Study Material on Natural Farming

NATIONAL INSTITUTE OF AGRICULTURAL EXTENSION MANAGEMENT (MANAGE)
(An Autonomous Organization of Ministry of Agriculture and Farmers Welfare, Government of India)
Rajendranagar, Hyderabad-500030, Telangana State, India.
www.manage.gov.in

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About the Publication

Natural Farming- Study Material for Master Trainers was prepared with the help of experts from different organisations like WASSAN, CSA, Patanjali, Isha Foundation, Art of Living, ICAR, SAUs, NCOF, PRAN and Natural Farming Practitioners who participated in the **"National Workshop for Module Development for Natural Farming during 24-29 July, 2023"** and contributed study material through online and offline.

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List of Experts and Practitioners participated through online and offline in the "National Workshop for Module Development on Natural Farming" during 24-29 July, 2023 at MANAGE and also contributed for development of Study Material

Mr. Anil Kumar Verma, Chief Functionary, PRAN, Gaya

Ms. Anusha Jookuri, Founder, LR Products. Hyderabad, Telangana,

Mr. Ashraf Ali , Operational Coordinator, Isha Foundation, Coimbatore, Tamil Nadu

Dr. C. P. Chandrashekhara, Professor and PI of NPOF, UAS Dharwad

Dr. H.B. Babalad, Dean (Agri), College of Agricuture, UAS, Dharwad

Mr. E Anand, Project Director, Isha Foundation, Coimbatore, Tamil Nadu

Dr. Gagnesh Sharma, Director I/c, National Centre for Organic and Natural Farming (NCOF), Ghaziabad, Uttar Pradesh

Mr. Jagadeesh Reddy, Natural Farmer and Practitioner Chittoor, Andhra Pradesh

Dr. Jagat Ram Verma, Subject Matter Specialist (SMS), Dept of Agriculture, PK3Y SPIU-HP

Mr. Jagat Singh, Deputy Director, National Centre for Organic and Natural Farming (NCOF), Ghaziabad, Uttar Pradesh

Dr. K S Varaprasad, Senior Consultant & Former Director, ICAR-IIOR, Hyderabad, Telangana

Mr. Kosaraju Suresh, Consultant, Agriculture and Communication, Hyderabad

Mr. Kumar Neeraj, Director, KHETEE, Lakhisarai, Bihar

Mr. Mohinder Singh Bhawani, Deputy Director of Agriculture, Dept of Agriculture, PK3Y SPIU-HP

Dr N. Ravisankar, Principal Scientist (Agronomy), ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh

Mr. Pawan Kumar, Chief General Manager, Patanjali Research Institute, Haridwar, Uttarkhand

Dr. R. K. Ravikumar, Scientist National Innovation Foundation, Gandhinagar, Gujarat

Dr. R. Raman, Professor of Agronomy, Director, Centre for Natural Farming and Sustainable Agriculture, Tamil Nadu

Dr. Raghuveer Singh, Scientist, ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut

Mr. Rajashekhar, COO & Program Manager, Centre for Sustainable Agriculture (CSA), Hyderabad

Dr. Rajashekhar Basnaik, Assistant Professor, UAS Raichur

Dr. Ramanjaneyulu, Executive Director, Centre for Sustainable Agriculture (CSA), Hyderabad, Telangana

Mr. Ravindra A, Director, Watershed Support Services and Activities Network (WASSAN), Hyderabad, Telangana

Ms. Roopal Jena, Regional Coordinator, WASSAN

Dr. S. Jawahar, Faculty of Agriculture, Annamalai University, Tamil Nadu – 608002

Dr. Sabyasachi Das
Director, WASSAN and National Coordinator, Hyderabad

Mr. Sandeep C S, Technical Expert on Natural Farming, WASSAN

Dr. E. Somasundaram, Professor, Directorate of Crop Management, and PRO of Tamil Nadu Agricultural University, Coimbatore

Dr. Sudhir Verma, Principle Scientist (Soil science), Dr. Y. S. Parmar University of Horticulture & Forestry, Solan. Himachal Pradesh

Ms. Umamaheshwari Chakilam, Director-Projects, Art of Living, Bengaluru, Karnataka

MANAGE Team

Dr. N Balasubramani, Director (CSA & CCA), MANAGE, Hyderabad

Dr. Sreelakshmi. C., Academic Associate, MANAGE, Hyderabad

Dr. S. K. Jamanal, Consultant, MANAGE, Hyderabad

FOREWORD

Green Revolution has transformed India from Food Deficit to Food surplus country. But, now the country is facing second generation problems especially sustainability of natural resources such as deterioration of soil health, depletion of groundwater, depletion of bio diversity, degradation of ecology and environment, poor nutrition and less farm income due to high input cost etc.

