any option other than committing suicide.

The crisis in agriculture has caused many international institutions, universities, governments and research centers, some NGOs, and others, to finally recognize 'agroecology' as a way forward.

Agroecology is nothing new. It has been practiced for centuries not just as a system of production but as a way of life. Understanding agroecology begins from understanding the ecosystem around, listening to her, learning from her and building a bond with her. To recognize that human beings are a part of the nature and the universe, hence it is vital to protect the equilibrium between nature, the universe and human beings. To create a harmonious relationship with mother earth and respecting traditional knowledge systems, which has passed the test of times, is agroecology. So, it is not a mere set of practices that ensure production but a system that respects nature and learns from it.

Agroecology is not only philosophical but also a political articulation. Agroecology has the strength to reconstruct all that has been devastated by the so-called Green Revolution and the industrial food production model.Agroecology drastically reduces use of externally purchased inputs that are bought from industry. There is no use of agrotoxics, artificial hormones,

genetically modified organisms (GMOs) or other dangerous new technologies in agroecology.Agroecology is a key form of resistance to an economic system that puts profit before nature and life.

Agroecology is the only way of achieving swaraj or self-rule by the peasantry. When we don't bring anything from outside and produce the necessary biofertilizer or bio pesticide with what is available in the nature for free, the idea of a market economy or consumerism of the producers will get dismantled. It is also a way of bringing back the culture of cooperation and wipe away the culture of competition in villages, making them a place of love, affection and peace.

Agroecology has the strength to invite youth, who have lost hope in agriculture and left their villages. It can create a dynamic space where the rural youth can rebuild this lost hope for the future and re-establish dignity of their villages.

2015 is the UN Year of Soil. It is also a year where farmer's suicide in India has considerably risen. It is the need of the hour to clarify our path that we all want to take from now on. Agroecology is the only way forward, not only for the producers but also for the consumers as well as the environment. I would like to congratulate Focus on the Global South for all the hard work put behind this booklet and the series and I wish that it will reach many people and that it plays a vital role in waking people up from their slumber.

Chukki Nanjundaswamy
Working President KRRS and Green Brigade
Managing Trustee, Amrita Bhoomi- La Via Campesina School of Agroecology-South Asia
Chamarajanagar District, Karnataka

Introduction

This Handbook on Agroecology: Farmers' Manual on Sustainable Practices is third in the series of booklets on Agroecology for small and marginal farmers, brought out by the Focus on the Global South in partnership with the Rosa Luxemberg Stiftung (RLS), South Asia.

The idea to bring out this booklet was conceived at a farmers' workshop on Small Farmer Agriculture: Vitality, Viability and Possibilities organised by Focus on the Global South & Rosa Luxemberg Stiftung on 22-23 October 2013 in New Delhi where farmers demanded for a manual on agroecological practices. In this booklet we have tried to present the various agroecological practices such as Permaculture, Organic Farming, Natural Farming, Bio-dynamic Agriculture, Zero Budget Natural farming, and Agroforestry etc.

All these diverse agroecological practices are quite prevalent in India and there are organisations who are also working for promotion of one or the other forms of these low cost agricultural practices. Still many small farmers in India are unwilling to suddenly switch over to these sustainable agricultural practices due lack of incentives, low availability of resources, fear of loss of crop, increased initial costs, lack of proper government support etc. Therefore, some efforts are urgently required to educate and inform farmers about the pressing need to change to sustainable and safe food production methods.

This booklet is aimed to educate and inform small farmers about the diverse possibility of sustainable and safe food production methods and its techniques. This handbook is designed as a practical guide to understand various practices of agroecology and their specific principles, techniques and strategies. We hope that these techniques would help address the needs of small and marginal farmers who are contemplating to switch over to low-cost agriculture. We also hope that the sustainable agricultural practices mentioned here can easily be adapted by small farmers without involving much input costs. However the set of practices mentioned here is not the only valid roadmap available for adopting low-cost organic agriculture. A skillful agroecology practitioner can come up his/her own innovative techniques by applying different agroecological principles to suite particular crops, soil conditions and available natural resources.

Soil erosion, water scarcity and a polluted environment are some of the crucial issues that small farmers confront on a day-to-day basis. This booklet aims to help farmers understand the need to reduce soil erosion, water conservation and environment protection by adopting these

agroecological practices, while fully utilizing the meager resources available to a small farmer in his immediate environment.

The diverse agroecological practices described in this booklet are further explained with easy to-do steps for follow-up action. The handbook presents several options and approaches for different types of crops production, water management, soil protection, crop protection and organic pest management techniques and so on. The farmers can choose crops and vegetables that suit local climatic conditions and soil types.

This handbook is not a comprehensive book on agroecological practices but has widely used the resources that are already available and acknowledge their role in spreading knowledge about agroecological farming practices. Hope this booklet would help small farmers to understand agroecological practices better.

With this booklet, we also hope that those small and marginal farmers who we will be able to reach out to, could embrace agroecology by adopting any of these methods explained here and bring about an alternative to chemical, fertilizer and pesticide based agriculture they are engaged in at present.

This is a small attempt by us to strengthen the agroecology movement in India.

Afsar Jafri
Co-ordinator, Focus on the Global South
New Delhi

The Indian Agricultural Scene

"Can mankind regulate its affairs so that its chief possession - the fertility of the soil - is preserved? On the answer to this question the future of civilization lies."

-Sir Albert Howard, pioneer of the organic method

Traditional Knowledge-System of Agriculture

Agricultural history of India goes back several thousand years. Farming communities in this vast country of varied landscapes and climates have survived for generations with the support of the natural resources that the earth has provided. Subsistence farming, which aims to sustain livelihoods and protect soil and environment, has been the primary form of traditional agriculture practiced throughout the country. Some of the important types of subsistence farming include dry land farming, wetland cultivation and jhoom cultivation (also called "slash and burn"). In this historical process, farming communities also evolved knowledgesystems through their collective experiences. These knowledgesystems, accumulated and refined over centuries, have been handed down from one generation to the other, mainly through oral traditions. Farmers in India have thus created and nourished an enduring relationship with land, water, streams, forests, rivers and mountains that forms the core of their culture and heritage. These indigenous or traditional knowledgesystems have been a vital force for sustainable living and protection and maintenance of natural resources across the country

Figure1– A farmer ploughing field with a pair of bullocks. Source : http://upload.wikimedia.org/wikipedia/commons/a/a0/Ploughing_with_cattle_in_West_Bengal.jpg

Challenges to Traditional Knowledge Systems

Since the mid-20th century, these traditional knowledgesystems have been pushed aside due to the introduction of scientific approaches to problem solving. In India, agriculture and farming, too, have experienced the sidelining of traditional farming techniques in favor of synthetic, chemical and fertilizer based farming systems, especially with the arrival of the Green Revolution.

Impacts of the Green Revolution

"Green Revolution" refers to the widespread movement of renovation in the field of agricultural practices that first began in Mexico in the 1940s. Research by the American scientist Norman Borlaug – called "the father of the Green Revolution" –led to the creation of high-yield varieties of wheat that produced bumper crops and led to a food surplus in Mexico. By the 1950s and 60s, the technologies of the Green Revolution were adopted by the United States and much of the rest of the world.

The Green Revolution was introduced throughout India with the aim of attaining self-sufficiency in food production to meet the fast-rising demand for food in the world's second most populous country. The Green Revolution appeared successful in its initial years, with bumper crops year after year, creating a food surplus. But after the initial success of high-yield crops, the realities began to emerge, with severe impacts on environment, health, and traditional agricultural practices.

The indiscriminate use of chemical fertilizers, hybrid seeds and pesticides resulted in numerous environmental and health hazards, coupled with socio-economic problems. Farmers and consumers were unable to tackle the environmental hazards and keep up with the high input costs.

Figure 2. Green Revolution–Introduced heavily mechanized agriculture in India. Source: The Green Revolution, O Ecotextiles, online at: https://oecotextiles.wordpress.com/category/green-revolution/. Photo retrieved from: https://oecotextiles.files.wordpress.com/2011/06/triop8190013_jpg.jpg

The excessive use of chemicals wore down the natural resilience of crops to pests and insects. Over time, pests developed more resistance, which compelled farmers to buy more expensive and stronger pesticides and weed killers to control the menace. The high cost of these items made farming highly unviable. The cost of production rose sharply, while yields began to decline year after year. The Green Revolution proved to be a paradox, as many small and marginal farmers chose to leave agriculture to become agricultural laborers or daily wageworkers. Rural to urban migration has become widespread, as the government has closed its eyes to the plight of subsistence farmers.

Is There a Way Out?

Sir Albert Howard commented on the problems of industrial agriculture in the West in his book, Agriculture Testament, in 1943: "These mushroom ideas of agriculture are failing; mother earth deprived of her manorial rights is in revolt; the land is going on strike; the fertility of the

soil is declining…the soil is no longer able to stand the strain. Soil fertility is rapidly diminishing…the loss of fertility all over the world is indicated by the growing menace of soil erosion…diseases are on the increase…the diseases of crops and animals which feed on them."[1]

Howard's observations about the drawbacks of Western industrial agricultural practices are proving true for the post-Green Revolution scenario in India, which we are witnessing now. The aftermath of Green Revolution tragedies has now become an enduring agrarian crisis. One of its manifestations is large-scale suicide by rural farmers in India, approximately 300,000 since 1997.

In this scenario, we need to follow what Sir Albert Howard did. He was sent to India as a botanist in 1905 by the British Empire to transform Indian agriculture into an industrial system with chemical farming. But when he saw the rich and bio-diverse agriculture system, free from pests of all kinds, he became a fan of Indian farmers and decided to simply observe the practices of peasants and absorb their traditional knowledge. He saw Indian peasants as his professors of agriculture. Today, Sir Howard is known as the founder of modern organic farming and composting for his refinement of the traditional Indian composting system into what is now known as the "Indore method."[2] For Sir Albert Howard, a healthy agriculture system should have no pests. It will have insects, but because of the balance, no one insect will become a pest, just as no one organism will become a disease. Today's industrial agriculture is based on producing poisons; it's not the science of ecology of pest control. We need to make our soil poison free to make it fertile and rich in nutrients.

Fertile soil is the primary source of human life. Without fertile soil, we would not be able to cultivate food or survive. When we destroy fertile soil, we destroy our future. How can we stop destroying the soil, and at the same time ensure that we continue to produce food?

The answer is sustainable agriculture, which promotes balance in the relationship between farming, the environment and fertility of the soil. It is a holistic approach that does not depend on chemicals and fossil fuel-based energy inputs. Sustainable agriculture helps farmers to conserve resources, adapt crop management, and enable high level of productivity that is economical, environmentally sound and socially just.

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[1]Howard, Albert. An Agricultural Testament, Oxford University Press, Inc., New York & London, 1943. Retrieved from http://www.zetatalk3.com/docs/Agriculture/An_Agricultural_Testament_1943.pdf

[2]Albert Howard, The Waste Products of Agriculture, 1931.Online at: http://gutenberg.net.au/ebooks02/0200321.txt

Agroecology

In 2013, the Food and Agricultural Organization (FAO) in one of its reports showed that over 842 million people (approximately 14 percent of the world's total population) are chronically malnourished.[3] The report subtly points at the inability of our governments and the corporate controlled, industrialized global agriculture businesses to feed the entire population of the world. The report indirectly warns us that the farming system practiced throughout the world is adversely impacting the health of the people and the planet. Therefore, an alternative mechanism should be evolved to protect farmers, consumers and our delicate Mother Earth.

Recently, the United Nations (UN) declared 2014 as the International Year of Family Farming. The UN exhorts the global community of small, marginalized and subsistence farmers to celebrate farming.

How can this be possible?

Farmers are already burdened by the excessive input costs and ever-declining yields, and are confronted by the impacts of climate change. The UN's proposition can only be fulfilled if the global community of small and subsistence farmers willingly move away from chemical fertilizer and pesticide based farming, and adopt more ecologically sustainable farming methods. In India, this can be highly possible through the efficient use of abundant local knowledge, and sustainable and innovative farming methods that are practiced even today in many parts of the country. Several small and marginal farmers in India can and are improving yields to create a more nutrient-dense and diverse food system while retaining soil quality and its nutrients. Going back to a bio-diverse and sustainable form of agriculture which is now commonly referred as agroecological agriculture (or Agroecology) can arrest the rural to urban migration, create more jobs at the village level; improve rural economy; and also revitalize local small markets and the agriculture sector.

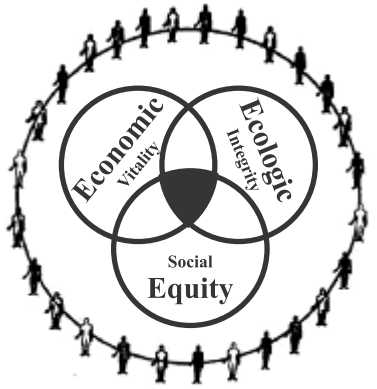

Figure 3 – Agroecology-Science for Sustainable Agriculture. Retrieved from: http://johngerber.world.edu/2011/09/21/agroecology-science-sustainable-agriculture/. Photo courtesy: http://world.edu/wp-content/uploads/2011/09/threeEs.jpg

[3]"The State of Food Insecurity in the World 2013.The multiple dimensions of food security"Agriculture Organization of The United Nations, Rome, FAO, IFAD and WFP, 2013. Retrieved from: http://www.fao.org/docrep/018/i3434e/i3434e.pdf

What is Agroecology?

Agroecology (agricultural ecology) is the study of living organisms and their inter-relations in the context of agriculture and land use. It is the scientific base for sustainable agriculture and applies ecological concepts and principles to the design and management of sustainable agro-ecosystems.[4]

Why is Agroecology important for India?

Agriculture sector in India is beset with all kinds of issues ranging from declining output, unaffordable input costs, very low subsidies for small farmers, lack of proper procurement mechanism by government and low prices for agricultural products at the peak of harvesting season that result in farmers suicides and so on.

According to Olivier De Schutter, former UN Special Rapporteur on the Right to Food, "Agriculture must be redirected to environmentally sound, socially just production methods to address the food and energy crises, hunger, poverty and climate change."[5] He states that agroecology could improve incomes and livelihoods for millions of poor farmers around the world and at the same time provide food security to everyone.

In response to social and environmental problems caused by the global industrial agricultural and food production system, agroecology has become the foundation of both a set of land management practices and a vibrant social movement. With climate change-related disasters occurring frequently around the world, it is vital for small farmers to transition immediately to agroecology, especially in India, where agriculture is in the hands of millions of small farmers.

Main features of Agroecology

Agroecology as a sustainable agricultural ecological model has three features:[6]

1. It is a scientific discipline involving the holistic study of agro-ecosystems, including human and environmental elements.
2. It is a set of principles and practices used to enhance the resilience and the ecological, socio-economic and cultural sustainability of farming systems.
3. It is a movement seeking a new way of considering agriculture and its relationship to society.

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[4]Altieri,Miguel A.Agroecology: principles and strategies for designing sustainable farming systems, University of California, Berkeley. Retrieved from: http://nature.berkeley.edu/~miguel-alt/principles_and_strategies.html

[5]Schutter,Olivier De. "Eco-farming addresses hunger, poverty and climate change," LEISA India, Volume 16,No. 2, June 2014. Retrieved from Agricultures, online at: http://www.agriculturesnetwork.org/magazines/india/breaking-poverty/eco-farming

[6]"Principles of Agroecology and Sustainability," in Agroecology, retrieved from: http://www.agroecology.org/Principles_List.html

Agroecology can mitigate many major problems in agriculture today, especially the challenge of providing safe and nutritious food for everyone. It can also help the country achieve food security, food safety and environmental protection.

Agroecology is based on five principles:[7]

1) It enhances the recycling of biomass and optimizes and balances nutrient flow. On an agricultural farm, a huge amount of biomass is produced year after year (cow dung, wheat and paddy hay, corn husk etc.). Farmers recycle this biomass to enhance the nutrient levels in the soil. Agroecological practices enable a farmer to maximize the use of biomass available to him or her from all available sources (mostly from within the farm) to increase productivity.

2) It enhances soil biotic activity by managing organic matter. Organic matter assists favorable soil conditions for better plant growth. Organic matter (both plant and animal residues), when decomposed, creates positive effects on soil properties and improves soil quality.

3) It minimizes losses through microclimate, soil and water management. Microclimatic conditions depend on several factors such as temperature, humidity, wind, turbulence, dew, frost, heat, balance, and evaporation. The effect of soil type on microclimates is considerable. Agroecological practices help to minimize losses due to excess sunlight, heat, air and water. This is done through microclimate management, water harvesting and soil management through increased soil cover.

   Another benefit of microclimate management is that it allows the soil to absorb and retain moisture, depending on the composition of the soil and its use. Vegetation is also an integral part of soil and water management, as it controls the evaporation of water into the air through transpiration.

4) It enhances species and genetic diversification. Selective breeding of plants leads to monocultures of genetically identical plants, which makes crops extremely susceptible to widespread diseases. In contrast, species and genetic diversity helps plants adapt to changing environments.

5) It enhances beneficial biological interactions among organisms. An organism's interactions with its environment are fundamental to its survival and to the functioning of the ecosystem as a whole. Biological interactions are the effects organisms in a community

[7]Varghese, Shiney & Karen Hansen-Kuhn, "Scaling Up Agroecology: Toward the Realization of the Right to Food," Institute for Agriculture and Trade Policy(IATP), Minnesota, USA. Retrieved from: http://www.iatp.org

have on one another. In the natural world, no organism exists in isolation, and thus every organism is connected to the environment and to other organisms.

In contrast to conventional agriculture, agroecology aims to maintain ecosystem processes so that they perform the chief functions needed to grow crops, rather than forcing them through external inputs such as chemical fertilizers or pesticides. Agroecology does this through managing a series of biophysical properties and characteristics through soil processes, nutrient sourcing, and the conservation of water and soil. Agroecology – the effort to mimic ecological processes in agriculture – could provide a framework for this reinvestment. Already, agroecological practices are being used around the world, increasing productivity and improving efficiency in the use of water, soil, and sunlight.

The following chapters in this booklet will explain various agroecological practices such as permaculture, organic farming, natural farming, bio-dynamic agriculture, and agro-forestry. Small and marginal farmers in India– who form the majority of farmers – could embrace agroecology using these methods and bring about an alternative to chemical, fertilizer and pesticide-based agriculture. By adopting agroecology, they can improve yields, conserve resources, and ensure adequate safe food for the vast population of India. The graph given below explains how agroecology can bring about a holistic change in our lives.

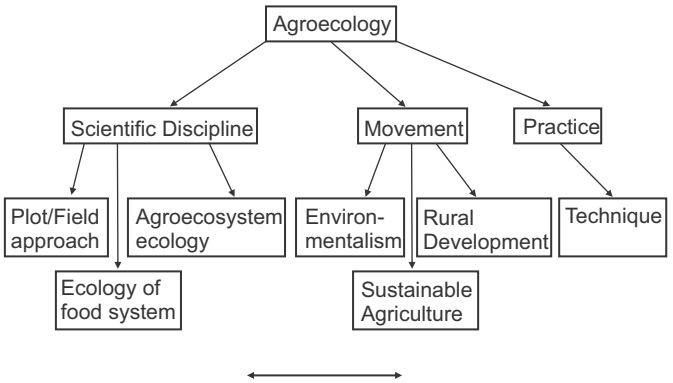

Figure 4 - Agroecology as a science, a movement and a practice. A review. Retrieved from Agronomy – Online at: http://www.agronomy-journal.org/articles/agro/full_html/2009/04/a8122/F1.html. Diagram retrieved from: http://www.agronomy-journal.org/articles/agro/full_html/2009/04/a8122/a8122-fig1.jpg

Sustainable Farming vs. Industrial Farming

During the 1960s, the Green Revolution seemed to be a great success due to successive bumper crops in wheat and rice. However, by the 1980s,its ill effects became visible: a large number of cancer cases caused by overexposure to fertilizers and pesticides were reported, and groundwater was depleted at an alarming rate due to excessive extraction, which became a serious issue that needed urgent attention. Farming in India began to suffer due to soil erosion and salination because of heavy use of chemical fertilizers and pesticides. Persistent poverty and debt among small and marginal farmers became common in several parts of the country. The rate of suicides among farmers shot up in several states. Apart from these maladies, the excessive use of pesticides and chemical fertilizers also made several weeds and pests resistant to them, causing severe crop failure.

The Green Revolution introduced large-scale industrial agriculture globally and sidelined small-scale traditional farming. Agriculture and crop cultivation was commercialized, with foreign companies like Monsanto gaining huge profits from agriculture. Indian agriculture, too, was gradually transformed into industrial agriculture, focusing more and more on increasing the output of few select grains like wheat and rice to attain food security. The shift to intensive, chemical-based farming gradually pushed many marginal and subsistence farmers into severe poverty and debt.

Sustainable farming, on the other hand, presents a holistic solution to the problems of ever-growing hunger, malnutrition, unemployment and environmental degradation. Sustainable farming practices could bring about long term solutions to the maladies caused by industrial farming and help bring small and marginal farmers who were forced to abandon their livelihoods back to farming.

In general, sustainable farming relies on resources found and recycled on the farm and based on traditional management practices, rather than on purchased fertilizers and pesticides. This approach can significantly reduce production costs. Moreover, sustainable farming uses a combination of human labor and livestock resources, instead of heavy machinery and costly technologies, making farming more viable for small and marginal farmers.

In this chapter we shall look into the various factors that make sustainable farming excel above industrial farming in terms of costs of production, productivity, farmers' income and price for consumers.[8]

[8] Horrigan, Leo., Robert S. Lawrence, and Polly Walker, "How Sustainable Agriculture Can Address the Environmental and Human Health Harms of Industrial Agriculture," Environmental Health Perspectives, Vol. 110, Number 5, May 2002, pp. 445-456. Online at: https://www.leopold.iastate.edu/sites/default/files/2002-05-sustainable-agriculture.pdf

Cost of Production

Land : Purchasing or leasing land comprises a major chunk of input costs. Land price or rents are fixed as per soil type, and the costs of conventional commodity crops are made less by farming practices. Thus, land prices remain more or less the same in sustainable farming and industrial farming.

Fertilizers : Agroecological farming – or sustainable farming – follows cultivation of legumes among major crops or as part of crop rotation to increase the levels of important nutrients in the soil, such as nitrogen, phosphorus, and potassium (which are called "macronutrients"). Legumes are known to meet the nitrate requirements of soil. Farmers rely on organic manures and composts for further nutrient requirements. This farming practice, hence, eliminates the cost of chemical fertilizers and pesticides. Most Indian farmers practice livestock farming besides crop cultivation, hence organic manure and compost production can be done on site.[9]

Pesticides : Agroecological farmers do not use chemical pesticides on field crops. Instead, they use integrated pest management practices such as trap crops, inter-cropping, multi-cropping, or releasing beneficial organisms or insects into the field to control pests and weeds. Thus, pesticide costs are negligible on sustainable farms.[10]

Seeds : Sustainable farms grow and keep their own seeds for the next crop cycle. Thus the cost of seeds tends to be low, and forms a far lesser percentage of input costs. Compared to this, farmers on industrial farms pay a much higher price, especially for hybrid or genetically modified seeds like Bt. Cotton. And because they can't generate those seeds themselves, farmers on industrial farms have to buy more every year and are perpetually dependent on multinational corporations.[11]

Labor : Sustainable farming requires more human labor than industrial farming practices. Industrial farming uses machines and emphasizes one-time crop cultivation or monocropping, leading to unemployment and seasonal unemployment. Sustainable farming practices, on the other hand, involve multi-cropping and inter-cropping, which produce employment and earning opportunities for small farmers throughout the year.

In India, the agricultural sector provides the largest share of employment opportunities. Industrial agriculture, with its excessive use of machines, negates many of the important roles

[9] Baldwin, Keith R. "Soil Fertility on Organic Farms," Organic Production, Center for Environmental Farming Systems, North Carolina State University United States. Retrieved from: http://www.cefs.ncsu.edu/resources/organicproductionguide/soilfertilityfinaljan09.pdf

[10] Ibid

[11] Shiva, Vandana. Dr. and Kunwar Jalees, "Seeds of Suicide: The Ecological and Human Costs of Seed Monopolies and Globalisation of Agriculture," Navdanya, May 2006. URL: http://www.navdanya.org. Retrieved from: http://www.navdanya.org/ attachments/WTO_and_Globalization2.pdf

of human, especially, many of the key roles played by women such as seed keeping, planting, transplanting of rice saplings, weeding, harvesting, and winnowing.

Sustainable or agroecological farming recognizes the important role of women in agriculture. In industrial agriculture, women's work has often been invisible. Since sustainable agriculture employs more people on farms and reinforces their vital role in farming, sustainable agriculture is better suited to India's employment needs.

Productivity

There is a general assumption that sustainable farming produces lower yields than industrial methods of farming. However, because sustainable farming involves multi-cropping and inter-cropping, it can lead to even bigger yields per hectare over time.

A transition from conventional farming to sustainable farming may reduce the crop productivity in the initial years. This is because chemical fertilizers and pesticides can remain in the soil, and it takes some years for it to recover and be accustomed to non-chemical farming techniques. Also, it may take time for farmers to learn sustainable techniques. But over a period of 3-5 years, the yield from agroecological farming practices tends to be either equal to or greater than the yield under conventional farming methods.

Farmer Income

The initial boom of the Green Revolution produced high yields and profits to the farmers, particularly for farmers with large landholdings in the states of Punjab, Haryana and Andhra Pradesh. But by the 1990s, a considerable slowing was observed in agricultural production, particularly the yields of cereals, sugarcane, jute, cotton, and potato. This decline greatly affected the livelihoods of Indian farmers. Many who could not bear the burden of making ends meet resorted to taking loans and falling into a cycle of debt, which caused a spike in farmer suicides. This dismal situation prompted many farmers to adopt agroecological farming, which is not only cheaper, but also environmentally friendly and more productive than chemical-heavy farming.

S. Ravichandran and his team of researchers conducted a study in the paddy fields of northeastern Tamil Nadu analyzing the economics of bio-inputs in these fields compared to fields that did not adopt bio-inputs. They found that those who adopted bio-inputs had higher net incomes that those who did not; Rs.17,000 compared to Rs.14,000.[12]

[12] Kumar, Praduman., N.P. Singh and V.C. Mathur, "Sustainable Agriculture and Rural Livelihoods: A Synthesis," Agricultural Economics Research Review,Vol. 19 (Conference No.) 2006 pp 1-22., retrieved from: http://ageconsearch.umn.edu/bitstream/57774/2/Synthesis.pdf

A study on the economics of organic farming in the Udham Singh Nagar district of Uttarakhand revealed similar results. Farmers in this district are resource-poor, and hence apply small quantities of fertilizers and pesticides. The yields from organic and non-organic paddy farms were 29 quintals/hectare and 33 quintals/hectare, respectively. Likewise, the yields on organic wheat farms were lower than that of non-organic wheat farms. However, the organic farmers procured higher prices for their produce, and hence raised their relative income. A comparison on the net profitability from organic and non-organic sugarcane fields in Maharashtra revealed that the yields were marginally higher on non-organic fields, while profits were higher for farmers of organic fields.[13]

This demonstrates that organic farming is superior in terms of the economic wellbeing and livelihood security it provides for farmers, and it also provides enormous potential for improving the sustainability of agriculture.

Prices for the Consumers

As mentioned above, farmers fetched a higher price for crops produced agroecologically than those produced through industrial methods. There is a huge demand for agroecologically-produced crops in both urban and rural areas. Therefore, several chemical agribusiness industries, particularly the fertilizer and pesticides companies, see agroecological farming as a threat to their business, and often run dubious campaigns against such practices.

Moreover, consumers are often blind to the additional costs they bear due to environmental and health degradation caused by the consumption of food produced with chemical fertilizers. Overuse of pesticides and fertilizers degrades the fertility of soil. Many of these chemicals are also absorbed by plants and are transmitted to animals, birds, insects and humans. A lot of these fertilizers and pesticides also seep into the groundwater or flow into rivers along with the soil, polluting the sources of drinking water. Increased use of pesticides has also caused mutation among the pests, making them resistant to chemicals. A good example is the use of DDT (DichloroDiphenylTrichloroethane), a non-biodegradable and non-water soluble chlorinated hydrocarbon used as an agricultural insecticide that became ineffective with the appearance of DDT-resistant pests.

Health Costs

Consumers face increased health costs due to the consumption of food produced through industrial farming. Hormone-related ailments are a big concern. Many scientists also attribute the growing cancer epidemic to the use of chemicals in farming.

[13] Singh, Joginder. Dr."Impact Assessment study of Center of Organic Farming I & II, Uttarakhand State," Sir Ratan Tata Trust, December, 2009. Retrieved from: http://www.srtt.org/institutional_grants/pdf/COF.pdf

A first statewide survey conducted in Punjab found that 18 people die of cancer in that state every day. Over the last five years, some 33,318 people have died of cancer. The Malwa belt of Punjab region has the highest incidence of cancer in the country.[14]

While our counterparts in the West have already become victims of obesity, high cholesterol and heart ailments caused by the consumption of industrial fast-food diets, we, too, are quickly moving towards this lifestyle.

Farmers in this scenario face problems, too. Besides suffering from lung ailments due to the inhalation of fumes during the application of pesticides and fertilizers, as consumers, they also suffer from the above-mentioned additional health hazards.

On the surface, it seems that agroecological products are expensive and chemically produced foods are affordable. But summing up the costs a consumer bears in the form of ill health makes the organic products more affordable in the long term.

Table – 1 Sustainable farming vs. Industrial farming

	Sustainable Farming	Industrial Farming
Cost of Production:	Overall low	Overall high
1. Land	More or less equal	More or less equal
2. Fertilizers	No use of fertilizers	Use of harmful chemical fertilizers
3. Pesticides	Minimal or no use of pesticides	Use of chemical pesticides
4. Seeds	Marginally expensive, but forms a minor portion of the total cost of production	Relatively cheaper
5. Labor	High requirement of labor	Mechanized farming, hence, labor requirement is low
Productivity	Relatively high or equal over a period of time	Declines over a period of time
Income to the Farmers	Lesser cost of production, therefore, net income relatively higher	High cost of production and lesser income generation
Prices for the Consumers	Tends to be relatively expensive	Cheaper, but associated health problems and environmental degradation can raise the overall cost of living

[14] "18 die of cancer in Punjab everyday." Tribune News Service, 28 January, 2013. Retrieved from Indian Agrarian Crisis, online at: http://agrariancrisis.in/2013/01/31/18-die-of-cancer-in-punjab-everyday/

Different Agroecological Practices

Over the last two decades a new system of agriculture known as agroecology has gained the confidence of small and marginal farmers in several countries. Agroecology (agricultural ecology) consists of a wide set of agricultural practices including permaculture, agro-forestry, organic farming, biodynamic farming, ecological farming, organic manure, green manure, intercropping, biological pest control, and more. Some of the major agroecological practices gaining popularity in India will be discussed in the following sub-sections.

Permaculture

A holistic method of agriculture developed by Bill Mollison and David Holmgren, permaculture enables small farmers to make a decent living without degrading or destroying their land. This method helps them carefully manage water and soil, creating an ecosystem that supports human beings and protects the environment. This method is based on the philosophy of cooperating with nature, and not confronting it. Permaculture has now evolved into a great movement of individuals and groups in several rich and poor countries. Permaculture can be described as an "integrated, evolving system of perennial or self-perpetuating plant and animal species useful to man."[15]

Permaculture seeks to mimic nature to meet critical human needs in a sustainable, regenerative and restorative way. It is based on the idea that our planet has finite resources and there should be limits on human consumption and industrial growth.

Principles of Permaculture

The foundation of permaculture lies in its emphasis on adhering to ethical principles. The three ethical principles of permaculture are :[16]

1. Care for the earth
2. Care for people
3. Return of surplus to earth and people (also called "fair share")

Since permaculture is basically a design system for long-term planning, the following principles need to be followed while setting up a permaculture farm.[17]

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[15] Mollison, Bill. Holmgren, David. " The Origin of Permaculture," Holmgren Design: Permaculture vision and innovation, retrieved from http://holmgren.com.au/about-permaculture/

[16] "Pemaculture Ethics," Deep Green Permaculture, retrieved from: http://deepgreenpermaculture.com/permaculture/permaculture-ethics/

[17] ibid

I. Relative location: Every component (element) in permaculture design is placed in relationship and connection to others to achieve mutual benefits.

II. Multiple functions: It follows the principal that "each element performs many functions." For an efficient permaculture practice, every element in the design should be placed in such a way that it serves as many functions as possible. This requires a thorough knowledge of each element in the design.

III. Each important function is supported by many elements: This principle calls for identifying the functions of each element (such as water, food, energy, fire protection) and ensuring that these critical functions are supported in two or more ways.

IV. Zones and sectors: For efficient energy planning, the permaculture farm needs to have zones and sectors to make most effective use of energy. Thus, trees, plants, structures and buildings are planned so that they effectively use energy such as sunlight, wind, water resources etc.

V. Use of biological resources: Biological resources are efficiently used to do work and conserve energy. Instead of using non-renewable energy sources such as diesel, petrol, or coal, permaculture design effectively uses plants and animals to perform most functions.

VI. Energy cycling: This principle is related to recycling energy by capturing, storing and using energy on site. Solar energy sources and other renewable energy sources are put to maximum use.

VII. Small-scale intensive systems: Permaculture systems are designed for small-scale operations so that they can be easily and efficiently managed.

VIII. Accelerating succession and evolution: This uses and accelerates natural plant succession to establish favorable sites and soils, allowing nature to play its role in protecting the soil by growing plants that help to rebuild the soil naturally.

IX. Diversity: Permaculture is a poly-culture, and supports diversity of beneficial species for a productive and interactive system. By raising more than one species of plant or animal at a time, it allows the culture of multi-cropping and crop rotation and thus provides greater diversity.

X. Edge effect: The principle of edge effect allows the use of edge and natural patterns for best effect. It adopts the natural patterns found in nature for better productivity.

XI. Attitudinal principles: This works as a people-centric principle, based on the idea that: a) everything works both ways; and b) permaculture is information- and imagination-

intensive. For example, persistent strong wind might be a disadvantage to a small farmer if it destroys crops. This wind energy could be transformed into an advantage for the farmer by installing a small windmill to capture energy or by planting trees along the wind path and cultivating crops that can grow in the shade.

Case study : Punarvasu Family Farm in South Karnataka[18]

Punarvasu, a five-acre traditional family farm, is located about 15 kilometerssouth of Udipi and 3 kilometers inland from south Karnataka coast. In 2007, the family began to transition the farm to permaculture. The first year, they built a broad-scale water harvesting system and two catchment ponds (one higher up and one mid-farm) and made some gulley plugs to slow down the water flow throughout the site. They also installed a grey-water re-use system (used for dish and clothes washing). During the second year, they installed grey-water re-use systems (one for an indoor sink, another on the bathhouse which feeds a small nursery). Then they prepared holes for a small multi-species cashew orchard (planted during the monsoon) and some cacao plants in the existing coconut and pepper orchard. They also experimented by building a solar dryer and a small poly-house, and started linking banana clumps in the banana orchard with bunding (creating central mulch pits) that were planted with pineapple, sweet potato and papaya. Later, they also installed a biogas plant for cooking. They also designed and converted the cow barn into guest housing, enlarged the main catchment pond, began the creation of a jungle garden, and continued bunding and planting banana circles. Every year, they host hands-on work weeks and trainings as well. They continue to live on the old traditional family farm and consume farm-grown food.

Agro-forestry

Agro-forestry is an approach that increases farm production through land management. This method incorporates trees into the farming system so that the same piece of land is used for trees, crops and livestock. Agro-forestry combines production on the same plot of land from annual agricultural activities (such as crops and pasture) and from delayed long-term production by trees (for example, timber and services). This is done by either planting trees on the agricultural plot or by planting crops in forest areas.

Figure 5 – A Sample of Agro-forestry. Retrieved from: Planet for a Future: http://www.pfaf.org/UserFilesCms/Gua-2004-21.jpg

[18] "Punarvasu Demonstration Site, South Karnataka Coast, India," Itinerant Permaculture. Retrieved from: http://i-permaculture.org/itinerant-permaculture/

Agro-forestry has been practiced for a long time in India. Historically, farmers in many regions have allowed trees to grow amidst agricultural farms. Various forms of agro-forestry are practiced throughout the country, providing fuel and wood for local communities and raw materials for pulp, paper and other wood-based industries. Some of the most prominent agro-forestry systems practiced in India are agri-silviculture and agri-horticulture systems in the Western and Eastern Himalayas, agri-horti-silviculture systems in the upper and trans-Gangetic plains, and agri-silviculture and silvi-pastoral systems in the southern plateau and hilly regions.[19]

According to an estimate by the Forest Survey of India, there are 2.68 billion trees grown in India outside forests that supply around 201 million tons of fuel wood and 64 million cubic meter of timber annually.[20] Several studies have been conducted in India to understand the role of agro-forestry in improving production as well as soil health. Growing trees on farms provides timber, firewood and other products that are useful for farming households. Trees can protect crops by sheltering them from wind. They can modify solar radiation, which reduces water evaporation and helps retain soil moisture. Soil samples collected from lands where agro-forestry is extensively practiced have revealed that the method reduces nitrogen leaching by 50 percent. Similarly, since the roots of trees grow deeper into the soil than those of monoculture crops, they absorb more soil nutrients. When the dead leaves of these trees fall onto the field, they make these nutrients available for the crops.

From the productivity perspective, it has been found that 100 hectares of agro-forestry produces as much crop produce as 140 hectares of farmland, where trees and crops are planted separately. This effect results from the stimulation of complementarity between trees and crops on agro-forestry plots. Thus, weeds that are spontaneously present in young forestry plantations are replaced by harvested crops or pasture, for the maintenance is less costly and environmental resources are better used. With regard to profit, agro-forestry provides equal or greater incomes than monocultures.

Experimental Case Study of Agro-forestry

The National Research Centre for Agro-forestry conducted an experimental study of agro-forestry on farmers' fields in Jhansi in the state of Uttar Pradesh during the period of 2009-10. The main objective of the study was to assess the on-farm potential and preference of bamboo

[19] Rizvi, R. H., Dhyani, S. K. , Yadav, R. S., Singh, Ramesh. "Biomass production and carbon stock of poplar agro-forestry systems in Yamunanagar and Saharanpur districts of northwestern India," National Research Centre for Agro-forestry, Jhansi, Current Science, Vol. 100, No. 5, 10 March 2011, pp. 736-742. Retrieved from: http://www.indiawaterportal.org/sites/indiawaterportal.org/files/Biomass%20Production%20%26%20Carbon%20Stock_Poplar%20Agro-forestry%20Systems_%20Yamunanagar%20and%20Saharanpur_Current%20Science_2011.pdf.

[20] Singh, Vijai Shanker. Pandey, Deep Narayan. "Multifunctional Agro-forestry Systems in India : Science-Based Policy Options," Climate Change and CDM Cell Rajasthan State Pollution Control Board Jaipur, RSPCB Occasional Paper, No. 4/2011, 2011, p.5. Retrieved from: Environment Portal, online at: http://environmentportal.in/files/file/multi_Ag_System.pdf

cultivation in the midst of wheat and pulses. The study reports that farmers had shown keen interest to adopt bamboo in their field boundary under agro-forestry. They planted 85 per hectare of *bambusa vulgaris* (also called golden bamboo or *baans* in Hindi) at Hastinapur village in the field of Shri Harpal Singh Rajpoot. They harvested 282kg. per hectare groundnut during *kharif* (monsoon) season, and 3,756 kg. per hectare of wheat in *rabi* (winter) season. They also planted *dendrocalamus strictus* (Male Bamboo, Solid Bamboo or Calcutta Bamboo, a tropical and subtropical clumping species native to Southeast Asia used for food and paper pulp at village Nayakhera in the field of Shri Shobha Ram Rajpoot(280 over two hectares). During *kharif* season, they harvestedurd (515 kg./hectare), mung (525 kg./hectare), groundnut (550 kg./hectare). In *rabi* season, they harvested wheat *Var Malviya* 234 (3260 kg./hectare). The bamboo plants had no adverse effect on the crops.[21]

Note : Details of agro-forestry can be found in the chapter on "Importance of Trees in Farming."

Forest Gardening

Forest gardening is a low-maintenance sustainable food production system based on combining plants and trees in a natural woodland-like pattern. This agroecological practice is very similar to agro-forestry, and thus reaps similar benefits. It incorporates fruit and nut trees, shrubs, herbs, vines and perennial vegetables that have yields directly useful to humans.

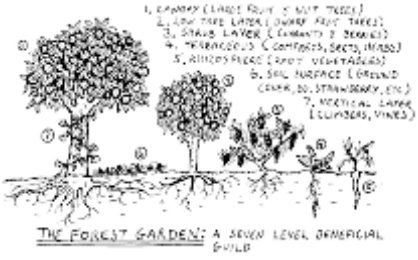

Figure 6 – Seven layers of forest garden. Retrieved from: http://www.lend-a-hand-india.org/Permaculture%20Picture%202%20(400%20x%20251).jpg

Forest gardens or home gardens are more popular in tropical regions. In India, this is practiced extensively in Kerala and the Northeast. A forest garden in Kerala, for instance, will consist of coconut trees, black pepper, cocoa and pineapples.

[21] Dhyani, S.K., Ahlawat, S.P., Palsaniya, D.R. (Eds.), "Development of Bamboo based Agro-forestry Systems for Six Agro-climatic Zones" Eds.) National Research Centre for Agro-forestry, Jhansi (U.P.). Retrieved from the website of National Bamboo Mission, online at: http://nbm.nic.in/Reports/ICAR_Jhansi.pdf

System of Rice Intensification (SRI)

The System of Rice Intensification (SRI) was developed in Madagascar in the 1980s to increase rice yield by using less water than usual, through intensive labor and organic farming. Dr. Norman Uphoff of Cornell International Institute for Food and Agriculture introduced this method to the world in the late 1990s.[22] This method is now widely used by Indian farmers and is also being promoted by government agencies.

SRI is a combination of several practices that includes changes in nursery management, time for transplanting, water and weed management. Specifically, it involves transplanting single young seedlings with wider spacing, carefully and quickly into fields that are not kept continuously flooded, and where soil has more organic matter and is actively aerated.

Figure 7 - A single rice seedling. The SRI method ensures that the rice plants' roots avoid saturation. Young rice seedling with roots, seed and soil mass intact. Retrieved from: http://awsassets.wwfindia.org/img/rice_14_single_plant_161066_32159.jpg

SRI Cultivation Method[23]

While practicing SRI, farmers must take the utmost care in transplanting seedlings from the nursery bed to the field, as seedlings are just 8-15 days old. The nursery bed should be raised in a 40 square meter plot (small beds, each of 1.25 meter x 8 meter in dimension) for an acre of transplantation. This bed is prepared with the application of farmyard manure and soil in four alternating layers :

- 1st layer: 1 inch (2.54 centimeters) thick well decomposed farmyard manure,
- 2nd layer: 1.5 inches (3.75 centimeters) soil,
- 3rd layer: 1 inch (2.54 centimeters) thick well decomposed farmyard manure,
- 4th layer: 2.5 inches (6.3 centimeters) soil.