Government has realized the need for long term strategy to address these challenges and to ensure sustainable food system. Hence, various schemes and programmes such as Paramparagat Krishi Vikas Yojana (PKVY), Rashtriya Krishi Vikas Yojana (RKVY), National Mission on Sustainable Agriculture (NMSA) and Bharatiya Prakritik Krishi Paddhati Programme (BPKP) etc., were launched to address these challenges.

In addition to this, Government is also promoting Natural Farming as one of the strategy to optimize the efficiency of natural resources, conserve and enhance agro biodiversity, augment climate resilience and ensure economic viability of farm. The Hon'ble Prime Minister of India Shri. Narendra Modi Ji has also highlighted "Need to take farming out of chemistry lab and connect it to nature's lab" in the National Conclave on Natural Farming at Gujarat on 16th December, 2021.

In this context, Ministry of Agriculture and Farmers Welfare has designated National Institute of Agricultural Extension Management (MANAGE) as the Nodal Organization and Knowledge Repository for promoting Natural Farming.

As a part of this, National Institute of Agricultural Extension Management (MANAGE) has conducted a National Workshop for Module Development for Natural Farming during 24-29 July, 2023 by inviting experts and practitioners of natural farming such as State Agricultural Universities, ICAR institutes, Isha Foundation, Art of Living, Patanjali, WASSAN, National Centre for Organic Farming (NCOF), Centre for Sustainable Agriculture etc.. With the help of these organizations a comprehensive study material covering various aspects of Natural Farming has been developed for Master Trainers. The study material will help Master Trainers and Extension Functionaries to create awareness and sensitize the farmers at Grass root level.

I thank all the practitioners and scientists for sharing their study material. I congratulate WASSAN and Centre for Climate Change and Adaptation (CCA) team, MANAGE for collating the available material and bringing out a very comprehensive study material for the benefit of various stakeholders associated with Natural Farming.

(P. Chandrashekara)
Director General
MANAGE

Content

Introduction to Natural Farming

NATURAL FARMING

01. OVERVIEW OF NATURAL FARMING

The production of food within India was insufficient in the years from 1947 to 1960 as there was a growing population. Food availability was only 417 g per day per person. Many farmers were in debt, and they had become landless laborers. There was a severe shortage of food grains as well as agri-based raw material for industries.

What is the Green Revolution?

During 1960s chemical fertilizer based intensive agriculture was introduced in the regions with assured irrigation. This went with the name 'Green Revolution' (GR). The traditional varieties, which were long would not respond to the chemical fertilizers. Hence, dwarf, sturdy and short duration varieties were introduced which went by the name High-Yielding Varieties (HYVs). In fact, they are only high-responding (to chemical fertilizers) varieties. It is true that the GR helped in increasing food production in the country, mainly due to: (1) increased area under farming, (2) double-cropping, (3) adoption of HYV of seeds, (4) increased use of inorganic fertilizers and pesticides, (5) improved irrigation facilities, etc.

After the green revolution, the production of cereal crops tripled with only a 30% increase in the land area cultivated. Studies also showed that without the green revolution, caloric availability would have declined by around 11–13%. The green revolution helped India move from a state of importing grains to a state of self-sufficiency.

However, critics observed that this 'self-sufficiency' in food grains was achieved with the increase in imports of crude oil, fertilizers, edible oil, etc. Further, some adverse effects of the green revolution were noticed. Hence, it needs to be checked for its eco-friendliness and sustainability features.

Carrying forward intensified usage of pesticides is not advisable in an ever-deteriorating environment, and alternative solutions that can promote economic growth, increased yield, and less harm to the environment can be implemented. The vicious cycle of problem-solution-negative impacts has to be broken at some point of time. Instead of this, techniques to promote sustainable agriculture can be considered. Hence, there has to be a wake-up call before the repetition of history.

IMPACTS OF THE GREEN REVOLUTION

IMPACTS ON AGRICULTURE AND ENVIRONMENT

Pests and Pesticide

There has been a significant increase in the usage of pesticides, and India became one of the largest producers of pesticides in the whole of Asia. For instance, it is reported that the presence of pesticides within freshwater is a costly concern with detected levels exceeding the set limits of pesticide presence. Although the average amount of pesticide usage is far lower than in many other countries, there is high pesticide residue in India. This causes a large amount of water pollution and damage to the soil. Another major issue is the pest attack, which arises due to an imbalance in the pests. Due to increased pesticide usage, the predator and prey pests are not in balance, and hence there is an overpopulation of one kind of pest that would attack certain crops. This leads to an imbalance in the production of those kinds of crops. These crops would need stronger pesticides or pesticides of new kinds to tackle the pests attacking those. This also has led to the disruption in the food chain.