All these layers should be mixed well to help with the easy penetration of roots. Compost or vermicompost can also be used; it is spread it over all the bed in 3-5 centimeter

[22] "System of Rice Intensification," retrieved from: http://www.sri-india.net/html/aboutsri.html
[23] "System of Rice Intensification," retrieved from: http://www.sri-india.net/html/aboutsri.html

layer. To drain excess water, provide appropriate channels on all sides by making irrigation channels (0.5-1 foot in width). To prevent soil erosion, reinforce the bed on all sides with wooden reapers or planks or paddy straw, etc.

Seed treatment

About 2kg. of seeds are required for each acre of transplantation. Seeds are soaked in a large container of water for 24 hours. Viable seeds sink to the bottom and non-viable seeds float to the surface, and can easily be removed. The treated seeds are then transferred into water-soaked gunny bags and kept in them for 24hours. Once the seeds have sprouted, they are transferred to the nursery bed. Seeds are sown non-densely in a seedbed with good soil structure. Each plant has space to grow, and roots can develop easily and will not get entangled.

Transplanting[24]

Prior to transplantation, the main field should be well puddled and leveled. After leveling the field, a marker can be used to lay out the plot into wider spacing (i.e. 25 centimeter x 25 centimeters row to row and plant to plant). This can also be done with the help of rope by marking.

Rice seedlings 8-12 days old are transplanted as compared to 25-30 days old seedlings in traditional method of rice cultivation. The advantage of early transplantation is that the young rice seedlings with 2-3 leaves have great potential for abundant growth and root development.

Nutrient requirement[25]

Sustainable farming practitioners should only use organic manures or vermicompost for SRI cultivation, as they give better response and improve soil health. Application of farmyard manure or compost (10-12 tons/hectare) before ploughing would provide enough nutrition for the rice plants. Green manures that are 45-60 days old could also be applied to the field for better plant growth.

Note : To manage pest and insects please refer to the chapter on Organic Pesticides

Water requirement[26]

Unlike traditional rice cultivation, SRI method does not require continuous flooding. Initially, water irrigation is done to maintain soil moisture. Water is let in when the surface soil develops hairline cracks. The watering intervals can vary depending on the type of soil and texture; soils with low water-holding capacity require frequent irrigation.

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[24] "System of Rice Intensification (SRI) - Principles and Methods," Directorate of Rice Development, Patna. Retrieved from: http://drd.dacnet.nic.in/Downloads/SRI-Book-Part1.pdf

[25] ibid.

[26] ibid.

Advantages of not flooding the field

As the paddy field is not flooded, the roots of the paddy plants grow healthy, deep and in all directions. Since the rice seedlings are planted with wide spacing, root growth is extensive. The intermittent irrigation method allows microorganisms to grow and thrive in the soil and, in turn, make nutrients available to the plants.

Weeding[27]

At the time of weeding, the field should be irrigated to have 2-3 cm of water. After completion of weeding, the water should not be let out of the field. As there is no standing water in SRI, weeds are more common. For effective weeding and turning the weeds into soil, an implement called "weeder" is used in SRI. The weeder should be used on the 10th and 20th day after transplanting. Further weeding should be done on a 10-15 days interval until crop reaches panicle stage.

In areas where SRI method is practiced, rice production has increased by 25-50 percent, and water use has declined by over 40 percent. Research has verified that SRI crops are more resistant to pests and diseases and have better tolerance to adverse climatic phenomena like drought, storms, hot spells or cold snaps. The length of the crop cycle (time to maturity) is also reduced, with higher yields. The improvement in rice yields is so great that this method is now being promoted in the production of wheat and other cereals, as well.

System of Rice Intensification: Weeding method
http://upload.wikimedia.org/wikipedia/commons/b/b4/Seed_bomb_aka_Seed_ball_(Guerilla_gardening).jpg

[27] Ibid.

Natural Farming

Natural farming is not just a method of agriculture, but also a philosophy and a way of life. It is an environmentally friendly approach to farming that demands respect for all forms of life. Natural farming stresses the importance of non-tillage of land and does not use herbicides, pesticides, chemical fertilizers or any artificial heating. It is a form of agriculture that does not pollute the earth.

Natural farming is a sustainable way of agriculture that relies on inputs from natural materials and observes the laws of nature. It respects all life forms and attempts to heal the soil by elimination it of harmful chemical fertilizers, pesticides and herbicides. It does not depend on machines and expensive petroleum products, but is practiced to make the soil and water bodies clean.

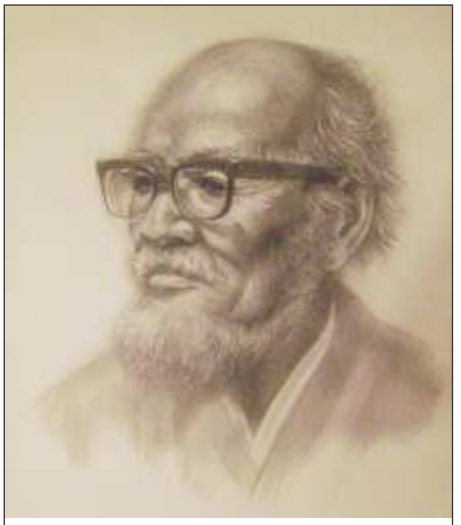

Figure 8 – Masanobu Fukuoka. Picture courtesy: https://lahuellagallery.files.wordpress.com/2013/05/masanobu-fukuoka3.jpg

The motto of natural farming is to "do nothing." Doing nothing should not be interpreted as not doing any work; rather, it means allowing nature to work on its own and avoiding unnecessary human intervention. The Japanese farmer Masanobu Fukuoka was an important proponent of these no-till, no-herbicide grain cultivation farming methods.

By adopting natural farming practices, small and marginal farmers are not exposed to exploitation by multinational corporations that often overprice their seeds, fertilizers and pesticides. Natural farming, by its simple approach, can drastically cut input costs for the cultivation of crops. By keeping costs to a bare minimum, farmers can ensure a better and more sustainable form of agriculture while earning good profits.

Natural Farming Methods

Fukuoka's Natural farming is based on four major principles:

- No tilling
- No pesticides
- No fertilizers
- No weeding[28]

[28] "Natural Farming Technique of Masanobu Fukuoka," Garden Food.org, retrieved from: http://www.gardenfood.org/2012/10/natural-farming-technique-of-masanobu.html?view=classic

No Tillage: Natural farming does not involving tilling the land, but instead uses earthworms, microorganisms and other small animals which naturally till the earth. It is found that earthworms can dig soil up to a depth of 7 meters. They also fertilize soil with their excreta, which is a better method than tilling the land with machines.

In Fukuoka's opinion, tilling destroys some crucial characteristics of the soil. When a farmer ploughs or tills afield, this alters the water suction ability of the soil, changes its moisture retention capacity, and disrupts the established flow of nutrients. By tilling the land, the flow of oxygen to the soil is accelerated, which causes an imbalance in the natural decomposition process that otherwise takes place in a balanced form. Natural farming without tilling land conforms to a dynamic and more balanced system of food production by using the natural resources of sunlight, water and soil, and effectively using microorganisms that are present in the soil.

No Pesticides: Natural farming abstains from pesticides. Pesticides used in agriculture kill insects and their particles remain in the soil and get into the crops. When eaten by humans, birds and animals they can do serious harm. When pesticides get into the soil, they contaminate groundwater, rivers, lakes and oceans. There are several plants that can effectively tackle pests and harmful insects. Farmers in India are fully aware of the use of bitter plants such as neem seeds, neem leaves, cow dung and other materials that can effectively combat pests and harmful insects.

No Herbicides: Natural farming does not use herbicides. because herbicides kill not only weeds, but also several useful microorganisms that live in the soil. Natural farming, in fact, uses weeds by turning them into useful mulch, which effectively controls weeds without the harmful side effects.

No Chemical Fertilizers: Adding too many fertilizers to plants weakens their natural ability to draw nutrients from the soil. Therefore, natural farming does not use any chemical fertilizers. It acquires nitrogen, phosphorous, potassium, calcium and other elements essential for plant growth from natural sources. Fish amino acid provides nitrogen, eggshells give calcium, and animal bones are a source of phosphoric acid. Natural farming inputs are cheap and highly effective.

No Pollution: Natural farming does not pollute air and water. It does not use any noisy machines. Industrial farming has destroyed our soil and contaminated water sources. By avoiding chemical fertilizers and pesticides, the soil is free from pollution. No air or noise pollution is involved in natural farming.

No Artificial Heating: Natural farming does not use any artificial heating or lighting. Instead, it uses natural sunlight. Farmers can save a lot of money by avoiding the use of fossil fuels and electricity. Natural farming allows nature to do its work with minimum human interference.

Importance of Preserving Seeds

In natural farming and gardening, the traditional practice of preserving seeds is an important aspect of maintaining agricultural crops year after year. Farmers in India have historically saved their seeds for the next cycle of cultivation. Recently, this practice has been reversed as multinational corporations have flooded the market with all kinds of ready-to-sow genetically modified and hybrid seeds.

Fukuoka stressed the need to protect traditional seed varieties to preserve the parental characteristics of the original plant. He revived the ancient technique of keeping seeds in clay balls and popularized it on his farm. Today, the clay seed ball technique is practiced widely.

Clay Seed Balls[29]

Clay seed balls are an ancient technology in which seeds for the next season's crops are mixed together with humus or compost and rolled with clay to form small balls. The balls are then dried in the sun for a few days and kept in a moisture-free area until the next season. Fukuoka popularized this technique on his natural farm. He called them "earth dumplings" *(tsuchidango)*, and they were an important part of his hands-off method of raising crops. Clay seed balls can be effectively used to grow grains without tilling and sowing. Governments can use this method for restoring degraded forests and eroded areas.

Making Clay Seed Balls

The preparation of clay seed balls is very simple. First of all, the seeds that need to be preserved are combined with clay and organic materials like compost, manure etc. A small portion of finely cut straw could also be used to give the seed balls tensile strength. The mixture is moistened and formed into compact lumps or balls, allowed to dry, then cast out into fields at the appropriate time of the year, depending on the seed mixture and the climate and rainfall patterns.

Clay Seed Ball
http://nature1st.net/ync/wp-content/uploads/2014/04/seedbomb.jpg

Ingredients for Clay Seed Balls:

1) 5 parts dry clay
2) 3 parts dried organic compost of any kind and a bit of finely cut hay or straw
3) Seeds

[29] Coyne, Kelly. Knutzen, Erik. "How to Make Seed Balls" in Mother Earth Living, online at: http://www.motherearthliving.com/gardening/how-to-make-seed-balls.aspx#axzz3NCHVXtRV

Method of preparation of seed balls:

1) Mix the clay and compost.
2) Add just enough water to make it like dough.
3) Take enough dirt or clay to make a marble sized ball.
4) Stick seed or seeds in the center and roll the clay around it.
5) Leave to dry for a couple of days.
6) When the season arrives, distribute these balls at the rate of about 10 balls per square yard of ground.

Farmers in India have also been saving their seeds using indigenous techniques. The traditional method of treating seeds with cow dung, cow urine, soil and lime are widely practiced in seed saving methods. Coating seeds with cow dung protects them from various diseases and insects.

Natural Farming Inputs – Nutritive Cycle Theory[30]

Most farmers are misguided by the notion of "more is better"– the more fertilizer, the better the crop. This idea could be fatal both for the farmer, as well as for the crops. The growth of a crop is not determined by the nutritive cycle and large amount of fertilizers. Maximum crop can be harvested when the correct type of nutrients is made available for the crop at the appropriate time. The correct kind of nutrient varies according to the stage of the plant's life cycle.

While some believe that natural farming is outdated, it is in fact a very scientific form of farming that allows nature to work on its own. Nature works precisely under very precise conditions.

Plants undergo several changes in their life cycle (i.e. they grow, flower, fruit and die) that can broadly be divided into two growth stages: vegetative and reproductive. During the vegetative phase, plants turn carbohydrates into organic nitrogen. In the reproductive state, plants store carbohydrates in their fruits and other organs. The Nutritive Cycle Theory enables a farmer to understand the various nutritive needs of the crop. Accordingly, the farmer can provide the appropriate amount of nutrients to the soil. Natural Farming emphasizes the right use of the right material, at the right stage, and in the right quantity.

Natural Inputs

Natural Farming does not require artificial inputs like chemicals, fertilizers, pesticides or hormones, as they can be destructive. Instead, it promotes natural biological activity in the soil and natural protection from diseases.

[30] Kyu, H. Cho. "Nutritive Cycle Theory,"Natural Farming Philosophy. Retrieved from Thai Natural Farming, online at: http://www.thainaturalfarming.com/index.php?lay=show&ac=article&Id=38076

The most important nutrients (like nitrogen, phosphate, potash, iron, sulfur, calcium) are already present in the soil, but may not be readily available to the plant. Natural farming ensures that these nutrients are made available to the plant by creating appropriate conditions in a natural way. For example, microorganisms (bacteria and microbes) and earthworms can be introduced to the soil to begin the natural biotic activity in the soil. Applying composted cow dung or other animal dung can also effectively introduce microorganism into the soil and begin the biotic process.

Indian farmers practicing Natural Farming have improved this technique by using some natural catalytic agents that promote the growth of humus in the soil. For example, jiwamrita (a concoction of water, cow dung, cow urine, jiggery, pulse flour and soil) is a very effective catalytic agent that contains enormous amounts of microorganisms. When applied to the soil, the healing process begins and humus begins to form.

Who Can Benefit from Natural Farming?

Unlike large industrial farming, natural farming is intended mainly for subsistence farmers whose land holdings usually vary from 0.5 to 2 hectares. Most farming communities in India are comprised of small farmers engaged in subsistence farming. The adoption of Natural Farming by millions of subsistence farmers in India can ensure livelihood, safe food and self-reliance for one of the largest farming communities in the world.

A large-scale transition from chemical-based farming to Natural Farming can potentially become a massive farmers' movement to return to nature and switch to sustainable farming systems across the country. Indian small farmers are the main food producers for the second largest population in the world, and they have a say in the way food is produced in this country. If sustained efforts are made to interact with farming communities to encourage them to change to natural farming, it could turn out to be a large farmers' capable of challenging corporate control over agriculture.

Lastly, Natural Farming could be a rehabilitation strategy for the government to arrest the massive tide rural-to-urban urban migration that is happening in the country now. Natural Farming practices can give farmers their dignity, pride, self-respect and self-confidence in their own knowledge and capabilities in making small-scale agriculture a viable activity and an enduring way of life.

Multiple Cropping Systems

Numerous agricultural practices are employed throughout the world due to the differences in climate and soil, varying landscapes, weather patterns and different availability of resources. Traditional farming methods combined with indigenous knowledge and limited resources are gaining popularity all over the world due to their ability to maintain biological diversity and soil nutrients without harming nature and human beings.

Multiple cropping, which is a traditional, intensive farming method, is finding wide acceptance in developing countries and is also being tried in developed nations. In India, farmers have been growing mixtures of legumes and non-legumes for several generations. Farmers in China, Indonesia, Philippines, and many countries in Africa have also followed similar practices. In all these countries, land scarcity and the huge demand for food have led farmers to adapting new ways to increase agricultural productivity through different multi-cropping practices.

The main objective of this chapter is to help farmers with small landholdings to adapt multi-cropping patterns so that they can increase agricultural productivity and, in turn, ensure better food security and higher income.

What is Multiple Cropping?

Multiple cropping is defined as growing more than one crop on the same piece of land during one calendar year. This age-old practice has been in use in regions where more rainfall, higher temperatures and longer growing seasons favor continuous crop cultivation. Multiple cropping can be done for annual food crops, fodders, vegetables, fruit plants and perennial crops.[31]

This practice ensures continuous food supply for farmers while maintaining ecological sustainability. It also ensures better food security, takes care of the nutritional needs ofpoor farmers, and at the same time helps farmers use their land more productively.

Crops are prone to insect attacks, which may cause losses and reduction in crop yield. Multiple cropping minimizes incidents of crop failure owing to biotic agents such as pests. One crop may provide cover to another against such agents through biological control. For example, canola *(rai)* is intercropped with wheat to shift aphid from wheat to canola, and okra *(bhindi)* intercropped with cotton diverts insect pests towards the latter.

[31] Gliessman, R. Stephen. Dr. "Multiple cropping Systems: a Basis for Developing an Alternative Agriculture," Environmental Studies, University of California. Retrieved from Princeton University Library archive. Online at :www.princeton.edu/~ota/disk2/1985/8512/851207.PDF

Reasons for Adopting Multiple Cropping[32]

- Population growth leads to an increased demand for food, and the shortage of cultivable land for subsistence farming forces farmers to seek new ways to increase agricultural productivity to meet this demand.
- The introduction of the Green Revolution caused a dramatic decline in traditional farming methods. Poor farmers, lured by the dream of very high output, readily abandoned traditional methods and embraced industrial monoculture farming.
- Dependence on technology and industrial farming introduced during the Green Revolution had severe impacts on human health and environment.
- Propagation of genetically modified crops also brought woes for poor farmers. In the cotton-growing belt of Maharashtra, the number of farmers committing suicide has gone up considerably during the last several decades. There have been immense oppositions and movements against the propagation of genetically modified seeds in India.
- Plants have varied habits and different nutritional requirements. Plants also absorb solar energy in different patterns. While some plants need little sunlight, others fully enjoy the daylong sunlight. It is found that maximum utilization of sunlight occurs when plants of different varieties are planted together. A combination of shade and openness helps plants thrive.
- Plants also have different nutrient intakes from soil. Some plants consume a particular nutrient in larger quantity, leaving other nutrients untouched in the soil. Multiple cropping enables better utilization of nutrients and nitrogen from soil. When different crops are grown together, the yield is better. Better and more regular yield for farmers ensures food diversity and food security, and also takes care of nutritional requirements.
- Multiple cropping helps prevent water evaporation by retaining moisture in the soil. Soil protection is higher when plants cover the soil in a better way during the growing season, which also reduces erosion due to rain and wind.
- Multiple cropping systems also allow better pest and insect control and management than mono-cropping.
- Multiple cropping narrows the space available for weeds to grow and hampers their growth through exudation of allelochemicals (toxic chemicals produced by a plant to defend it from herbivores or competing plants).[33] Nevertheless, weeds are the hidden

[32] "Benefits of multiple cropping," retrieved from: http://www.dawn.com/news/968385/benefits-of-multiple-cropping

enemy of crops; imparting irreversible damages to resources. The suppression of weeds through multiple cropping thus leads to enhanced food production.

Advantages of Multiple Cropping:[34]

- Better use of land and solar energy.
- Better management of soil nutrients by fully utilizing the varying nutrient needs of different crops.
- Less subject to extreme climatic conditions.
- Saves water evaporation and retains soil moisture.
- Saves soil from erosion through cover crops.
- Improves soil structure and organic content.
- Better weed control and pest control.
- Increases productivity and food security.

Multiple cropping can be divided into three types of cropping patterns that are generally practiced throughout the world:

Intercropping is the practice of growing of two or more crops at the same time with no distinct row arrangement. Small farmers in several states of India practice intercropping to sustain themselves.

Mixed intercropping is the growing of two or more crops without any row or strip arrangement.

Mixed cropping is a feature in which a variety of crops are grown simultaneously or at different times on the same land. Mixed cropping promotes photosynthesis and avoids competition for nutrients, because different plants draw their nutrients from different depths of the soil.[35]

In every season, care should be taken to maintain legume cropping on at least 40 percent of the crop area. Legumes fix atmospheric nitrogen and make it available for companion or succeeding crops. To get maximum benefit from multiple cropping, the entire farm should have at least 8-10 types of crops at all times. In the case of small plots of land, each plot should have at least 2-4 types of crops, of which one should be legume. If only one crop is cultivated on a particular plot, then the adjacent plots should have different crops.[36]

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[33] Retrieved from: http://www.merriam-webster.com/dictionary/allelochemical

[34] Gliessman, R. Stephen. Dr. "Multiple cropping Systems: a Basis for Developing an Alternative Agriculture, " Environmental Studies, University of California. Retrieved from Princeton University Library archive. Online at :https://www.princeton.edu/~ ota/disk2/1985/8512/851207.PDF

[35] "Technical Brochure on Organic Farming System - An Integrated Approach for Adoption," Ministry of Agriculture, New Delhi. Retrieved from: http://www.midh.gov.in/technology/Organic_Management_NHM.pdf

[36] Yadav, A. K. "Organic Agriculture, (Concept, Scenario, Principals and Practices)," National Centre of Organic Farming, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India. Retrieved from: http://ncof.dacnet.nic.in/Training_manuals/Training_manuals_in_English/Organic_Agriculture_in_India.pdf

Even high-nutrient demanding crops like sugarcane can be grown with a suitable combination of various legumes and vegetable crops with optimum productivity. Farmers on mixed cropped farms also generally plant marigold (genda) to take care of pest control.