Water Consumption

India has the highest demand for freshwater usage globally, and 91% of water is used in the agricultural sector now. Currently, many parts of India are experiencing water stress due to irrigated agriculture. The crops introduced during the green revolution were water-intensive crops. Most of these crops are cereals, and almost 50% of dietary water footprint is constituted by cereals in India (Kayatz et al., 2019). Since the crop cycle is less, the net water consumed by these crops is also really high. The production of rice currently needs flooding of water for its growth[1] (International Rice Research Institute). Canal systems were introduced, and there were irrigation pumps that sucked out water from the groundwater table to supply the water-intensive crops, such as sugarcane and rice (Taylor, 2019). Punjab is a major wheat- and rice-cultivating area, and hence it is one of the highest water depleted regions in India[2] (Alisjahbana, 2020). It is predicted that Punjab will have water scarcity in a few years (Kumar et al., 2018). Diminishing water resources and soil toxicity increased the pollution of underground water. The only aim of the green revolution was to increase food production and make it sufficient to feed everyone. The environmental impacts were not taken into account (Taylor, 2019). Based on the previous allocation of budget, irrigation was allotted 9,828 crore INR as compared with 3,080 crore INR for agriculture, excluding

irrigation. This pattern has been persistent in the past 3 years (NABARD, 2020). Overall, the GDP from agriculture is 380,239 crore INR (16.5% of GDP) (Economics, 2020; India, 2020). This indicates that there has been a higher investment on irrigation of water due to its increased need in comparison with the other inputs required for agriculture.

Air Pollution

Air pollution introduced due to the burning of agricultural waste is a big issue these days. In the heartland of the green revolution, Punjab, farmers are burning their land for sowing the crops for the next cycle instead of the traditionally practiced natural cycle. The next crop cycle arrives very soon because the crop cycle is of short duration for the hybrid crops introduced in the green revolution. This contributes to the high amount of pollution due to the burning of agricultural waste in parts of Punjab (Davis et al., 2018). This kind of cultivation can lead to the release of many greenhouse gases, such as carbon dioxide, methane, nitrogen oxides, etc. (de Miranda et al., 2015).

IMPACTS ON SOIL AND CROP PRODUCTION

There was a repetition of the crop cycle for increased crop production and reduced crop failure, which depleted the soil's nutrients (Srivastava et al., 2020). Similarly, as there is no return of crop residues and organic matter to the soil, intensive cropping systems resulted in the loss of soil organic matter (Singh and Benbi, 2016). To meet the needs of new kinds of seeds, farmers used increasing fertilizers as and when the soil quality deteriorated (Chhabra, 2020). The application of pesticides and fertilizers led to an increase in the level of heavy metals, especially Cd (cadmium), Pb (lead), and As (arsenic), in the soil. Weedicides and herbicides also harm the environment. The soil pH increased after the green revolution due to the usage of these alkaline chemicals (Sharma and Singhvi, 2017). The practice of monoculture (only wheat–rice cultivation) has a deleterious effect on many soil properties, which includes migration of silt from the surface to subsurface layers and a decrease in organic carbon content (Singh and Benbi, 2016). Toxic chemicals in the soil destroyed beneficial pathogens, which are essential for maintaining soil fertility. There is a decrease in the yield due to a decline in the fertility of the soil. In addition, the usage of tractors and mechanization damaged the physicochemical properties of the soil, which affected the biological activities in the soil. In the traditional methods, soil recovers in the presence of any kind of stressors (Srivastava et al., 2020). However, this does not happen with these modern

methods. In a study conducted in Haryana, soil was found to have water logging, salinity, soil erosion, decline, and rise of groundwater table linked to brackish water and alkalinity, affecting production and food security in the future (Singh, 2000).

Although for around 30 years there was an increase in the production of crops, the rice yield became stagnant and further dropped to 1.13% in the period from 1995 to 1996 (Jain, 2018). Similarly with wheat, production declined from the 1950s due to the decrease in its genetic potential and monoculture cropping pattern (Handral et al., 2017). The productivity of potato, cotton, and sugarcane also became stagnant (Singh, 2008). Globally, agriculture is on an unsustainable track and has a high ecological footprint now (Prasad, 2016).

Extinction of Indigenous Varieties of Crops

Due to the green revolution, India lost almost 1 lakh varieties of indigenous rice (Prasad, 2016). Since the time of the green revolution, there was reduced cultivation of indigenous varieties of rice, millets, lentils, etc. In turn, there was increased harvest of hybrid crops, which would grow faster (Taylor, 2019). There is a large increase in the cultivation of wheat, soybeans, and rice. In addition, there is a large decrease in the cultivation of sorghum, other millets, barley, and groundnuts. The increase in certain crops was due to the availability of HYVs of seeds and an increase in the area of production of these crops (Singh, 2019). The preference of farmers also changed in terms of the cultivation of crops. The native pulses, such as moong, gram, tur, etc., and some other oilseed crops, such as mustard, sesame, etc., were not cultivated further on a larger scale than it was before. Traditionally grown and consumed crops, such as millets, grow easily in arid and semi-arid conditions because they have low water requirements. However, there was the unavailability of high-yielding seeds of millets, and hence farmers moved to only rice and wheat (Srivastava et al., 2020).

IMPACTS ON HUMAN HEALTH

Food Consumption Pattern

Traditionally, Indians consumed a lot of millets, but this became mostly fodder after the green revolution (Nelson et al., 2019). The Cambridge world history of food mentions that the Asian diet had food items, such as millets and barley (Kiple and Ornelas, 2000). As already mentioned, after the period of the green revolution, there were significant changes in

food production, which in turn affected the consumption practices of Indians. The Food and Agriculture Organization (FAO) has recorded that over the years 1961–2017, there are a decrease in the production of millets and an increase in the production of rice (Food and Agricultural Organization, 2019; Smith et al., 2019); thus, rice became the staple diet of the country. Though the green revolution made food available to many, it failed to provide a diverse diet but provided increased calorie consumption.

Health-Related Impacts on the General Population

Most of the pesticides used belong to the class organophosphate, organochlorine, carbamate, and pyrethroid. Indiscriminate pesticide usage has led to several health effects in human beings in the nervous, endocrine, reproductive, and immune systems. Sometimes, the amount of pesticide in the human body increases beyond the capacity of the detoxification system due to continuous exposure through various sources (Xavier et al., 2004). Of all, the intake of food items with pesticide content is found to have high exposure, i.e., 10^3-10^5 times higher than that arising from contaminated drinking water or air (Sharma and Singhvi, 2017).

IMPACTS ON FARMERS

Most of the farmers who use pesticides do not use personal protective gear, such as safety masks, gloves, etc., as there is no awareness about the deleterious effects of pesticides. Pesticides, applied over the plants, can directly enter the human body, and the concentration of nitrate in the blood can immobilize hemoglobin in the blood. Organophosphates can also develop cancer if exposed for a longer period. Since it is in small quantities, the content may not be seen or tasted; however, continuous use for several years will cause deposition in the body. Dichloro Diphenyl Trichloroethane (DDT) was a very common pesticide used in India, now banned internationally as it is found to bioaccumulate and cause severe harmful effects on human beings (Sharma and Singhvi, 2017). However, there is still illegal use of DDT in India. In India, women are at the forefront of around 50% of the agricultural force. Hence, most of these women are directly exposed to these toxins at a young age and are highly vulnerable to the negative impacts including effects on their children. It is proven that there is a significant correlation between agrochemical content in water and total birth defects. The damaging impact of agrochemicals in water is more pronounced in poor countries, such **as** India (Brainerd and Menon, 2014)**.**

Discussion

Efforts are underway to produce genetic variants of millets that can withstand biotic and abiotic stresses. Earlier, the introduction of genetic variants of rice and wheat and pesticides was the solution for malnutrition, but it led to environmental destruction in a few years. In the short term, food scarcity might rise again due to increased water depletion and soil damage. Any new interventions should be carefully introduced not to disrupt other systems to prevent future adversities. A domino effect is expected to occur when there is any disruption in the ecosystem, such that if even one link in the food chain is affected, it affects other parts of the chain also. Most of the ecological disruption is by human intervention (Vaz et al., 2005). Pesticides used for agricultural activities are released to the environment through air drift, leaching, and run-off and are found in soil, surface, and groundwater. This can contaminate soil, water, and other vegetation. Pesticide residues are found to be present in almost all habitats and are detected in both marine and terrestrial animals (Choudhary et al., 2018). The mechanisms include absorption through the gills or teguments, which is bioconcentration, as well as through the consumption of contaminated food, called bio magnification or bio amplification. In marine systems, seagrass beds and coral reefs were found to have very high concentrations of persistent organic pollutants (Dromard et al., 2018). It also affects the activities of insects and microbes. It kills insects and weeds, is toxic to other organisms, such as birds and fish, and contaminates meat products, such as chicken, goat, and beef. This can lead to bioaccumulation in human beings along with poor food safety, thus impairing nutrition and health. Repeated application leads to loss of biodiversity (Choudhary et al., 2018). Consumption of pesticide-laden food can lead to loss of appetite, vomiting, weakness, abdominal cramps, etc. (Gerage et al., 2017). There is a decline in the number of pollinators, for instance, the destruction of bumblebee colonies that are an important group of pollinators on a global scale (Baron et al., 2017). There is an extinction of honeybee populations, and it poses a great threat to the survival of human beings (Hagopian, 2017). The residue level of these pesticides depends on the organism's habitat and position in the food chain. This is a serious issue because the predicted usage of pesticides is that it will be doubled in the coming years (Choudhary et al., 2018).