The following intercropping practices were found to be more profitable than sole crop of groundnut even under drought or excessive rainfall in Andhra Pradesh:[37]

Groundnut + Red gram (pigeon pea)	7:1 ratio
Groundnut + Castor	7:1 ratio
Groundnut + Sorghum	6:2 ratio
Groundnut + Pearl millet	6:2 ratio

(7:1 ratio indicates 7 rows of groundnut and one row of the other crop)

Groundnut + Sorghum inter cropping system is recommended for farmers to meet the fodder needs of cattle and milching animals.[38]

Another set of crop combinations that are widely practiced by farmers in several states are as follows :

State	Crop combination
Maharashtra	Groundnut + Red gram (6:1/4:1)
	Groundnut + Soybean (6:2)
	Groundnut + Sunflower (6:2/3:1)
Gujarat	Groundnut + Castor (9:2/3:1)
	Groundnut + Sunflower (3:1/2:1)
Tamil Nadu	Groundnut + Bengal gram (4:1)
	Groundnut + Pearl millet (4:1)
	Groundnut + Green gram (2:1)
Karnataka	Groundnut + Chili (2:2)
	Groundnut + Sunflower (3:1)
	Groundnut + Red gram (4:1)

[37] "Groundnut Production Practices new - Intercropping and Mixed cropping practices," Intercropping Cropping system. Retrieved from: http://agropedia.iitk.ac.in/content/groundnut-production-practices-new-intercropping-and-mixed-cropping-practices

[38] Ibid.

Multi-cropping of various other combinations of cereals, pulses and cash crops in several other parts of the country also include:[39]

Jammu Region	:	Rice or wheat and sorghum
Rajasthan	:	Groundnut and wheat
Western part of Haryana	:	Cotton and wheat
Madhya Pradesh	:	Rice and wheat
Saurashtra(Western Gujarat)	:	Cotton and groundnut
Vidarbha region of Maharashtra	:	Cotton and groundnut
South Karnataka	:	Cotton and groundnut
Thanjavur region of Tamil Nadu	:	Rice and blackgram/Sesame or rice/groundnut

Several other combinations of cereals or pulses and legumes are also practiced throughout the country, depending on climatic and soil conditions.

Relay cropping : Relay intercropping or relay cropping is a system in which a second crop is planted before harvesting the first crop that has flowered or reached maturity. Relay cropping reduces the time overlap of two or more crops. Usually, shade-tolerant varieties of crops are planted in this type of farming. Cassava, cotton sweet potato, lentils and wheat are often planted in this way.[40]

Crop rotation or sequential cropping is another type of practice in which two or more crops are grown one after the other on the same plot of land. Crop rotation prevents pests very effectively, as it takes time for pests to get used to the new plant that is planted. Planting legumes after a non-legume crop significantly helps to fix nitrogen in the soil.[41]

Crop rotation is the backbone of organic farming practices. It is essential to keeping the soil healthy and to allowing the natural microbial systems to work. Crop rotation is the succession of different crops cultivated on the same land. A rotation plan of 3-4 years should be followed. All high-nutrient demanding crops should precede and follow legume-dominated crop combinations. Another method is the rotation of pest host and non-pest-host crops, which helps control soil-borne diseases, pests and weeds. Legumes should be used frequently in rotation with cereal and vegetable crops. Green manure crops should also be included in rotations.

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[39] Pujari, Saritha. "Cropping System in India: Biological Efficiency and Land Use Efficiency!" Retrieved from: http://www.yourarticlelibrary.com/crops/useful-notes-on-cropping-system-in-india-1185-words/11457/

[40] Gallaher, N. Raymond."Multiple cropping Systems," Management of Agricultural Forestry and Fisheries Enterprises, Vol. 1. Institute of Food and Agricultural Science, University of Florida. Retrieved from: http://www.eolss.net/Sample-Chapters/C10/E5-15-02-04.pdf

[41] Ibid.

Advantages of Crop Rotation

1. Crop rotation controls the growth of weeds, especially the cover crops, which suppress the growth of weeds.
2. Control of pests and diseases. When different crops are planted one after another, pests get disrupted as their food supply is curtailed by the growth of another crop. For example, the cultivation of legumes after a rice crop is harvested could control the rice stem borer.
3. Improved organic content in the soil. The planting of soybean, other grain legumes, sweet potato and vegetables returns sufficient quantities of plant residues to the soil, as their leaves drop on the ground or their body parts are left on the field after harvesting, instead of being burned as is commonly practiced with sugarcane.
4. Improved soil fertility. The continuous growing of a single crop results in the depletion of certain soil nutrients. Crop rotation, on the other hand, promotes soil fertility through alternate planting of crops that have different nutrient needs.

Multiple Vegetable Crop Cultivation:
http://upload.wikimedia.org/wikipedia/commons/3/38/Organic-vegetable-cultivation.jpeg

Organic Farming

Indian farmers employed the practice of organic farming, commonly known as *Jaiv Krishi* or *Jaivik Kheti*, for hundreds of years before the intervention of Green Revolution. Several tribal communities around the country still practice slash and burn cultivation *(Jhumkheti)*, which is very much organic. Over the last decade or so, farming communities, policy makers and scientists have realized that the Green Revolution, which encouraged heavy use of agrochemicals, has reached a state where it is being sustained by limited and non-renewable resources. Thus, a sustainable and natural balance needs to be maintained at all costs for the existence of life. This could be made possible by adopting organic farming practices.

What is Organic Farming?

Organic farming is a method in which farmers cultivate and raise crops by keeping the soil alive. The soil's health is maintained by the use of organic wastes such as cow dung, goat dung, buffalo dung, farm wastes, aquatic wastes and other materials that contain beneficial microbes. Bio-fertilizers help release nutrients to crops – a method that is highly sustainable, pollution free and environmentally friendly.[42]

Organic farming works in harmony with nature rather than against it. Organic farmers do not leave their farms to be taken over by nature; instead they use all the knowledge, techniques and available natural resources to work hand in hand with nature. This involves combining traditional farming practices with modern scientific knowledge to create a healthy balance between nature and farming, where crops and animals can grow and thrive.

Organic farming excludes the use of chemical fertilizers, pesticides, hormones or feed additives. Instead, it relies on composting, green manure, crop rotation, crop residues, mixed cropping and animal manures for plant and soil protection. In this way, organic farming promotes agro-ecosystem health, protects biodiversity and increases biotic activity in the soil.

Organic Farming in India

Organic farming is practiced in almost all the states of India. Official data shows a tremendous growth in organic farms across the country. While there were only 42000 hectares of certified

[42] Rana, S. S."Organic Farming," Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishva Vidyalaya, Palampur, 2014, pp 1-73. Retrieved from: http://hillagric.ac.in/edu/coa/agronomy/lect/agron-3610/TeachingManual-Organic-Farming-SSR.pdf

organic farms in 2003-04,[43] this figure has grown several folds after 6 years. As per the data of 2010, there are about 528,171 hectares of land under organic farming in India. This number includes both certified organic farms as well as areas under the process of conversion to organic agriculture.[44]

Types of organic farmers in India

Organic farmers in India can broadly be categorized into three groups. First, there is a group of farmers with very small landholding and have very little financial resources to invest in for organic farming practices. In order to save input cost on costly chemical fertilizers and pesticides, they opt for organic farming. Secondly, there is another category of farmers who have better financial strength, practicing chemical fertilizer and pesticide based agriculture, but has switched to organic farming recently. Thirdly, there are those industrial organic farms that produce in large quantities to cater to the global organic food industry.

Problems faced by small organic farmers in India

Organic agriculture is gaining popularity due to the high demand for healthy and environmentally-friendly food. Because of its huge demand, agribusiness corporations have entered into the organic farming business with intentions of making huge profits. As a result, small farmers are unable to compete in the market with big agribusiness firms.

Another problem faced by small farmers while switching to organic farming is that of certification. Certified organic food fetches better prices in the market, and consumers mostly prefer branded products to the products of small producers. Certification of organic food is an institutional and cumbersome process that is expensive and time-consuming for small farmers with meager land holdings.

This chapter aims to help small and marginal farmers to adopt organic farming so that they can produce safe food without much investment and sell the surplus to immediate neighbors or in the nearby small market without undergoing the cumbersome process of certification. It also seeks to create awareness among small farmers about how to use inputs that are easily available within their farm without depending on costly industrial products. Many farmers who want to switch to organic farming are confronted by the forces that promote industrial organic products such as organic bio-pesticides or bio-fertilizers that are as costly as the chemical fertilizers and pesticides. This defeats the purpose of controlling production costs and makes farmers dependent on external inputs that have to be purchased.

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[43] "The World of Organic Agriculture in India," retrieved from: http://ncof.dacnet.nic.in/OrganicFarming-AnOverview/TheWorldofOrganicAgricultureinIndia%202010.pdf

[44] P, Ramesh. Panwar, N. R. et al., "Status of Organic Farming in India," Current Science, Vol. 98, No. 9, 10 May, 2010, pp. 1190-94. Retrieved from: http://www.currentscience.ac.in/Downloads/article_id_098_09_1190_1194_0.pdf

Principles of Organic Farming

Organic Farming operates on four principles:[45]

Health : The role of organic farming is to sustain and enhance the health of ecosystems and organisms, from the smallest ones in the soil to human beings. Hence, it avoids the use of fertilizers, pesticides, animal drugs and food additives that can have adverse health effects.[46]

Ecology : Organic agriculture should be adapted to local conditions, ecology and culture in order to attain ecological balance. It must work with the living ecological systems and cycles, and should help in sustaining them. It must improve environmental quality and conserve resources by reuse, recycling and efficient management of materials and energy.[47]

Fairness : Organic agriculture should provide everyone with a good quality of life and contribute to reducing poverty. It aims to provide a sufficient supply of good quality food in order to use natural and environmental resources in a socially and ecologically just manner.[48]

Care : Organic farming should be practiced in a responsible manner to protect the health and wellbeing of current and future generations and also the environment. Precautions should be taken while making development and technology choices in organic agriculture. Along with scientific knowledge, practical experiences and traditional practices should be adopted to ensure that organic agriculture is healthy and ecologically sound.[49]

Objectives of Organic Farming

In modern methods of farming, the prolonged use of artificial fertilizers, pesticides and herbicides causes many adverse effects. This results in soil with low organic matter content, poor structure, aeration and decreasing nutrient availability. Artificial chemicals are easily washed away from the soil and pollute rivers and lakes. They also enter our food chain, where they build up in the bodies of animals and humans, causing health problems. Pests and diseases also become difficult to control, as they become resistant to artificial pesticides.[50]

In view of these problems, organic farming aims to increase long-term soil fertility, control pests and diseases without harming the environment, ensure the cleanliness and safety of water, use available resources to reduce the cost of farm inputs, and increase profits by producing high quality and nutritious crops that can be sold at a good price.

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[45] "Principles of Organic Agriculture - Preamble," International Federation of Organic Movement (IFOAM), Germany. Online at: http:www.ifoam.org. Retrieved from: http://www.ifoam.org/sites/default/files/ifoam_poa.pdf

[46] "Organic Farming," Thiruporur Farmers Network, Thiruporur. Retrieved from: http://thiruporurfarmers.blogspot.in/2012/12/ organic-farming.html

[47] Ibid.

[48] Ibid.

[49] Ibid.

[50] "What is Organic Farming?" HDRA – The Organic Organisation, United Kingdom, 1998. Online at: Website: www.hdra.org.uk Retrieved from: http://www.infonet-biovision.org/res/res/files/488.OrgFarm.pdf

Methods used in Organic Farming[51]

To yield the best results in organic farming, the essential components need to be developed in a systematic manner.

i. Habitat development
ii. On-farm facilities for input production
iii. Cropping sequence and combination planning
iv. 3-4 year rotation plan
v. Growing of crops suited to the region, soil and climate

Development of Farm Facilities and Habitat

IInfrastructure : 3-5 percent of farm space should be reserved for utilities such as space for cattle, vermicompost bed, compost tank, irrigation well, water pumping infrastructure and such means that aid in increasing productivity with effective use of resources. At least 5-7 trees should be planted in this area to provide shade to the utility infrastructure. Percolation tanks for rainwater conservation should be dug at appropriate places. A few 200-litertanks for liquid manure preparation and a few containers for botanicals should also be kept.[52]

Habitat and biodiversity : Management of an appropriate habitat for sustenance of different life forms is an essential component of organic farming. This can be achieved by maintaining a wide variety of trees and bushes suited to the local climate. Trees and bushes ensure that the nutrients from air and deep soil layers are brought to the surface. They also attract birds, predators, friendly insects, and provide them with food and shelter. Small losses in productivity due to the shading effect may be compensated by reduced problems with pests.[53]

Conversion of Soil to Organic

Banning of chemicals: Some biological processes of plants involved in acquiring nutrients such as nitrogen are inhibited by adding nitrogen fertilizers and lead to a deficiency of micronutrients. Hence, organic farming avoids the use of chemicals and encourages the use of organic compost.[54]

Manuring and soil enrichment: Soil fertility can be improved through the use of organic inputs like well decomposed organic matter, green manure, plant biomass, cattle dung manure and

[51] Yadav, A.K. "Organic Agriculture, (Concept, Scenario, Principals and Practices)," National Centre of Organic Farming, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India. Retrieved from: http://ncof.dacnet.nic.in/Training_manuals/Training_manuals_in_English/Organic_Agriculture_in_India.pdf

[52] Ibid.

[53] Ibid.

[54] Ibid.

bio-fertilizers in appropriate quantity. Well-fed, healthy soil that is rich in micro-flora and micro-fauna takes care of crop nutrient requirements. However, use of high quantities of manure should be avoided.[55]

Liquid organic manure: Application of liquid manure is essential for maintaining the activity of microorganisms and other life forms in the soil. Easy preparation methods of some liquid manure from the most commonly available organic materials are given below :

Panchgavya - Mix 5 kg. fresh cow dung, 3 liters cow urine, 2 liters cow milk, 2 liters curd, 1 kg.cow butter oil and ferment the mixture for 7 days. Stir the mixture twice per day. Dilute 3 liters of *panchgavya* in 100 liters of water and spray over soil. 20 liters *panchgavya* is needed per acre for soil application along with irrigation water.[56]

Amritpani - Mix 10 kg.cow dung with 500 g. honey and mix thoroughly to form a creamy paste. Add 250 g.of desi cow ghee and mix at high speed. Dilute with 200 liters of water. Sprinkle this suspension in 1 acre over soil or with irrigation water. After 30 days, apply a second dose in between the rows of plants or through irrigation water.[57]

Jivamrut - In 200 liters of water, mix 10 kg. cow dung, 10 liters cow urine, 2 kg. jaggery, 2 kg. of any pulse grain flour, and 1 kg. forest soil. Ferment for 5 to 7 days. Stir the solution regularly three times a day. Use on one acre of land with irrigation water.[58]

Mulching : A farming technique which involves covering bare soil with cut leaves, straw leaves and litter while farming is still going on. This method prevents the washing away of topsoil, which lies bare between the crops. It also enhances soil fertility and soil infiltration capacity, which thereby increases water retention and helps suppress weeds.

Mulching also allows the multiplication of the microorganisms and earthworms that are required to improve soil quality. This allows the overall per acre yield of crops to increase.[59]

Mulching can be of two types :

Temporary mulch : In this kind of mulching, the mulch comprises of dry green leaves and other vegetable litter mixed with compost, which is layered over fallow soil and ploughed in. Once

[55] Ibid.

[56] Panchagavya: How to Make. Retrieved from Agriculture Information. Online at: http://www.agricultureinformation.com/forums/general-questions-answers/15995-panchagavya-how-make.html

[57] Bindumathi Mohan, "Preparation of Amritpani," Appendix -3, Evaluation of Organic Growth Promoters on Yield of Dryland Vegetable Crops In India, T.S. Srinivasan Centre For Rural Training (TVSES), Hosur, India. Retrieved from: http://www.organic-systems.org/journal/Vol_3(1)/pdf/23-36%20Mohan.pdf

[58] Yadav, A.K. "Organic Agriculture, (Concept, Scenario, Principals and Practices)," National Centre of Organic Farming, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India. Retrieved from: http://ncof.dacnet.nic.in/Training_manuals/Training_manuals_in_English/Organic_Agriculture_in_India.pdf

[59] Ibid.

the crops have been planted, the soil is re-mulched. This allows the dry leaves and vegetable matter to rot and gives soil the required nutrients.

Permanent mulch : Completely rotted compost, semi-decomposed biomass and fresh biomass are mixed together and spread over the soil into a thick layer before seedlings are planted. As per this method, afresh layer of biomass is added only twice a year, and the soil does not have to be dug again. Water is frequently added to the mulch to maintain it.[59]

Use of Bio-Fertilizers and Microbial Cultures[60]

Bio-fertilizers contain living organisms like rhizobium, azotobacter, azospirillum, phosphate solubilizing bacteria (PSB), and pseudomonas, which are applied to seeds, plant surfaces or soils to promote their growth by increasing the supply of primary nutrients to the host plant. Recently, bio-fertilizers better adapted to local climatic conditions have been developed and made available commercially.

Methods of Application

Biofertilizers can be applied to different crops and plants in three different ways:

Seed treatment: Suspend 200 grams each of azotobacter/azospirillum and PSB in 300-400 milliliters of water and mix thoroughly. Pour this slurry onto 10-12 kg. seeds and mix by hand till all the seeds are uniformly coated. Dry the treated seeds in shade and sow immediately.

Seedling root dip treatment: Suspend 1-2 kg. each of azotobacter/azospirillum and PSB into sufficient quantity of water (5-10 liters, depending upon the quantity of seedlings required to be planted in one acre). Dip the roots of seedlings in this suspension for 20-30 minutes before transplanting. In the case of paddy, make a sufficient sized bed (2meters x 1.5meters x 0.15 meters) in the field, fill it with 5 centimeters of water and suspend 2 kg. each of azospirillumand PSB and mix thoroughly. Now dip the roots of seedlings in this bed for 8-12 hours (overnight) and then transplant.

Soil treatment: For soil treatment, depending upon the total number of plants per acre, 2-4 kg. of azotobacter/azospirillumand and 2-4 kg. of PSB are required for one acre. Mix the bio-fertilizers in 2-4 liters of water separately and sprinkle this suspension on two separate heaps of 50-100 kg. compost. Mix the two heaps separately and leave for incubation overnight. After 12 hours, mix the two heaps together. For acidic soils, mix 25 kg. of lime with this mixture.

Seed Treatment

In organic management, protection measures are used only in case of problematic situations. Use of disease-free seed stock and resistant varieties is the best option. There is no standard

[60] Ibid.

formulation or treatment methodology available, but farmers use different methods. The following are a few such innovative seed treating formulations:[61]

- Hot water treatment at 53° C for 20-30 minutes
- Cow urine or cow urine-termite mound soil paste
- Beejamrut - Put 5 kg. fresh cow dung in a cloth bag and suspend in a container filled with water to extract the soluble ingredients of dung. Suspend 50 g. lime in 1 liter of water separately. After 12-16 hours, squeeze the bag to collect the extract, and add 5 liters cow urine, 50 g. virgin forest soil, lime water and 20 liters of water. Incubate for 8-12 hours. Filter the contents and use the filtrate for seed treatment.
- 250 g. asphoetida in 1liter of water for 10 kg. seeds

Seed Treatment with Turmeric Rhizome Powder and Cow's Urine[62]

Boil 10 liters of water and cool it and keep it for a day. The next morning, add 4 liters of cow's urine and 200 g. of rhizome powder to the cooled water. Stir it well. Then add seeds that are to be sown to this solution and mix well. Remove the damaged seeds that float to the surface of the solution. Allow the remaining seeds in the same solution for 15 minutes. Filter the solution and separate the seeds. This seeds can be sown directly in the field. This gives protection and resistance against pathogen and pests.

1 liter of cow's urine and 50 g. of rhizome powder is required for treating 1 kg. of seed.

Seed treatment for Sorghum (Jowar)[63]

- Treat the seeds with asafoetida solution (75-100 g. in 1 liter of water) and shade dry before sowing. This seed treatment method prevents ergot disease in sorghum
- Mix the seeds with the extract of *Ashwagandha and datura* (for 1 kg. seeds, pound 250g. of ashwagandha/amukura *(Withania Somnifera)* roots and 50 g. of datura/ Oomathai (daturametel) leaves by adding water and shade dry before sowing. This will help produce healthy and disease-free seedlings.

Temperature Management

High temperature in summer months can be managed by keeping soil covered with biological mulch. Surface mulch has been reported to conserve soil moisture and improve water use

[61] Yadav, A. K. "Organic Agriculture, (Concept, Scenario, Principals and Practices)," National Centre of Organic Farming, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India. Retrieved from: http://ncof.dacnet.nic.in/Training_manuals/Training_manuals_in_English/Organic_Agriculture_in_India.pdf

[62] Rural Organic Farming Technologies in Integrated Polyculture Farming System, online at: http://www.farminggroup.org/index.aspRetrieved from: http://www.farminggroup.org/ipfs/generalinfo/ruralorganicfarming_showsub.asp

[63] Sridhar, Subhashini. et al. "Seed Treatment techniques for Millets," in Seed Treatment Techniques (K. Vijayalakshmi, Ed.) Centre for Indian Knowledge Systems, Chennai, Revitalising Rainfed Agriculture Network, December 2013 p5. Retrieved from: http://www.ciks.org/6.%20Seed%20Treatment%20Techniques.pdf

efficiency. Temperature control can also be achieved by planting different types of trees like neem, amla, tamarind, gular, zizipus bushes and gliricidia on bunds.

Pest Management[64]

As the use of synthetic chemicals is prohibited in organic farming management, pest management is done by: (i) cultural or agronomic, (ii) mechanical, (iii) biological, or (iv) organically acceptable botanical extracts or some chemicals such as Copper Sulfate and soft soap, etc.

Cultural alternative - Use of disease-free seed or stock and resistant varieties is the best preventive practice in organic pest management. Maintenance of biodiversity, effective crop rotation, multiple cropping, habitat manipulation, and use of trap crops are also effective practices which can keep the population of pests below the economical threshold limit.

Mechanical alternative - Removal of affected plants and plant parts, collection and destruction of egg masses and larvae, installation of bird perches, light traps, sticky colored plates and pheromone traps are the most effective mechanical methods of pest control.

Biological alternative - Use of pest predators and pathogens has also proved to be an effective method of keeping pest problems below the economical threshold limit. Inundated release of Trichogramma Sp at 40,000-50,000 eggs per hectare and Chrysoperla Sp at 5,000 eggs per hectare after 15 days of sowing and other parasites and predators after 30 days of sowing can effectively control pest problems in organic farming.

Botanical pesticides - Many plants are known to have pesticidal properties and their extracts or refined forms can be used to manage pests. Among various plants identified for the purpose, neem has been found to be the most effective, helping in the management of approximately 200 insects, pests and nematodes. It is very effective against grasshoppers, leaf-hoppers, plant hoppers, aphids, jassids, and caterpillars. Neem extracts are also very effective against beetle larvae, butterfly, moth and caterpillars.

Mixed leaves extract - Crush 3 kg. neem leaves in 10 liters of cow urine. Crush 2 kg. custard apple leaves, 2 kg. papaya leaves, 2 kg. pomegranate leaves and 2 kg. guava leaves in water. Mix the two and boil 5 times at some intervals until it becomes half. Keep for 24 hours, then filter the extract. This can be stored in bottles for 6 months. Dilute 2-2.5 liters of this extract to 100 liters for 1acre. The extract is useful against sucking pests and pod or fruit borers.

[64] Yadav, A.K. "Organic Agriculture, (Concept, Scenario, Principals and Practices)," National Centre of Organic Farming, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India. Retrieved from: http://ncof.dacnet.nic.in/Training_manuals/Training_manuals_in_English/Organic_Agriculture_in_India.pdf

Practices Linked to Organic Farming

Organic farming consists of a variety of agricultural practices without the use of chemical fertilizers and pesticides. The purpose of organic farming is not only to move away from chemical-based farming, but also to grow poison-free food crops and achieve better and more diverse food productivity and food security for small farmers. **Multiple cropping** and **crop rotation** are two important features of organic farming systems because they provide mechanisms for building healthy soils, controlling pests and increasing productivity.

For small farmers, the purpose of using multiple cropping and crop rotation methods to is to understand the management of crop rotation; avoid crop rotation problems; and use multiple cropping patters to build better soil, control pests, and develop profitable farms.[65]

Multiple Cropping

Mixed cropping is an important feature of organic farming which involves growing a variety of crops simultaneously or at different times on the same land. Mixed cropping promotes photosynthesis and avoids competition for nutrients, because different plants draw their nutrients from different depths of the soil.

Note : For details, please refer to the chapter on Multiple Cropping Systems in this booklet.

Crop Rotation

Crop rotation is the backbone of organic farming practices. To keep the soil healthy and to allow the natural microbial systems to work, crop rotation is must. Crop rotation is the succession of different crops cultivated on the same land. For best results, farmers should follow a rotation plan of 3-4 years. All high-nutrient demanding crops should precede and follow legume-dominated crop combinations. Another method is the rotation of pest host and non-pest host crops, which helps control soil-borne diseases, pests and weeds. Legumes should be used frequently in rotation with cereal and vegetable crops. Green manure crops should also find a place in planning rotations.

Some important benefits of crop rotations are:

a. Not all plants have the same nutritive needs,

b. Soil structure is improved through different types of roots,

c. Pest buildup is avoided

d. Weed buildup is avoided

[65] Mohler, L. Charles. Sue Ellen Johnson, (Eds.), "Crop Rotation On Organic Farms: a planning manual," Natural Resource, Agriculture, and Engineering Service (NRAES) Cooperative Extension, July 2009. Retrieved from: http://www.nraes.org

Successful Organic Farms in India

1) Ningappa Belavatagi, age 67, of Halyal village in Hubli, Karnataka used chemical fertilizers on his crops for 40 years. However, he suffered major crop loss when his chili crops were damaged for three years in a row. The major reason for the loss was found to be the use of chemicals. In 2002, Ningappa came in contact with a local NGO involved in organic farming. Taking suggestions from them, Ningappa, who owned 12.5 acres of land, decided to start organic farming on 2.5 acres. For the first three years, his organic farming yielded no profits. It was only after 2005 that his hard work brought results. Earlier, Ningappa used to spend over Rs. 20,000 to grow crops on one acre of land, but after switching to organic farming, he spent about Rs. 5,000. Seeing the profits from organic farming, Ningappa converted his entire 12.5 acres of land into an organic farm. Currently, his family uses only organic food, including organic jowar, green gram, chili, vegetables, groundnut and oil. Seeing his success, about 70 families in the village followed his footsteps.[66]

2) Oddoor Farms is situated around 25 km away from Mangalore city. Rajesh Naik converted the 120 acres of his barren ancestral land into a self-sufficient organic farm by developing a 50-feet deep lake on two acres of land. This lake generates around 40,000 liters of water that is utilized to irrigate the whole farm. Oddoor Farms is one of the largest organic farms in the area, with areca nut plantations across 10acres of land, besides growing coconut, mangoes, haldi, pepper, bananas, cashew nuts, fruits and vegetables. Rajesh also started a dairy farm that has around 200 cows that supply approximately 800-1000 liters of milk that is regularly taken up by the Karnataka Milk Federation. The farm is self sufficient in every aspect. There is a big grass-cutting machine in one of the sheds that provides ample supply of green grass for the cattle. The farm uses manure generated from cow dung, and cow urine is used with other local herbal products to generate organic pesticides. The cow dung and urine, along with grey water from the cowshed, are collected in a tank, which after fermentation generates large amounts of methane. The methane is used to run a 60KV generator that produces its own electricity to run the whole farm. The slurry generated is used in the fields and is rich in minerals and calcium.[67]

3) Suresh Desai is a founding member of an Organic Farmers Club in Belgaum District of Karnataka, India. It has 400 members, some of which are already growing crops

[66] Kattimani, F. Basavaraj. "Farmer scripts organic farming success, " *Times of India*, October 2009. Retrieved from: http://timesofindia.indiatimes.com/city/hubballi/Farmer-scripts-organic-farming-success/articleshow/6837267.cms

[67] Kelkar-Khambete, Aarti. "Transforming 120 acres of barren land into a self-sufficient organic farm: The story of Rajesh Naik and Oddoor farms," The Better India, April, 2013. Retrieved from: http://www.thebetterindia.com/7097/transforming-120-acres-of-barren-land-into-a-self-sufficient-organic-farm-the-story-of-rajesh-naik-and-oddoor-farms/#sthash.kscOVTct.dpuf

organically, while others are in the process of shifting to organic farming. On his 4.5-hectare farm, Desai grew sugarcane and tobacco. Sugarcane is a water-intensive crop. Initially, he used some of the residue after harvesting sugarcane for roofing and burned the remaining residue. Burning prevents pest infestation, but most of the ash leaches away during the first irrigation, reducing the benefits that could be reaped from the ash. He used chemical fertilizers to maintain the soil's fertility. Later, having learnt about the harmful effects of chemical fertilizers, he decided to use the residue from roofing to make compost manure, which he applied on the soil as an organic fertilizer. However, as water demand increased and the groundwater became severely depleted, Desai decided to use the residue for mulching. He spread the mulch in alternate rows and provided water in between each row of mulch. Likewise, he was able to reduce his irrigation requirement by 50 percent. He continued to store the sugarcane residue for mulching, and in three years he realized that chemical fertilizers were no longer needed.[68]

[68] "Farmers innovation, community development and the ecological management in organic agriculture," CASE STUDY 1, No-till sugar cane cultivation with alternate row irrigation, Belgaum, Karnataka, India. Retrieved from FAO Corporate Document Repository: http://www.fao.org/docrep/005/y4137e/y4137e07.htm

Bio-dynamic Farming

The word biodynamic is a combination of two Greek words: "bios," meaning life, and "dynamos," which means energy. Biodynamic farming refers to the agricultural science that recognizes the basic principles at work in nature and applies this knowledge of life forces to bring about balance and healing in the soil. This method of farming treats the farm as a living system that interacts with the environment to build healthy living soil and to produce food that nourishes, vitalizes and helps to develop humanity. Biodynamic farming was first developed in 1920 based on the ideas of Austrian writer, educator and social activist Dr. Rudolf Steiner.[69]

In India, the biodynamic movement was started in the early 1990s by Shri T.G.K. Menon of Indore. He collaborated with Peter Proctor, a farmer from New Zealand, to teach Indian farmers about biodynamic farming.[70]

Biodynamic farmers follow spiritual methodology and practice an accompanying series of steps to keep the farms sustainable and self-nourished. Thus, a farm is not just a piece of land where food is produced. Biodynamic farming practices are in tune with the rhythms of nature. For example, the phase of the moon may impact the time to plant seeds, or the planets may affect plant growth. Thus, biodynamic farming is a combination of astrological beliefs and sustainable farming practices.

In biodynamic farming, there is no place for chemical fertilizers or pesticides. Instead, farmers use natural and biological nutrient providers like bacteria, algae, fungi, mycorhiza, and actinomycetes. Pests are managed by use of natural predators like birds and parasites instead of chemical pesticides. These agents are nurtured on the farms or augmented through such activities that favor their flourished activities. Composting, green manuring, crop rotations, intercropping, mixed cropping, as well as bird perches and trap crops are all used to promote such biological activities. That is why practitioners of biodynamic farming claim that it is a holistic approach which involves the role of every contributor in farming activities including soil, animals, birds, influence of the ecosystems and the cosmic forces – and of course, the farmers. Biodynamic farming recognizes the influence of cosmic forces on living things; hence an astronomical calendar is used to indicate the optimal date for the planting or sowing of seeds depending on the planetary positions of the moon. Apart from these, the cow is an inseparable

[69] "What is Bio-Dynamic Agriculture?" Bio-Dynamic Association of India (BDAI), Tamil Nadu. Retrieved from: http://www.biodynamics.in/

[70] Ibid.

part of this farming practice, especially because cow dung, cow urine and milk are key inputs for making humus and manures, made from bio-resources available on the farm itself.

Principles of Bio-Dynamic Farming

- Plant diversity: In order to maintain the soil's health, a variety of plants are allowed to grow on uncultivated land which is followed by mixed cropping. This is done so that plants dwell in a symbiotic relation (i.e., if one plant depletes one kind of nutrient, another plant on the farm releases the same nutrient into the soil, hence replenishing the soil with the nutrient it lost). Plant diversity is achieved through crop rotation and raising varied animals on the farm along with cover crops and green manures that enrich the soil reduce parasites and control weeds and pests.

- Composting: This is an integral part of biodynamic farming. Compost enhances the health of the soil. It mainly consists of recycled manures and organic wastes, which are mixed together in a compost pit for days. The wastes decompose and ferment and eventually form humus, which is vital for the plants. Humus stabilizes nitrogen in the soil, which is vital for crop productivity. In order to assist composting, several Biodynamic preparations are used. The Bio-Dynamic Preparations (BD Preps) are based on the original indications given by Rudolf Steiner. A healthy agriculture requires balance, which can be achieved only by using all nine of the BD Preps (BD #500-508) in one form or another. These nine BD Preps are based on extracts from animals, plants and mineral manures, each of which is diluted and sprayed to homeopathically treat compost, soil and plants through a process called dynamization (some examples are horn manure, crushed quartz, etc.).[71]

- Life force: This is the principle that separates dynamic farming from other farming techniques. As per this principle, the technique acknowledges that, in addition to earthly influences, cosmic forces (the sun, the moon and the seasons) also play a key role in the life of the farm.

The following is a case study from Tamil Nadu, which will shed light on the success of biodynamic farming.

Case Study: Mettupalayam, Tamil Nadu

T. Navaneethakrishnan of Mettupalayam, Tamil Nadu is an ardent practitioner of biodynamic farming. For about a decade, he has been practicing biodynamic farming on his 5 acres land, coupled with organic farming. According to the results, he claims that bio-intensive farming is

[71] "Bio-Dynamic Preparations," Josephine Porter Institute for Applied Bio-Dynamics, USA. Online at: https://www.jpibiodynamics.org/product-category/preparations/

the best form of agricultural practice. Inspired by Dr. Rudolf Steiner, Navaneethakrishnan claims that he has been planting when the ascending moon is in the Fire Constellation and transplants when the descending moon is in the Fire Constellation. Likewise, he carries out pesticide spraying, seed germination, ploughing and other activities according to the moon's position, which can be read from a biodynamic calendar. This farming practice has allowed Navneethakrishnan to produce about 1,200 varieties of plants, including toxic-free fruits, vegetables and leaves. Owing to its good results, Navaneethakrishnan aspires to promote biodynamic farming, by teaching farmers this technique for free.[72]

[72] T. Navaneethakrishnan, "He is an ardent votary of bio-dynamic farming," The Hindu, January, 2007. Retrieved from: http://www.thehindu.com/todays-paper/tp-national/tp-tamilnadu/he-is-an-ardent-votary-of-biodynamic-farming/article1779128.ece

Zero-Budget Natural Farming[73]

Zero-budget natural farming (ZBNF) is a particular type of natural farming which relies on zero cost of production. It requires no monetary investment for purchase of inputs like seeds, fertilizers and other plant protection chemicals from the market. ZNBF practitioners do not have to depend on credits from private moneylenders or government institutions. Moreover, the aim of this method of farming is to make the farmers self-reliant and thus reduce dependency, even on hired labor. This farming practice only requires a native breed of cattle, which is an integral part of this system. It does not even require ploughing or weeding.

In this system, the farmer produces his own seeds or borrows seeds from neighboring farmers. This way, he does not rely on the hybrid or genetically modified seeds available in the markets. With this system of farming, farmers get huge relief in cost of production because they can completely avoid chemical fertilizers and pesticides, which often form the largest portion of input costs. This way, farmers free themselves from the clutches of local moneylenders and high-cost inputs from the market.

According to the pioneer of ZNBF in India, Subhash Palekar, Zero-budget farming (which he also calls Zero Budget Spiritual Farming) means that the production cost will be zero. In ZBNF, nothing has to be purchased from outside the farm. All things required for the growth of the plant are available around the root zone of the plants. There is no need to add anything. Our soil is prosperous and full of nutrients, and crops take only 1.5-2.0 percent of the nutrients from the soil. The remaining 98-98.5 percent of nutrients are taken from air, water and solar energy.[74]

The main points of ZNBF are:

(i) Zero-budget: Farmers do not need to invest money in seeds, fertilizers and plant protection chemicals

(ii) Treatments for seeds *(beejamrutha)* and crops *(jeevamrutha)* are made with a mixture produced using the cow dung and urine as the main compounds

[73] Babu, R. Yogananda. "Action Research Report on Subhash Palekar's Zero Budget Natural Farming," retrieved from: http://www.atimysore.gov.in/PDF/action_research1.pdf

[74] Subhash Palekar's home page on ZNBF; http://palekarzerobudgetspiritualfarming.org/zbnf.aspx#sthash.ixcQGTNQ.dpuf

(iii) Mulching is done with organic residues

(iv) Plant protection only uses homemade and natural pesticides

Zero-budget farming emphasizes treating seeds, crops and soil with homemade pesticides and fertilizers, the key ingredients of which are easily available home and around the farm. The seeds or planting materials are treated in *beejamrutha*, which is a concoction of water, cowdung, cowurine, farm soil and lime. *Beejamrutha* can be prepared by mixing 50 grams. of lime, 5 kg. of cow dung, 5 liters of cow urine, one handful of soil and 5 liters of water in a plastic tank. After 12 hours, the seed treatment product is ready for use. For 7 days, the mixture can be re-used once or twice depending on the kind of seeds being used.

Beejamrutha protects the crops from harmful soil-borne and seed-borne pathogens during the initial stages of germination. Once the seeds are sown, the crops are then treated with *jeevamrutha* (a concoction of water, cowdung, cowurine, Jaggery, flour of any pulse and farm soil). To prepare *jeevamrutha*, a farmer needs to mix 10 kg. of cow dung, 10 liters of urine, 2 kg. jaggery, 2 kg. blackgram, one handful of soil in 200 liters of water in a tank and mix twice a day. After two days, the mixture is ready to use, and it can be used for a period of seven days. After this period, a new mixture needs to be prepared.

Jeevamrutha is sprayed on the crops once in a fortnight or at least once a month. *Jeevamrutha* is not a fertilizer or pesticide; it is a catalyst to promote the biological activity in the soil. Increased biological activity in the soil increases the availability of nutrients for the plants. Whether in *beejamrutha* or *jeevamrutha*, the cow dung used is from desi cows (local Indian cow breed) and not the one crossbred with Jersey or Holstein cows. According to Palekar, the desi cow dung is richer than the one of crossbred cows. One desi cow is enough to cultivate thirty acres using the ZBNF approach.

To increase the nutrient content in the soil, mulching is done. Mulch consists of organic waste matter that is mixed with cow dung and cow urine, then fermented and decomposed for a period of 14days or a month in a pit. This decomposed organic matter forms humus and is called compost. Mulching reduces tillage and thus labor requirement. The humus formed during compost formation not only helps in enhancing soil nutrients, but also increases the water retention capacity of the soil, and suppresses water evaporation and weeds. Overall, the cost of irrigation, fertilizers and water usage in irrigation is largely minimized. In order to further enhance soil nutrient levels, farmers are encouraged to practice mixed cropping and crop rotation. While mixed cropping provides a buffer against total crop failure and widens a farmer's income source, crop rotation ensures nutrient replenishment of soil and prevents buildup of endemic pests.

The following is a comparison between small-scale organic farming methods (and not industrial organic farming) and zero-budget natural farming techniques.

Organic Farming	Natural farming
- No use of chemical pesticides and fertilizers	- No use of chemical pesticides and fertilizers
- Inter-cropping, crop rotation	- Inter cropping, crop rotation and agro-forestry
- Farm yard manure, liquid manures and other organic preparations	- No addition of organic matter to the soil
- May access external organic inputs, including botanical pesticides occasionally	- Rely only on inputs available on the farm
- Can be labour intensive	- Constant cover crops and mulching
- Ploughing (at least the first time)	- No ploughing
- Weeding	- No weeding
	- No cultivation of the soil
	- Only sowing and harvesting

Importance of Trees in Farming

Indian farmers today must tackle the challenges of severe soil degradation and loss, and threats to the ecosystem and other natural resources. In this context, it is crucial to examine the role of trees in farming and how they can be economically beneficial and viable.

Trees are an essential part of India's agricultural systems, as they provide food, medicines, income and agricultural raw materials. Indian farmers have traditionally practiced forest farming, for perhaps more than 1,000 years. Our farmers planted trees along farmlands to restore degraded soil and to conserve the ecosystem. The role of trees in maintaining stability in the ecosystem is based on traditional knowledge, and this practice had been incorporated into farming systems across the country.

Figure 10 – Importance of trees. Retrieved from: http://www.greenpop.org/wp-content/uploads/2011/11/New-Novmber-Why-trees-Main-image-Facts-3-.jpg

However, the role of trees in agriculture became neglected with the onset of technological advancements as part of the Green Revolution, which introduced the heavy use of artificial fertilizers and chemical pesticides. This was supposedly done to increase productivity, but research shows that industrial farming techniques have only depleted soil quality, degraded soil, and polluted the water and air.

Experiences from studies on traditional farming systems tell us that agriculture, when mixed with trees, has many advantages for farmers, especially for the subsistence farmers who could benefit economically when the trees grow older. When crops and trees are grown together on the same plot of land, they interact with each other, which at many times is beneficial for farmers. It increases the overall productivity of the farm, besides providing green fodder for the soil and firewood for farmers, and controlling soil erosion.

Trees are grown on farms in various forms. Some farmers in India grow trees as hedgerows, which form a fence around the farm to protect the farmland, and also act as windbreaks. Sometimes, farmers also plant trees along contours to prevent soil erosion. Farmers along the

western coastline of India have planted tree species like Acacia Nilotica *(Babool)*, Acacia Tortilis *(Israeli Babool)*, Prosopus Juliflora *(Angrezi Babool/Vilayati Babool)* and eucalyptus for soil amelioration in salt-affected areas.

However, the focus on farm forestry is also the result of changes in government policy on forests with the introduction of National Forest Policy in 1988, which restricted commercial plantations in forests and asked paper and pulp industries to source wood from farmers instead. The movement of farm forestry began to pick up towards the late 1990s.[75] However, it was mainly the big landholding farmers who were attracted to agro-forestry, because they could set aside a portion of their land for growing tress and use the rest for growing food and vegetables. But it is not sustainable for small and marginal farmers because there is a long growth period before harvest, sometimes as long as 7-10 years. Small and marginal farmers therefore cannot afford to practice agro-forestry. But they can certainly plant trees on the periphery of their field, which can provide shade, biomass for manures, nitrogen fixation for their fields as well as handsome monitory returns every once in a while.

Poplar Trees in Punjab and Haryana

Many of the big farmers in the states of Punjab and Haryana have shifted away from traditional crops like wheat and paddy and have adopted the plantation of cloned poplar trees. However, most farmers grow this tree on farm or canal bund. The increase in plywood manufacturing units, papermaking industries and furniture units has fuelled the demand for wood, which in turn has spurred the prices of poplar trees. Poplar trees are often used as poles for construction purposes, as filler material in plywood and as pulp in papermaking. The shift to agro-forestry has been extremely beneficial to the farmers, as it involves a minimal input cost, the market is assured and cases of crop failures are rare. On an average, a farmer earns Rs. 8-10 lakh per acre in five years from agro-forestry. In districts like Hoshiarpur (Punjab) and Yamunanagar (Haryana), 70-80 percent of farmers are fully engaged in agro-forestry. This has entirely changed the landscape of these regions, and these two states now hold 30-40percent of the plywood market. Farmers intercrop wheat, maize and sugarcane along with the

Figure 11 Poplar based agro-forestry (PBAF), in North India. Source: http://wca2014.org/poplar-creating-an-evergreen-revolution-for-food-and-wood-security-in-north-india/#.VKJCIsAA

[75] "Forest to farms," Down to Earth, 31 July 2014, http://www.downtoearth.org.in/content/forest-farms

plantation of cloned poplar and eucalyptus trees. This provides them with the option of earning normal yields from the crops for the first two years, and then harvesting the trees from the third year onwards[76]

Bamboo Cultivation in Madurai, Tamil Nadu

Severe labor shortages, increasing input costs, and heavy costs of fertilizers and pesticides forced many farmers in Madurai to opt for bamboo cultivation in their agricultural fields, in wastelands and non-forested areas. Bamboo does not require much manpower and provides constant yields over long periods of time. Since bamboo is a long-term crop and maintenance in the initial years is important, farmers intercrop pulses for the first three years to match the revenue loss. Bamboo absorbs 45 percent carbon dioxide and releases 30 percent oxygen, hence it is extremely environmentally friendly. It provides profits starting from Rs. 50,000 per hectare in the initial years and then provides steady profits for the next 30 years. Bamboo also improves the soil quality by fertilizing land. Dried leaves are used for creating manure and also for mushroom cultivation. Besides regular commercial uses, bamboo products are used with paper, artifacts, and incense stick industry.[77]

Nitrogen Fixing Trees (NFTs)

Nitrogen fixing trees (NFTs) are often considered to be critical components of sustainable agro-forestry systems. Nitrogen fixed by NFTs improves the production of trees, crops and animals, and soil fertility. Collection of pods from the trees is economically viable if the yield is high. These species boost the productivity of the pastures not only by contributing feed, but by also improving soil's physical properties, organic matter and conserving soil, moisture, and promoting nutrient cycling. In many parts of southern India, poles harvested from 3-4 year old trees are widely used for housing in rural areas and hence, fetch a premium price even in rural markets. As these species grow straight with very few side branches, the trees planted in rows on fields serve as windbreaks for protecting arable crops without competing for sunlight and moisture.

Nitrogen Fixing Non-Legume Trees

Casuarinaceae (Junglisaru/Vilayati Saru): Farmers in Orissa, Andhra Pradesh, Karnataka, and Tamil Nadu have identified a large-scale cultivation of Casuarina in agro-forestry and

[76] Krar, Parshant. "How farmers in Haryana & Punjab are earning Rs 8-10 lakh per acre in agro-forestry," The Economic Times, November, 2012. Retrieved from: http://articles.economictimes.indiatimes.com/2012-11-11/news/35034149_1_indian-farmers-crop-marginal-farmers

[77] "Manpower shortage forces farmers to switch to bamboo," The Times of India, January, 2012. Retrieved from: http://timesofindia.indiatimes.com/city/madurai/Manpower-shortage-forces-farmers-to-switch-to-bamboo/articleshow/11584543.cms

farm forestry.[78] The main reason for the preference of this tree species is that it is comparatively more profitable than the annual crops; it has low water requirements, drought tolerance, easy management, and minimum labor requirement for planting and maintenance. Casuarina poles are used for scaffolding, centering, roof building and also for mine props. Root nodules containing the actinorhizalsymbiont and Frankia, enable Casuarina to fix atmospheric nitrogen at the rate of 40-80 kg. per hectare per year.

Figure 12 - Casuarina tree
Source: http://upload.wikimedia.org/wikipedia/commons/f/fa/Casuarina_equisetifolia_0004.jpg

Nitrogen Fixing Legume Trees

Fabaceae *(Tarwar)*: This fast-growing tree has extraordinarily high nodulation that helps in fixing high amount of atmospheric nitrogen, and hence aids in soil improvement and rapid growth of trees. It is mainly cultivated as a climber for betel wine.

Gliricidia Sepium *(Madre Tree)*: Gliricidia makes a very effective living fence. Periodic trimming of these fences every month or two during the rainy season provides a large amount of foliage for fodder or green manure. Some farmers have increased their rice yields by 10 percent just by green manuring with Gliricidia alone.

Pongamia Pinnata *(Karanj)*: It is an evergreen tree that yields important fatty oil, which is used in lubricants and domestic lamps. It is commonly found along riverbanks and is planted in agricultural fields for shade and manure. Pongam oil, which is extracted from the seed, is used for medicinal purposes.

Mimosaceae *(Katha, Khair)*: Because of its rapid growth, ability to fix nitrogen, tolerance to infertile, acid, alkaline, saline or seasonally waterlogged soils, and tolerance of dry season and rainfall of 600-1000millimeters, it is a potential tree species for agro-forestry in semi-arid tracks. The heartwood is suitable for attractive furniture, turnery, carving, and also for construction work. The wood is ideal for firewood and charcoal, a good source of paper pulp, and produces large quantities of leaf litter, which enriches the soil. The tree is also capable of fixing atmospheric nitrogen at approximately 207kg/ha.

[78] "Casuarina plantations offer multiple benefits," *The Hindu*, May 11, 2012. Retrieved from: http://www.thehindu.com/todays-paper/tp-national/tp-andhrapradesh/casuarina-plantations-offer-multiple-benefits/article3407049.ece

Benefits of Trees:

- Trees enhance the management of maximum land use by combining agriculture with planting useful trees, and transform the landscape for better soil protection and sustainable mode of production.
- People rely on trees for income, food, nutrition and other useful things like fuel and fodder.
- Agricultural land planted with trees provides a good source of income during times of crop failure and food insecurity. Smaller farmers benefit the most from planting trees as their source of income is assured in times of adversity.
- Trees promote the diverse needs of a farmer, sustain production, and also protect the ecosystem.
- Trees provide a last minute financial backup for lean seasons or unforeseen contingencies.
- Trees create livelihood and support agro-forestry-based industries.
- Trees also mitigate climate change by absorbing carbon dioxide.

Nitrogen Fixing Tree: http://heart-institute.org/wp-content/uploads/2013/10/heart-alibizia.jpg

Importance of Cows and Other Animals in Agriculture

Prior to the introduction of Green Revolution technologies, Indian agriculture could not be imagined without cows, bulls, goats, buffaloes and various other domesticated animals. Many domesticated animals were farmers' friends. Bulls, male buffaloes and even camels were used to till and plough the field; cows, goats and buffaloes were used for their milk and dung, which provided an additional source of income to the farmers. Animal dung, especially cow dung, was the major manure used for farming. However, with the mechanization of agriculture and heavy use of fertilizers used during the Green Revolution, the role of these domesticated animals was greatly reduced, that the cattle population began to decline in India. As the ill effects of chemical fertilizers and pesticides have been brought to light and with the increasing demand for chemical-free food, many farmers and groups involved in sustainable agriculture are reconsidering the importance of these animals, especially the key role played by cows in agriculture. It has now therefore become important to understand the various reasons why cows and other domesticated animals are still considered to be the mainstay of Indian farming and friends of farmers.

Cows are considered sacred in Indian culture, and are venerated for their usefulness. They play a vital role in subsistence agriculture. Cows not only provide food, but also provide several valuable inputs like dung and urine as well as animal power for agriculture.

For many Indian farmers, besides the income generated from their small farms, livestock provides an additional source of income. Farmers owning cows, buffaloes and goats sell their milk and milk products to help support their families. Many have also ventured into sale of animal dung manure and dried cow dung cakes, which are rich sources of organic fertilizers and fuel, respectively. Cattle are also a form of capital reserve, built up in good times to be used when crops are poor or when the family is facing large expenses such as the cost of a wedding or medical emergency.

The use of cattle excreta, particularly cow dung in producing biogas, is a growing trend in many Indian villages. With the knowledge of the non-renewability of fossil fuels and generation of greenhouse gases by the burning of fossil fuels and firewood, Indian rural households have been encouraged to shift to cheaper sources of energy which can be used both for cooking purposes as well as electricity. In Karnataka,[79] fuel needs of several households in rural areas

[79] "From cow dung to biogas in Karnataka, India." Retrieved from: https://www.myclimate.org/fileadmin/myc/klimaschutzprojekte/indien-7149/klimaschutzprojekt-indien-7149-project-story.pdf

are fulfilled through biogas plants and family sized biodigesters are installed in houses that supply biogas to the family kitchen. So far as the electricity generation from the biogas plant is concerned, the University of Agricultural Sciences (UAS)[80] in Bangalore is saving around Rs. 50,000 a month from its electricity bill by using the power generated from a biogas plant on its campus. The wastes from the biogas plant is used as manure in the agriculture field. The UAS biogas plant generates three tons of organic manure a day.

The commercialization of Indian agriculture has forced many farmers to use tillers or tractors to till their fields. However, most agricultural holdings are too small for tilling with machines. Secondly, many farmers, in the hope of getting bumper crops, have switched to chemical fertilizers and pesticides. But over the years, the commercialization and mechanization of agriculture has robbed farmers off their wealth and health. The benefits of the Green Revolution did not last long, especially for small and marginal landholders. This trend resulted in rising production costs, so much so that many farmers are now returning to indigenous methods of farming. The use of bulls to plough fields is now a low-cost tilling and ploughing alternative. With the discovery that chemical fertilizers and pesticides cause many health and environmental problems, the use of cow dung and urine as manure is the call of the hour. Researchers have found that using cow dung and urine as manure replenishes the soil with organic nutrients, and helps sustain higher agricultural productivity in agriculture for a longer term.

Information about the importance of cows and their use in different agroecological farming practices is spread over this booklet in different chapters. However, the following subsections delve deeper into the benefits of cow dung and cow urine as bio-fertilizers. We have also further explained about this under the separate chapters on bio-fertilizer and bio-pesticide.

Cow Dung and Other Animal Dung as Fertilizer

Cow dung and other animal dung cannot be used as manure directly, as it is not very rich in nitrogen and its high ammonia content can burn plants as well. Therefore, cow dung and other animal dung manure is first composted and then used as a fertilizer on the farm. Composting animal dung not only eliminates ammonia gas, pathogens like E. coli, and weed seeds, but also adds a generous amount of organic matter to the soil.[81] Mixing this compost into the soil enhances its water retention capacity, meaning less frequent watering of fields, as the roots can use additional water and nutrients whenever needed. Moreover, it helps to break compacted soil, enhancing aeration.

[80] "UAS-B sets up biogas plant on its campus to save power," The Hindu, Bangalore, 21 May 2012; http://www.thehindu.com/todays-paper/tp-national/tp-karnataka/uasb-sets-up-biogas-plant-on-its-campus-to-save-power/article3440559.ece

[81] Phipps, Nikki."Cow Dung Fertilizer: Learn The Benefits Of Cow Manure Compost," retrieved from Gardening Knowhow, online at: http://www.gardeningknowhow.com/composting/manures/cow-manure-compost.htm

Compost dung manure also contains beneficial bacteria that can convert nutrients into easily accessible forms, which can be slowly released into the tender plant roots. Composting cow dung and other animal dung also reduces the release of greenhouse gases *(carbon dioxide, methane, nitrous oxide, and other fluorinated gases are called greenhouse gases is often abbreviated as GHG)* by a third, making it eco-friendly.

How to Compost Cow Dung

To create manure, cow dung is mixed in a bin with straw or hay in addition to organic substances obtained from vegetable matter, garden debris, etc., along with small amounts of lime or ash. The size of the bin is a matter of great importance. Composting requires a certain amount of heat that cannot be sufficiently produced in small bins. However, larger bins may not get enough air. Also, frequent turning of the bin is necessary for good compost to be made.

Importance of Cow Urine as Bio-Fertilizer[82]

In India, the use of cow urine as a medicine as well as a fertilizer can be traced to the Vedic and pre-Vedic periods. Due to its immense therapeutic value, cow urine has been widely referred as a medicine.[83]

Cow urine is not only used as a medicine for several ailments, but also has multiple uses in agriculture. Laboratory research on cow urine has shown that it contains sodium, nitrogen, sulfur, and vitamins A, B, C, D, and E. Cow urine is also rich in several minerals such as manganese, iron, silicon, chlorine, magnesium, calcium salts, phosphate, lactose and carbolic acid.[84]

Cow urine is not a toxic effluent. It mainly consists of 95 percent water, 2.5 percent urea, and the remaining 2.5 percent a mixture of various minerals, hormones, salts and enzymes. Urea is also a major component of many chemical fertilizers.[85]

Cow Urine in Agriculture

In the world of sustainable agriculture, cow urine is beneficial for farmers, since it contains a variety of nutrients that can be used as liquid fertilizer. The multiple uses of cow urine have been elaborately explained in several ancient Indian texts. Cow urine can be used as a bio-pesticide in organic farming along with cow dung, cow milk and other herbal ingredients.

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[82] Cow urine is new organic pesticide; Deccan Chronicle, 6 October 2014; http://www.deccanchronicle.com/141006/nation-current-affairs/article/cow-urine-new-organic-pesticide

[83] Mohanty, Ipsita et al. "Diversified uses of cow urine," International Journal of Pharmacy and Pharmaceutical Sciences, ISSN-0975-1491, Vol. 6, Issue 3, 2014. Pp 20-22. Retrieved from: http://www.ijppsjournal.com/Vol6Issue3/9051.pdf

[84] Ibid.

[85] Ibid.

The use of cow urine in various forms could help improve the deficiency of micro-organisms in soil and enhance the growth of crops. Farmers who have used cow urine have found that the residual effect is pronounced even in the next cropping. Cow urine can help improve soil texture and create a good environment for the growth of earthworms in soil. Cow urine could also be used as a growth promoter for various crops.

A farmer in Krishna district, Andhra Pradesh cultivated paddy by only cow dung and cow urine as manure and has been harvesting increased yields year after year. By practicing Zero Budget Natural Farming (ZBNF) method, he cultivated paddy only by using Jiwamrit (a concoction of cow dung, cow urine, jaggery and pulses flour mixed with water) found that the soil quality in his field had increased substantially as well as gave good crop yield of chemical- and pesticide-free rice. While practicing ZBNF, he found that applying Jivamrut prevented plant diseases like "sheet blight," and" rice blast'" and protected the rice plants against leaf folder insects.[86]

Cow urine and Vermicompost

By fully utilizing the organic farm wastes and cattle shed waste, a farmer could easily improve the quality of the soil in his field and produce good crops. By adding cow urine in the compost pit, a farmer can get superior quality vermicompost with higher concentration of micronutrients. Application of vermicompost made with the help of cow urine can significantly improve the yields.[87]

Cow Urine as Bio-Pesticide and Bio-Enhancer

Panchkavya made up of five cow products – milk, curd, ghee, urine and dung – is also used as fertilizers and pesticides in agricultural operations. Studies have also shown that, apart from good organic manure, cow urine is also a very effective pest controller and larvicide when used alone or in combination with several plant preparations.[88]

Studies have claimed that a farmer reaps twin benefits with the use of cow urine in combination with *neem* extracts as a pesticide. While *neem* wards off pests, cow urine is a rich source of urea, an important nutrient for enhancing soil fertility. He reaps the second benefit in the form of lower input costs.

Cows and other domesticated animals are still quite vital to Indian agriculture, as they provide cheap and easily available organic manure and fertilizers as well as animal power for

[86] "Farmer cultivates paddy with cow urine, dung," The Hindu, December 13, 2012. Retrieved from: http://www.thehindu.com/todays-paper/tp-in-school/farmer-cultivates-paddy-with-cow-urine-dung/article4193671.ece

[87] "Bioactivities of Cow Urine and its Arka (Distillate) for Utility in Agriculture and Health," Love for Cow Trust. Retrieved from: http://www.love4cow.com/bioactivitiesofcowurine.htm

[88] Mohanty, Ipsita et al. "Diversified uses of cow urine," International Journal of Pharmacy and Pharmaceutical Sciences, ISSN-0975-1491, Vol. 6, Issue 3, 2014. Pp 20-22. Retrieved from: http://www.ijppsjournal.com/Vol6Issue3/9051.pdf

agriculture. Milk and milk products become an additional source of income for farmers, thus ensuring both their food and income security.

Note : Various organic manures and organic pesticides, their ingredients and methods of preparation and application are explained in the chapters on organic manures and organic pesticides. Please refer them for further details.

Fresh cow urine: http://i3.mirror.co.uk/incoming/article3017749.ece/alternates/s1023/Fresh-Cow-Urine.jpg

Organic Manure

Manure is a substance that provides essential nutrients for the growth of plants. It comes from the Middle English word *manuren*, meaning, "to cultivate land."[89] Manure contributes to soil fertility by providing carbon and other constituents that affect the humus content, biological activity, and physical structure of soil. Manures can be categorized as organic and inorganic. Organic manure mainly consists of organic wastes like crop residues, cattle dung, and sewage waste from urban and rural areas. Inorganic manure refers to chemical fertilizers.

Figure 13 - A woman turning the compost for aeration. Source: Environmentally sound technologies for women in agriculture. Retrieved from: http://collections.infocollections.org/ukedu/collect/ukedu/index/assoc/ii01ee/p068a.gif

Over the past few decades, the use of inorganic manure has increased greatly in India. Its excessive use has affected the flora and fauna, increased the alkaline content of the soil, and lead to severe topsoil erosion. Besides making cultivation more costly, it also robbed the soil of its fertility. In an attempt to replenish fertility, these fertilizers have been used more often, which often leads to severe crop failure. This costly cycle has led large numbers of rural farmers to commit suicide. Sometimes, these fertilizers also seep through the drainage systems through rain and enter the groundwater or the ocean, which affects marine life. These fertilizers can cause genetic disorders and diseases like cancer. Much research is currently being done on the harmful effects of inorganic manures and scientists have recommended switching back to traditional and organic fertilizers.

Organic manure consists of cattle waste, crop residues and sewage waste. It contains all the nutrients required for soil and plants, but in a limited amount. Organic manure increases the water-holding capacity of soil and thus makes nutrients available to the plants, unlike the water-soluble chemical fertilizers, whose nutrients are generally lost into the atmosphere. Since organic manure boosts biological activity, nutrients in the depths of the soil are made available. Moreover, organic manure also improves the texture and physical nature of the soil, while reducing its evaporation rates. From the perspective of health, organic manure does not contain any chemicals, and therefore cause little or no harm to human health.

[89] "Manure Salts". Retrieved from Reference.com. online at: http://www.reference.com/browse/manure+salts

Compost

Compost is a form of organic manure that consists of decomposed organic crop residues. The process of piling up the crop residue, moistening it, turning it occasionally to aerate it and allowing it to partially decompose (generally in a pit) is known as composting. Applying crop residues directly to the soil leads to nitrogen immobilization, which deteriorates the soil quality. Composting, on the other hand, brings down the carbon-nitrogen ratio to 30:1, making it viable for soil application. The collected organic waste can contain sewage wastes from rural and urban areas, crop residues, vegetable wastes, paddy husks, straw, leaves, sugarcane trash, etc. – in other words, all biodegradable waste. What is eventually obtained after composting is brown-black humified material which, when applied to the soil, can replenish plant nutrients, maintain the organic content of the soil, and also improve its physical, biological and chemical conditions.

In India, two different techniques of composting are practiced. The first involves aerobic decomposition (there is frequent turning of the material for air passage) and the second involves anaerobic decomposition.

Aerobic Decomposition

Indore Method:[90] This method was introduced in India between 1924 and 1926. It takes about two to three months for the whole process of composting to finish. The raw materials used in this method include mixed plant residue, animal dung and urine, earth, wood, ash and water. Collect in a pile all organic material waste available on thefarm, such as weeds, stalks, stems, fallen leaves and fodder leftovers. Crush any hard woody materials like cotton pea stalks before adding to the compost pit. The woody ingredients should form only 10 percent of the total compost. Then dry and stack the green materials, which are soft and succulent, creating layers with each material with a thickness of 15 centimeters, until the entire pile is about 1-1.5 meters high. After this, cut the heap is into thick square cakes and spread in a cattle shed as bedding overnight. The next morning, transfer the bedding to the compost pit, along with cattle dung and urine. The Indore method has two sub-techniques, which are:

Pit method: In this method, construct a pit that is one meter deep and 1.5-2 meters wide (any length is suitable). The pit needs to be on raised ground so that rainwater does not flow into it during monsoon. It should also be close to the cattle shed and water sources.

Put the bedding from the cattle shed, along with the cattle dung and urine, into the pit in layers of 10-15 centimeters thickness. Each spread consists of slurry made up of 4-5kg. of dung,

[90] Howard, Albert.& Wad, D. Yeshwant. "The Manufacture of Compost by the Indore Method," The Waste Products of Agriculture -- Their Utilization as Humus, Journey to Forever. Retrieved from: http://journeytoforever.org/farm_library/HowardWPA/WPA4.html

3-4kg. of cattle urine and earth and 3-4kg. of inoculums from a 15-day-old compost pit. Sprinkle a sufficient quantity of water over the material in the pit. Over the week, fill it with layers of slurry. Turn the material in the pit every 15 days.

Heap method:[91] This technique is best suited to areas with heavy rainfall. The heap is prepared above the ground and protected by a shed. Like the pit, the heap is also approximately two meters high with a 1.5-2 meters wide base, which narrows toward the top of the heap. Sometimes a small bund is built around the heap to protect it from wind.

The heap starts with a 20-centimeters layer of carbonaceous material like straw, hay, dry leaves, or sawdust. On top of this layer, spread a 15-centimeters layer of nitrogenous material such as fresh grass, green plant residue, fresh or dry manure, or digested sewage sludge. Complete the heap with alternate layers of carbonaceous and nitrogenous materials, andwet sufficiently to make it damp. In order to maintain the heat inside the heap, cover it with soil or hay. Turn the heap every 6- 12 weeks. If there are no nitrogenous materials available, any leguminous plant like sun hemp can be sown or some green manure can be spread over the fermenting heap after the first turn. This method of composting takes about four months.[92]

Aerobic Decomposition

Bangalore Method:[93] This method of composting was developed in Bangalore, India, in 1939. It is recommended when night soil and wastes are used for preparing compost. The method overcomes several disadvantages of the Indore Method, such as protection of heap from adverse weather, nutrient losses due to high winds or bright sunlight, frequent turning requirements, fly nuisance and such, but the time involved in production of finished compost is much longer. The method is suitable for areas with scanty rainfall.

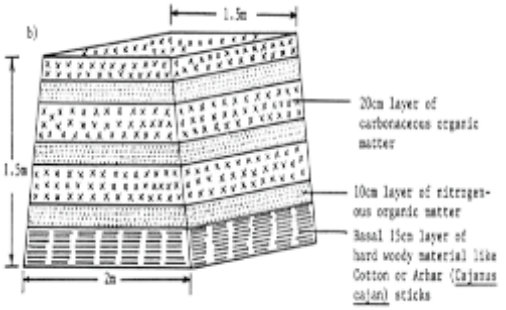

Figure 14 - an Organic compost pit. Retrieved from: Food and Agricultural Organisation (FAO) online at: http://www.fao.org/docrep/field/003/ab467e/AB467E43.gif

Trenches or pits of 1-2 meters deep are constructed in locations similar to the ones in the Indore

[91] "In Monsoon Season Make Heaps not Pits," The Compost Pit - Tradition Meets Science at Indore India. The Compost Gardener.com. Retrieved from: http://www.the-compost-gardener.com/compost-pit.html

[92] "Indian Bangalore Method," Anaerobic composting, Traditional methods, Small-scale composting in On-farm composting methods. Natural Resources Management and Environment Department. FAO Corporate Document Repository, Online at: http://www.fao.org/docrep/007/y5104e/y5104e06.htm

[93] "Indian Bangalore Method," Anaerobic composting, Traditional methods, Small-scale composting in On-farm composting methods. Prepared by Natural Resources Management and Environment Department. FAO Corporate Document Repository, Online at: http://www.fao.org/docrep/007/y5104e/y5104e06.htm

Method. The pits should have slopping walls and a floor of 90 centimeters slope to prevent water logging. Organic residues and night soil are put in alternate layers and, after filling, the pit is covered with a 15-20 centimeters thick layer of waste. The materials are not turned or watered for a span of three months. During this period, the material settles down due to reduction in the volume of biomass, and additional night soil and wastes are placed on top in alternate layers and plastered or covered with mud or earth to prevent loss of moisture and breeding of flies. The material initially undergoes aerobic decomposition for about 8-10 days and then undergoes anaerobic decomposition at a slow rate, thus taking about 6-8 months to get the final finished product.

Farmyard Manure

Farmyard manure is another kind of compost. It contains straws or hay for bedding and partially decomposed cattle dung and urine. The cattle dung is rich in nitrogen, potash and phosphorous. However, a high level of lignin and protein prevents a complete decomposition of the dung, and hence the nutrients are released slowly. Cattle urine is equally rich in nutrients that are more readily available. Straw and hay are used as bedding material in the cattle shed, mainly to prevent the loss of urine and also to increase the bulk of manure.

The mixture of straw, dung and urine are periodically collected and transferred into pits or collected in heaps and subjected to the pit or heap method of composting respectively. The quantity and quality of farmyard manure depends on the kind and age of cattle, the quality of their feed and the care given in collecting and transferring the raw materials. The manure is ready for use after 5-6 months. These methods should be initiated prior to rainy seasons and continued throughout the year. If properly preserved, the quantity of manure that can be produced per animal per year would be as much as 4-5 tons, containing 0.5 percent nitrogen. The raw materials used for making farmyard manure should not contain any heavy metal.[94]

Figure 15 - SIMPLE IDEA: Selecting the right kind of earthworms for making compost is important. Photo: S. Siva Saravanan. Retrieved from: http://www.thehindu.com/multimedia/dynamic/01514/VERMICOMPOST_1514058f.jpg

Vermicompost[95]

Vermicomposting is the process of turning organic debris into worm castings. Worm castings are very important to

[94] Chandra, Krishan. Dr. "Organic Manures," Regional Centre of Organic Farming, Bangalore, January 2005. Retrieved from:http://ncof.dacnet.nic.in/Training_manuals/Training_manuals_in_English/Organicmanures.pdf

[95] "Vermicompost," Organic Farming: Compost in Department of Agronomy, Tamil Nadu Agricultural University. Online at:http://agritech.tnau.ac.in/org_farm/orgfarm_vermicompost.html

the fertility of the soil, as they contain high amounts of nitrogen, potassium, phosphorus, calcium, and magnesium. Several researchers have demonstrated that earthworm castings have excellent aeration, porosity, structure, drainage, and moisture-holding capacity. The content of the earthworm castings, along with the natural tillage by the worms' burrowing action, enhances the permeability of water in the soil.

Preparation Method

Vermicompost can be prepared on the floor in a heap, in pits of up to 1 m depth, in an enclosure with a wall (1 meter) constructed with soil, rocks, brick material or cement, or in cement rings. Vermicompost should be prepared in shaded areas.

Selection of earthworms: The non-burrowing type of earthworms (red or purple, live on the soil surface, and eat 90 percent organic waste materials) is used for preparing vermicompost. The burrowing type of earthworms (pale in color, live inside the soil, eat 90 percent soil) is not used for vermicomposting.

Organic materials: The organic residues that can be used are sorghum straw, rice straw after feeding cattle, dry leaves, wheat husk, waste vegetables, soybean residues, weeds, sugarcane trash, animal manure, dairy and poultry wastes, municipal solid wastes, biogas sludge, bagasse from sugarcane factories, etc.

Procedure:

- Cover the bottom of a cement ring (90 centimeters diameter x 30 centimeters height) with a polythene sheet, and spread a layer (15-20 centimeters) of organic waste (50 kg.) onto the sheet. Sprinkle rock phosphate (2 kg.) on this layer.
- Prepare cow dung slurry (15 kg.) and sprinkle it as a layer.
- Fill the ring completely with organic materials in layers.
- Paste the top portion of the ring either with cow dung or soil, and allow the material to decompose for 20 days.
- After 20 days, release selected earthworms (500-750) through cracks.
- Cover the ring with wire mesh or gunny bags to prevent birds from picking the earthworms.
- Sprinkle water (5 liters at 3-day intervals) to maintain adequate moisture and body temperature of the earthworms.
- The vermicompost is ready in 2-2.5 months. It is black, light weight, and has no smell.
- When the compost is ready, remove it from the ring and heap it as a cone. Leave the heap undisturbed for 2-3 hours and allow the earthworms to move down the heap slowly.

- Separate the upper portion, and sieve the lower portion to separate the earthworms, which can be used again.
- Pack the compost in bags and store in a cool place.

Lime Treatment

Gardeners often find that where they use lignin-rich plant materials, the compost does not ripen rapidly. A technique for making good compost from hard plant materials involves mixing lime in a ratio of 5 kg. per 1,000 kg. of waste material. Lime can be applied as dry powder or after mixing with a sufficient quantity of water. Treatment with lime enhances the process of decomposition of hard materials. Instead of lime, powdered phosphate rock can be used in a ratio of 20 kg. per 1,000 kg. of organic waste. Phosphate rock contains a lot of lime. The phosphates and micronutrients contained in phosphate rock make composts rich in plant nutrients.

Vermi-Wash

Vermi-wash is a coppery-brown colored liquid fertilizer obtained by the passage of water through a column of worm activation. It is used as a foliar spray. Vermi-wash is rich in growth hormones like auxin and cytokinin, along with nutrients like nitrogen, potash, phosphorous and other such micronutrients. It acts as a plant tonic, and hence protects it from pest infestation. Vermi-wash, if mixed with cattle urine and water, acts as a bio-pesticide and liquid manure. It also increases the rate of photosynthesis in plants and increases the crop yield and the rate of decomposition of manure when used in composting. The principle behind vermi-wash is that when water is passed through a channel of worm activation, it takes away the secretions from earthworms and nutrients in the decomposed material.[96]

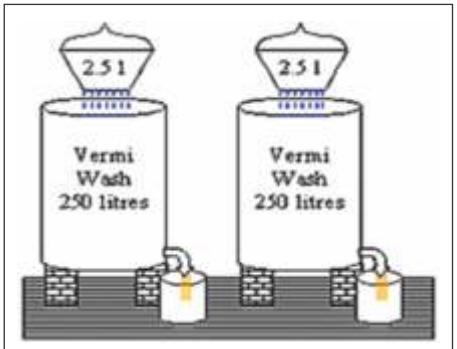

Figure 16 - Vermiwash – design by Vermiwash - Design ERF, Chennai. Retrieved from: http://www.erfindia.org/images/vermiwash.gif

Procedure: The process of vermi-wash can be carried out along with the process of vermicomposting.

- ➢ Drill a hole in the base of the barrel in which vermicomposting is carried out, and fix a tap to collect the water.
- ➢ At the base of the barrel, fix another vessel to regularly collect the vermi-wash.

[96] "Vermiwash," Ecoscience Research Foundation, Chennai. Retrieved from: http://www.erfindia.org/vermiwash.asp

- Fill the barrel with 4-5liters of water every day and within 10 days vermi-wash can be collected.
- Store the vermi-wash in a cool and dry place.

While making vermi-wash certain precautions should be taken: water should be poured slowly, no un-decomposed content should be mixed during watering, any green material should be strictly avoided and also, the content should not be allowed to compact.

Application: Seedlings, before transplanting can be dipped in vermi-wash solution (mix 5 parts water for every 1 part of vermi-wash) for about 20minutes. Similarly, cuttings can also be dipped before transplanting. Diluted vermi-wash (with 5 parts water) can be used to spray the foliage. It provides the plants with vital nutrients and protects them from pest infestation. The soil can be drenched with vermi-wash solution (contains 10 parts water for every 1 part of vermi-wash). This prevents some of the soil borne pathogens.

Panchakavya: *Panchakavya* is an age-old product that helps in promoting growth and providing immunity in plant systems. It consists of 9 ingredients: 10 liters water, 7 kg. cow dung, 10 liters cow urine, 3 liters cow milk, 2 liters curd,, 3 liters tender coconut water, 3 kg. jaggery, 1 kg. ghee, and 12 well-ripened bananas.[97]

Figure 17 Panchkavya ingredients. 1 cow dung, 2. Cow urine, 3. Ghee, 4. Cow Milk, 5. Water, 6.Curd, 7.Jiggery, 8.Tender coconut water and 9.Well ripened banana. Source: Agrimahiti: Free online agricultural information: http://agrimahiti.com/images/OrganicFarming/Pan1.png

Preparation: *Panchakavya* requires a preparation period of 30 days.

- Mix cow dung and ghee thoroughly in a huge earthen or plastic pot and leave it for 3 days with regular stirring in the morning and evening.
- To the above mixture, add the cow urine and water and keep for another 15 days with regular stirring in the morning and in the evening.
- After 15 days, add other ingredients and then leave the mixture for another 12 days under shade and keep it covered to prevent breeding of mosquitoes and flies.

Advantages:

Panchakavya consists of all major nutrients, micronutrients and growth hormones that are essential for plants. Lactobacillus, a bacteria present in curd, produces various essential

[97] "Panchakavya ingredients and method of preparation" Organic inputs and techniques – Organic farming, Tamil Nadu Agricultural University (TNAU) Retrieved from: http://agritech.tnau.ac.in/org_farm/orgfarm_panchakavya.html#Panchakavya

metabolites such as organic acids, hydrogen peroxide and antibiotics, which are effective against other pathogenic microorganisms besides its growth. Generally, *panchakavya* is recommended for all crops.

This solution can also be mixed with irrigation water at 50liters per hectare through drip irrigation or flow irrigation. Before planting the seedlings or sowing the seeds, they can be dipped in a 3 percent solution of panchakavya for 20 minutes. Rhizomes of turmeric and ginger and the sets of sugarcane can be soaked in the 3 percent solution for about 30minutes before planting.

During the pre-flowering stage, the crops can be sprayed with the panchakavya solution fortnightly and post the flowering stage in every 10 days

Green Manure

Green manure is the process of ploughing or turning non-decomposed green plant tissue into the soil to improve the soil quality by supplementing it with organic nutrients. Green manure crops can add nitrogen to the soil (particularly if the crop is a legume like pulses) because of the nitrogen fixing ability of the bacteria present in its roots. Green manure crops protect the soil against erosion and leaching.[98]

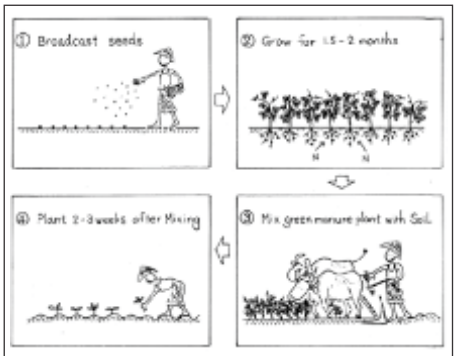

Figure18 Green Manure – retrieved from: http://www.nanaironosora.sakura.ne.jp/LFN/lfnimages/chapter5_images/3.gif

Some green manure crops are:

- Cowpea *(Lobhiya)*: a legume that is effective as green manure because it decomposes easily. It should be planted in June and July.
- Dhaincha: a green manure crop suited for loamy and clay-richsoil. It can correct the alkaline level of soil if planted continuously for 4-5 years. It is fairly resistant to drought and water stagnation.
- Sunn hemp *(Sunn)*: a fast growing green manure crop, which is ready for incorporation within 45 days of sowing. However, the crop cannot withstand heavy irrigation and is prone to damages by the leaf-eating caterpillars.
- Wild Indigo *(Sarphonk/Sharponkha)*: Grows well in light-texture soil, like single crop wetland. Wild indigo is a slow-growing green manure crop which the cattle do not

[98] "Green Manure: What is Green Manure?" Tarahaat. Retrieved from: http://www.tarahaat.com/organic_green.aspx

prefer grazing. Because its seeds have a waxy, impermeable coating, scarification is required to induce germination. Another way to induce germination is tosoak the seeds in boiling water for 2-3 minutes.

- Pillipesara *(Safed Musli)*: This is a dual-purpose crop, as it is a source of fodder for cattle and is also a green manure crop. It grows well in loamy and clay-rich soil.
- Karanj: A leguminous tree grown in wastelands. On an average, a tree can yield 100-120kg. of green matter. The leaves contain about 3.7 percent Nitrogen (on dry weight basis).

Green manure crops are to be incorporated into the soil before the flowering stage, because they are grown for their green leafy material, which is high in nutrients and protects the soil. Green manure does not break down in the soil quickly; therefore, some nutrients should be gradually added to the soil for the next crop. Besides improving the physical and chemical properties of the soil, green manure also provides nutrients to the standing crops and to the next crops. Cultivation of green manure crops prevents the growth of weeds. Moreover, since most of the green manure crops are leguminous, their cultivation in between the crops reduces the application of nitrogen fertilizers.[99]

[99] "Green Manure," Chapter-5, Soil Fertilization and Conservation, 5.3 Green Manure in Lessons from Nature. Retrieved from: http://www.nanaironosora.sakura.ne.jp/LFN/5_3.html

Chemical-free and Organic Pesticides

In order to grow, plants need a well-balanced diet. They also need to be protected from insects and pests. The Green Revolution introduced chemical pesticides in India that were effective in deterring pests that proved very harmful for plants, as well as for the animals and humans who consumed them.

Exposure to chemical pesticides like DDT can affect the central nervous system. Large quantities of the pesticides seep into the groundwater, and are eventually consumed by humans and animals. Some of these pesticides are also absorbed by the skin, leading to behavioral changes, encephalopathy, seizures and coma among children. Farmers exposed to chemical herbicides for over 20 years can suffer from non-Hodgkin's lymphoma.[100]

Exposure to chemical pesticides also affects the human reproductive system, leading to early puberty among girls, endometriosis and several hormonal disruptions among women, and lower sperm count in men, among other ailments. Several researches claim that the unprecedented increase in the number of cancer victims could be attributed to the excess consumption of pesticides present in food. Some of these pesticides also robbed the soil of nutrients that are necessary for the growth of plants.[101]

The long-term use of these chemicals has also led to the evolution of new breeds of pests that are resistant to chemical pesticides. Pesticides also harm wildlife in direct and indirect ways, causing poisoning or death.[102]

To combat the harmful effects of chemical pesticides and to reverse the slow process of topsoil degradation, scientists recommend the use of traditional and organic pesticides. Organic pesticides are made from cattle waste, and medicinal plants like *neem* and vegetable waste. These pesticides were historically used for controlling pest infestation. But since their preparation was tedious and time-consuming, farmers were encouraged switch to high-priced chemicals. However, in recent decades, as farmers around the world became aware of the harmful effects of chemicals, they have begun switching back to organic pesticides.

The following section explains how to prepare and apply some of the organic pesticides.

[100] Schinasi, Leah. Leon, E. Maria."Non-Hodgkin Lymphoma and Occupational Exposure to Agricultural Pesticide Chemical Groups and Active Ingredients: A Systematic Review and Meta-Analysis," Int J Environ Res Public Health, Apr 2014; 11(4): 4449–4527. Published online Apr 23, 2014. doi:10.3390/ijerph110404449. Retrieved from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4025008/

[101] Bergman, Åke. Et.al. (Eds.), "State of the Science of Endocrine Disrupting Chemicals – 2012, Inter-Organization Programme for the Sound Management of Chemicals, United Nations Environment Programme and the World Health Organization, 2013.

[102] Shiva, Vandana. Dr. et al."Chemical farming: Damage to the environment," in Principles of Organic Farming: Renewing the Earth's Harvest, Chapter-II, Navdanya, New Delhi, 2004.

Natural Pesticides[103]

Natural pesticides are the cheapest and the safest alternative to chemical pesticides. Before they are used, natural pesticides need to be dried in the sun, as direct sunlight can break up the active ingredients. *Neem* leaves and pulp mixed with water makes an effective insecticide. Similarly, seeds of custard apple, chili and pepper, as well as tobacco leaves containing nicotine are all potent insecticides that keep pests at bay.

Canavalia *(Khadsampal/Badisem)* is another plant that is effective on leaf-cutter ants. The ants do not eat the leaves they cut, but they do use them to breed a particular fungus they feed on. Canavalia prevents the breeding of this fungus, thus starving the ants. Cow's milk is also an effective pesticide, as mixing it with flour and water and spraying the solution kills insect eggs and acts against some virus-carrying insects.

Natural predators like snakes feed on rodents like rats. Even insects such as spiders eat small insects that harm crop and act as natural pesticides.

Several organic pesticides can be prepared by using natural resources. Some are listed below:

Agniastra[104]

Subash Palekar, (well known for zero budget natural farming) has developed several natural pesticide formulations that can easily be made from ingredients available to farmers. *Agniastra, neemastra* and *jiwamrita* are few such natural pesticides.

Agniastra's main ingredient is cow urine and is used for preparing organic mixtures and pest control solutions. Other natural herbs used in this are tobacco leaves, garlic, pepper, jaggery, green chili and water. This natural pesticide can be applied on vegetables, fruits, flowers and other agricultural crops. It is effective on leaf rollers, stem borers, fruit borers and pod borers.

Figure 19 - Desi Cow Urine, Tobacco Leaves, Garlic, Green Chilli, Neem paste[105]

[103] "Natural Pesticide Recipes," Nursery Manuals – Appendix 2, World Agro-forestry Centre. Retrieved from: http://www.worldagro-forestrycentre.org/NurseryManuals/Community/Appendix2.pdf

[104] "Agniastra," How to prepare a Agni Astra – Insect and pest management, KrishiKa Rishi, Zero Budget Spiritual Farming. Retrieved from: http://palekarzerobudgetspiritualfarming.org/Agniastra.aspx

[105] Photo credits: Desi Cow: Desi cow and calf - http://pasuthai.com/blog/wp-content/uploads/2013/07/599903_497792670236131_531775489_n.jpg; Cow Urine: http://eofdreams.com/data_images/dreams/garlic/garlic-12.jpg ; Tobacco leaves: http://upload.wikimedia.org/wikipedia/commons/6/6c/Kenbano_tobacco_leaf.jpgGarlics: http://eofdreams.com/data_images/dreams/garlic/garlic-12.jpg; Green Chilli: http://oddanchatramvegetablemarket.com/wp-content/uploads/2014/06/green-chilli.jpg; crushed neem leaves: http://pad2.whstatic.com/images/thumb/c/c0/Make-Fresh-Neem-Leaves-Paste-Step-3-Version-2.jpg/670px-Make-Fresh-Neem-Leaves-Paste-Step-3-Version-2.jpg

Ingredients: 10 liters cow urine, 1 kg. crushed tobacco leaves *(tambakhoo)*, 500 g. green chili, 500 g. garlic, 5 kg. *neem* leaves pulp.

Method of preparation:

- Make a thick paste of all the ingredients and mix it thoroughly with cow urine.
- Heat the contents and allow it to boil 5 times.
- Leave the mixture to ferment for 24 hours.
- Filter the contents through a cloth into a vessel.

While preparing Agniastra, ensure that no chemicals are added into it.[106]

Agniastra needs at least 21 days to be prepared and it should be used once every 4 days for the first and second applications, and once in a week for the subsequent application. The best time for application of agniastra is either in the early morning or evening hours.

Application:

1 litre of agniastra can be mixed with 50 liters of water and can be sprayed on the crops.[107]

Advantages:

- Acts as manure for soils and plants.
- Removes all kinds of pests and insects, and also improves the richness of the soil.
- Enriches the greenery of the plant.
- Yield level improvement.

Neemastra[108]

Neemastra is effective on removing pests and mealy bugs. The main ingredients of neemastraare: 100 liters water, 5 liters desi cow urine, 5 liters desi cow dung, 5 kg. crushed neem leaves

Method of preparation:

- Add cow urine to 100 liters of water.
- To this liquid mixture, add 5 kg. of cow dung and crushed neem leaves and its pulp.
- Let the solution ferment for 24hours.
- Stir the solution twice in a day with a stick.
- Filter the mixture using a cloth.

[106] http://palekarzerobudgetspiritualfarming.org/Agniastra.aspx

[107] ibid.

[108] "Neemastra" – How to prepare Neemastra, Insect and Pest Management, KrishiKa Rishi, Zero Budget Spiritual Farming, in Palekar's Zero Budget Farming. Retrieved from: http://palekarzerobudgetspiritualfarming.org/Neemastra.aspx

Figure 20. Neem Astra Ingredients: water, Desi cow urine, Desi cow dung, and neem leaves paste[109]

Figure 21. Filter the solution after 24 hours and spray in the field as per the method of application

Application:

Mix 2 litersof the *neemastra* with 100 liters of water and spray on the crops.

Jiwamrita[110]

This is the mixture of cow dung, urine, jaggery, pulse floor and soil from bund. Itis primarily used to spread over the soil to expedite the growth of the plants and give the soil more nutrients.

The main ingredients of jiwamrita are: 200 liters water, 10 kg. desi cow dung, 5-10 liters desi cow urine, 2 kg. jaggery, 2.5 kg. ground flour of pulses, and a handful of soil.

Method of preparation:

- Mix water, cow dung and cow urine together in a barrel.
- Add ground pulses and a handful of soil to the mixture.
- Stir the solution and keep it to ferment for 48 hours, away from sunlight.

[109] Neemastra photo credits: water container - http://www.aawaste.co.uk/120%20Litre%20TH120LTR.jpg
cow urine - http://media.geekgardener.in/wp-content/uploads/cow-urine-pr.jpg
Mix cow urine and cow dung - http://media.geekgardener.in/wp-content/uploads/cow-dung.jpg
crushed neem leaves - http://pad2.whstatic.com/images/thumb/c/c0/Make-Fresh-Neem-Leaves-Paste-Step-3-Version-2.jpg/670px-Make-Fresh-Neem-Leaves-Paste-Step-3-Version-2.jpg
cow dung - http://cdn.yourstoryclub.com/wp-content/uploads/cow_dung_ organic_residual_excrement.jpg
filter with a cloth - http://www.worm-composting-help.com/images/Wormteapreparedforbotteling.jpg
man spraying - http://images.wisegeek.com/men-spraying-pesticides-in-field.jpg

[110] "Jiwamrita, How to Prepare Jiwamrita," Four wheels of Zero Budget Natural Farming, KrishiKa Rishi, Zero Budget Spiritual Farming, in Palekar's Zero Budget Farming. Retrieved from: http://palekarzerobudgetspiritualfarming.org/Jiwamrita.aspx

Application:

Jiwamrita can be applied at the time of irrigation or can be directly applied to the crops. It can also be sprayed on the plants in a 10 percent solution (10 liters water and 1 litre *jiwamrita* solution).

Figure 22. Jiwamrita ingredients: water,desicow urine,desicow dung, jaggery, pulses flour, handful of soil[111]

Bijamrita[112]

This organic preparation is used for treating seed, seedlings or any planting material. The planting material has to be simply dipped in bijamrita before planting. It protects the crop from harmful soil borne and seed borne pathogens during the initial stages of germination and establishment.

Ingredients: 20 liters water, 5 kg. desi cow dung, 5 kg. desi cow urine, 50 g. lime, one handful of soil from the bund of the farm.

Method:

- Take 5kg. cow dung and tie it in a piece of cloth and make it into a small bundle. Fill a bucket with 20 liters of water and suspend the cow dung bundle in it for 12 hours.
- Every 4hours, squeeze the cow dung bundle tightly to get all the essence into the water.
- Take one liter of water and add 50 g. of lime powder into it. Mix well and keep overnight to stabilize the solution.

Figure 23. Bijamrita ingredients: Desi cow dung, water, desi cow urine, lime and handful of soil[113]

[111] Jiwamrita ingredients – photos courtesy: Water Drum - http://teja1.kuikr.com/i4/20150104/Blue-coloured-water-drum-200-litres-ak_L1298136891-1420345594.jpeg
cow dung - http://cdn.instructables.com/FBS/G6EO/I0LCD5EU/FBSG6EOI0LCD5EU.MEDIUM.jpg
cow urine - http://www.dailyexcelsior.com/wp-content/uploads/2013/02/4.jpg
jaggery - http://i1.ytimg.com/vi/aB4U5Kd6JJ0/0.jpg
pulses flour - http://agr.mt.gov/agr/_imageGallery/Images_NPGAPhotos/pulse_4309.jpg_116529035.jpg
handful of soil -http://www.evergreeninc.net/landscape/images/hands.jpg

[112] "How to Prepare Bijamirta,"Zero Budget Spiritual Farming. Retrieved from: http://palekarzerobudgetspiritualfarming.org/bijamrita.aspx

[113] Bijamrita ingredients – photos credits: WATER DRUM - http://teja1.kuikr.com/i4/20150104/Blue-coloured-water-drum-200-litres-ak_L1298136891-1420345594.jpeg
cow dung - http://cdn.instructables.com/FBS/G6EO/I0LCD5EU/FBSG6EOI0LCD5EU.MEDIUM.jpg
cow urine - http://www.dailyexcelsior.com/wp-content/uploads/2013/02/4.jpg
handful of soil -http://www.evergreeninc.net/landscape/images/hands.jpg
Lime - http://www.briquetting-machine.com/upLoad/news/month_1407/201407111426489866.jpg

- The next day, take out the cow dung bundle from the bucket and add a handful of soil, cow urine and lime solution to the cow dung solution. This solution is now ready for use.

Application:

Add the *bijamrita* to the seeds spread for sowing and allow the seeds to dry.

Brahmastra[114]

Brahmastra is another natural pesticide that can be easily prepared from raw materials often readily available to farmers. Brahmastra is also a component of low budget self prepared organic farming. It is used as a preventive as well as curative measure for heavy pest attacks.

Ingredients : 10 liters cow urine, 3 kg. neemleaves, 3 liters neem leaf pulp solution, 2 kg. pulp of custard apple (sitaphal) leaves, 2 kg. pulp of papaya (papita) leaves, 2 kg. pulp of pomegranate (anar) leaves, 2 kg. pulp of guava (amrud) leaves, 2 kg. pulp of Lantana Camella, 2 kg. pulp of white dhatura leaves.

Method of preparation:

- Mix the cow urine and pulp of neem leaves together.
- To this, add the pulp of the leaves of custard apple, papaya, pomegranate, guava, lantana Camilla and white dhatura and bring it to boil five times.
- Filter the solution using a cloth and allow the solution to ferment for 24hours.

Application:

Spray *brahmastra* solution (1 part *brahmastra* solution in 50 parts water) on the crops to control sucking pests, pod borers and fruit borers.

Growth Promoters – Fermented Buttermilk/Coconut milk[115]

This is a form of manure that can be made easily and can also be usedfor home-based vegetables and crops.

Ingredients : 5 liters buttermilk, 5 liters coconut milk

Method of preparation:

- Mix 5 liters each of coconut milk and buttermilk in a large pot.
- Allow the mixture to ferment for about a week.
- At the time of spraying, mix the above solution with water in the ratio of 1:10 (i.e. for every 1literof the solution, mix 10 liters of water).

[114] "How to Prepare Bramhastra (Bramha Missile)," Zero Budget Spiritual Farming. Retrieved from: http://palekarzerobudgetspiritualfarming.org/Bramhastra.aspx

[115] "Manures - Fermented Buttermilk & Coconut Milk Solution," Agriculture for Everybody, September 2013. Online at:http://agricultureforeverybody.blogspot.in/2013/09/fermented-buttermilk-coconut-milk.html

Application:

Spray the mixture on crops after fermenting it for a week. For best results, spray this mixture during the flowering stage of crops. Spraying of this mixture enhances plant growth, including flowering; repels insects; and increases resistance to fungal diseases. This mixture can also be used during irrigation at the rate of 5-10 liters per acre.

Pest Repellent[116]

Ingredients to prepare a pest repellent:

Leaves of certain plants that cattle do not relish, like lantana[117] (also known as *Lantana Camara* which is a weed), plants with milky latex (e.g. calotropis), leaves with bitter taste like neem and aloe vera, leaves with sour taste like *jatropha* and leaves with bitter-sour taste. Together, these leaves should be around 2kg.These pest repellents can be prepared by either boiling or soaking the ingredients together in water.

Figure 24. Lantana weed

Boiling Method: Cut the leaves and put them in an earthen pot with 10litersof water and boil the mixture till it reduces to half (around 5 liters).Cool the mixture and add 1kg.of turmeric powder, and keep it for 24hours.

Soaking Method: Cut and mix the leaves with 2 parts of cow dung and 4 parts cow urine in an earthen pot and keep the pot away from sunlight for a week.

Application:

The pest repellent obtained by either of the methods should be mixed with water in the ratio of 1:10 (One liter solution and 10 liters of water) and then sprayed on crops. Based on the extent of pest infestation, this can be sprayed twice or thrice over a week or 10 days.

Pest Repellents to Control Fruit Borers

Fruit borer pests are a menace to farmers, as they can damage 30-100 percent of vegetable and fruit crops. Farmers spend huge sums of money on spraying these insecticides. This problem is not only affecting human health and environment, but is also causing a huge drain on farmers' revenues due to crop losses and high costs. The organic pest control method can effectively defeat pests and save farmers from spending too much on dreadful chemical pesticides. This repellent is mostly used by farmers in Tamil Nadu.

[116] Pest Repellents, Crop Protection in Organic Farming Techniques n Myrada Krishi Vigyan Kendra, Erode, Tamil Nadu. Retrieved from: http://www.myradakvk.org/index.php?option=com_content&view=article&id=28&Itemid=24&lang=en#growth

[117] Lantana weed, photo courtesy: http://ponsetilandscaping.com/wp-content/uploads/2013/07/Lantana.jpg

Ingredients:

1-2 kg. *neem* seeds, 1-2 kg. *ghoraneem* or bakain, 1-2 kg. *karanja* seeds, 1 kg. *haritaki* seeds, 100-500 g. custard apple seeds *(Sitaphal)*, 100-500 g. golden nerium seeds.

Method of preparation:

- Grind any one of the above seeds into powder and mix it with 4-5 liters of water.
- Boil the solution till it is reduced to half and let cool.
- Once this mixture is cool, mix it with the pest repellent obtained via soaking or boiling method.

Figure 25 Ingredients for fruit borer organic pesticide: neem seeds, ghoraneem seeds, karanja seeds, custard apple seeds, golden nerium seeds and haritaki seeds.[118]

Application:

This pest repellent should be sprayed in the morning and evening time to control fruit borers pests.

[118]Pest repellent ingredients for fruit borer. Photo credits : Neem seeds - http://onevillage.org/neemseeds(big).jpg
ghora neem (bakain) seeds - http://upload.wikimedia.org/wikipedia/commons/0/01/Indian_Grey_Hornbill_(Ocyceros_birostris)_eating_Bakain_(Melia_Azadirachta)_berries_at_Roorkee,_Uttarakhand_W_IMG_9016.jpg
karanja seeds - http://www.heenatradingco.com/wp-content/gallery/forest-plant/karanja-tree.gif
Haritaki seeds - http://bff.nithyananda.org/wp-content/uploads/2013/03/haritaki1.jpg
Custard apple seeds - http://healthbenefitstimes.com/9/uploads/2012/12/Pinks-Mammoth.jpg
Golden Nerium seeds - http://upload.wikimedia.org/wikipedia/commons/f/fe/Nerium_oleander_seeds.jpg

Natural Predators and Trap Crops

There are several living organisms that reduce the occurrence and attacks of pests and diseases. They are usually found in plenty in any crop field. Some of these are useful for farmers, as they tend to control several pests that attack crops. These organisms are called natural predators (the organisms that are hunters) or natural enemies who feed on their prey (the organism that is attacked). Natural enemies can be classified into three groups: predators, parasites, and pathogens.

Predators: Animals or insects that hunt and eat other animals or insects. Predators include tigers, snakes, spiders, and ladybird beetles. They consume their prey for their daily dietary requirements. Predators have bodies designed to hunt, catch, kill and eat prey.[119] Tend to keep populations in check in three ways: by killing or eating prey, causing injury or causing diseases.

Parasites: Parasites also consume their victims by entering their body and obtaining nourishment from their fluids and tissues, which weakens or kills them. The parasites that attack insects are usually species of wasps or flies. An adult searches for a host and then lays eggs in or on the host's body.

Insect parasites can be classified as follows:

- Egg parasites lay their eggs in the eggs of other insects.
- Larval parasites lay their eggs in or on the larval stage of other insects.
- Pupal parasites develop in the pupal stage of other insects.
- Some parasites develop in the nymphal or adult stage of their hosts.[120]

Pathogens : Pathogens are microorganisms that cause disease by entering the body of their host, living and multiplying within, and weakening and killing it. Some pathogens require more than one kind of host to complete their life cycle. Types of pathogens include bacteria, fungi and viruses. Insects attacked by pathogens are usually swollen, exhibit color changes, move slowly, often stop eating and may be covered with a powdery substance.[121]

[119] "Natural Enemies," Sweet potato ICM technical manual, retrieved from:http://www.eseap.cipotato.org/MF-ESEAP/TResources/FFS-ICM-SP/III-4.pdf

[120] Ibid.

[121] Ibid.

Farmers can take advantage of the presence of various types of natural predators by taking care of them without destroying them. Some of the predator insects and plants are given below:[122]

Ladybird beetles : Adult ladybird beetles are round and small (1-10 mm long) and are usually colored in some combination of black and red, orange, or yellow, and often have spots on their wing covers. The adults and larvae of ladybird beetles are important predators of aphids. A single ladybird can eat 200-300 aphids in its lifetime.[123]

Figer 27 Lady Beetle - http://upload.wikimedia.org/wikipedia/commons/6/65/P-14_lady_beetle.jpg

Hover flies : Also known as flower flies, these belong to a big family varying from small to large flies. They are among the most frequent visitors of flowers in the crop fields, vegetable gardens and flower gardens. Hoverflies have spots, bands or stripes, of yellow, brown against a dark-colored background, sometimes with dense hair covering the body surface. Hover flies stay motionless in the air like a helicopter. They hover in the air to feed on nectar from flowering plants. They are very helpful in pollination. Their larvae are very useful as they are natural enemies of aphids and small caterpillars.[124]

Figure 28. Helicoverpa armigera. Photo courtesy: http://en.wikipedia.org/wiki/File:Helicoverpa_armigera.jpg

Ants: Ants are predator insects and attack many different types of prey. Ants can be very useful in combating caterpillars and other harmful pests that attack crops. They are considered to be one of the most important natural enemies of Helicoverpa armigera - the African Bollworm. This bollwormis a moth, the larvae of which feed on a wide range of plants, including many important cultivatedcrops. It is a major pest in cotton.

Trap Crops

Farmers can easily grow some cover crops (also called "trap crops") to keep pests away from the main crop. This can be done by companion planting in the crop field. When a trap crop is

[122] "Natural Enemies (farmers' friends)," Network for Sustainable Agriculture. Retrieved from: http://www.aglearn.net/resources/vegIPM/naturalEnemies.pdf

[123] "Lady Beetles," retrieved from: http://www.biokids.umich.edu/critters/Coccinellidae/

[124] "All about Hover Flies," retrieved from: http://www.microscopy-uk.org.uk/index.html?http://www.microscopy-uk.org.uk/mag/ artmay07/cd-hoverflies.html

planted near the main crop, the harmful insects tend to migrate to the trap crops, leaving the main crop unaffected.

Trap crops can be planted around the circumference of a large field or interspersed among crops on small land holdings. This form of companion planting can often save the main crop from decimation by pests without the use of pesticides. Farmers should select trap crops in accordance with the duration of the main crop and grow them during the same season.

Different Types of Trap crops

There are several types of trap crops. One of the most commonly used methods is known as "positive hosting." It involves crops or plants with significant pollination requirements benefitting from certain types of flowers. Flowers attract bees and other pollinating insects that benefit the crop.

Here is a list of crops, pest and trap crops for easy reference :[125]

	CROPS	PEST	TRAP CROP
1	Cotton, groundnut	Spodoptera	Castor, sunflower
2	Cotton, Chikpea	Helicoverpa	Marigold
3	Pigeonpea	Helicoverpa	Marigold
4	Groundnut	Spodoptera	Castor
5	Cotton	Spotted Bollworm	Bhindi
6	Cabbage	Diamond Back Moth	Mustard

Tips for successful trap cropping:[126]

- Make a farm plan - This will guide you on where the trap crops are to be sown or planted.
- Learn to know and identify the pests.
- Select a trap crop that is more attractive to the pest than the main crop. Ask for assistance from your local agriculturist.
- Monitor your plants regularly.
- Immediately control the pests that are found in the trap crop.
- Prune or remove trap crops once the pest population is high, otherwise they will serve as the breeding ground and the pests will attack the rest of your farm.
- Be ready to sacrifice your trap crop as an early crop and destroy them once pest infestation is high.

[125] "Empowering Agriculture, Food Processing and Food Safety," retrieved from: http://www.efreshglobal.com/eFresh/Content/Free.aspx?u=npmComponents

[126] "Trap Cropping," Online Information Service for Non-Chemical Pesticide Management. Retrieved from: http://www.oisat.org/ control_methods/cultural__practices/trap_cropping.html

Some Useful Contacts for Agroecological Farming Practices

Agroecological Practices	Organisations/Individuals, who can be contacted for Technical Assistance
Biodynamic Farming	Bio-Dynamic Association of India (BDAI) BDAI Secretariat, c/o EcoPro, Aurosarjan Complex, Auroshilpam, Auroville - 605 101, Tamil Nadu Phone: 09443137112, Email: lucasdl@auroville.org.in
	Biodynamic Association of India BDAI, c/o ICRA, 22, Michael Palya New Thippesandra, Bengaluru – 560075, Karnataka Phone: 080-25283370 / 25213104, Email: bdaind@gmail.com
Organic Farming	Organic Farming Association of India (OFAI) G-8, St. Britto's Apartments, Feira Alta, Mapusa -403 507, Goa Phone: 0832 - 2255913/ 2256479/ 2263305, Email: myofai@gmail.com
	Organic Farmers Association A/p Bedkihal, Taluq Chikodi, District Belgaum, Karnataka. Pin- 591214 Phone: 08338 - 262056, Mobile: 0-9480448256 Email: deshisuresh@gmail.com
	All India Organic Farmers Society 6A, Namdev Complex, Sirsa Road, Hisar-125001, (Haryana) Phone/Fax: 01662 - 2241164, E-mail: info@aiofsindia.com
Permaculture	Sadhana Forest, Auroville – 605101, Tamil Nadu. Phone: 0413 - 2677682 or 2677683 or 2002655 Email: sadhanaforest@gmail.com
Zero Budget National Farming	Zero Budget Spiritual Farming Research Shri Subhash Palekar 19, "CHANDA SMRITEE", Jaya Colony, Near Telecom Colony, Sai Nagar Post, Amravati– 444 607 (MAHARASHTRA) Phone: 09423601004, 09673162240, 09850352745 Email: palekarsubhash@yahoo.com
Vermi Compost and Vermi Wash	Dr. Sultan Ahmad Ismail Director, Ecoscience Research Foundation 99 Baaz Nagar, 3/621 – East Coast Road, Palavakkam, Chennai – 600041 Phone: 0-9384898358, Email: sultanismail@gmail.com
Expert on Soil Sciences	Om P. Rupela, Former Scientist of ICRISAT, 120, Phase 1, Saket Township, Kapra, ECIL-Post, Hyderabad – 500062, Andhra Pradesh Phone: 09490621798, Email: oprupela@gmail.com

Notes :

Focus on the Global South

Focus on the Global South is a policy research organisation based in Asia (Thailand, Philippines and India). Focus provides support to social movements and communities in India and the Global South by providing research and analysis on the political economy of globalisation and on the key institutions underlying this process. Focus' goals are the dismantling of oppressive economic and political structures and institutions, the creation of liberating structures and institutions, demilitarization, and the promotion of peace.

Rosa Luxemburg Stiftung (RLS)

The Rosa Luxemburg Stiftung (RLS) is a Germany-based foundation working in South Asia as in other parts of the world on the subjects of critical social analysis and civic education. It promotes a sovereign, socialist, secular and democratic social order, and aims to present alternative approaches to society and decision-makers. Research organisations, groups for self-emancipation and social activists are supported in their initiatives to develop models which have the potential to deliver greater social and economic justice.