In addition, it is not nearly possible to get back the lost varieties of indigenous rice. Likewise, further advancements should not lead to the extinction of the other indigenous varieties of grains, such as millets.

In conclusion, the effects of the green revolution are persisting. The green revolution, which was beneficial in ensuring food security, has unintended but harmful consequences on agriculture and human health. This requires new interventions to be tested and piloted before implementation, and continuous evaluation of the harms and benefits should guide the implementation. An already fragile food system is affected due to the aftermaths of the green revolution. The potential negative impacts are not part of the discourse as it can affect the narratives of development and prosperity. Developments introduced due to necessity may not be sustainable in the future. Organic ways of farming need to be adopted for sustainable agricultural practices. Similarly, alternative agriculture techniques, such as intercropping, Zero Budget Natural Farming (ZBNF) with essential principles involving the enhancement of nature's processes, and elimination of external inputs, can be practiced (Khadse et al., 2018). The government of Andhra Pradesh (AP), a Southern state in India, has plans to convert 6 million farmers and 8 million hectares of land under the state initiative of Climate Resilient Zero Budget Natural Farming because of the positive outputs obtained in the ZBNF impact assessments in the states of Karnataka and AP (Reddy et al., 2019; Koner and Laha, 2020) In AP, it was observed that yield of crops increased to 9% in the case of paddy and 40% in the case of ragi. Net income increased from 25% in the case of ragi ranging to 135% in the case of groundnut (Martin-Guay et al., 2018; Reddy et al., 2019). There is a need for a systems approach in dealing with food insecurity and malnutrition and other similar issues. Like the already mentioned example, the green revolution was brought in to reduce the problem of reduced yield. Now, there is a green revolution 2 that is planned. Before such interventions are taken, environmental risk assessments and other evaluation studies should be conducted for a sustainable future.

A detailed retrospective of the Green Revolution, its achievement and limits in terms of agricultural productivity improvement, and its broader impact at social, environmental, and economic levels is provided. Lessons learned and the strategic insights are reviewed as the world is preparing a “redux” version of the Green Revolution with more integrative environmental and social impact combined with agricultural and economic development. Core policy directions for Green Revolution 2.0 that enhance the spread and sustainable adoption of productivity enhancing technologies are specified (Pingali, 2012).

Substantial growth in food production has occurred from a narrowing diversity of crops over the last 50 years Agricultural policies have largely focused on the single objective of maximizing production with less attention given to nutrition, climate, and environment. Decisions about sustainable food systems require quantifying and assessing multiple dimensions together. In India, diversifying crop production to include more coarse cereals, such as millets and sorghum, can make food supply more nutritious, reduce resource demand and greenhouse gas emissions, and enhance climate resilience without reducing calorie production or requiring more land. Similar multidimensional approaches to food production challenges in other parts of the world can identify win–win scenarios where food systems meet multiple nutritional, environmental, and climate resilience goals (KyleFrankel Davis et. al. 2019).

02. NATURAL FARMING - PRINCIPLES, CONCEPTS AND COMPONENTS

Introduction :

The serious ecological and economic crisis in farming community in India and other countries has led to the evolution of new models of agriculture which are based on sound ecological principles making effective use of local resources and natural processes.

The alternative approaches are collectively called as agro-ecological approaches. But, based on the primary focus of the promoters the activities may vary significantly. While some focus on restoring the natural agroecosystems, some focused on making farming an ecologically sustainable model. While some believe in reviving traditional crops and practices, others use this as a tool for seed and food sovereignty.

Understanding different farming models

Across the Indian states, lakhs of farmers are now switching over to adopt agro-ecological practices to sustain their livelihoods. While some are driven by revived interest in moving back to traditional practices, majority are driven by the need to move away from high input use and reduce costs of cultivation.

The serious ecological and economic crisis in the farming community in India and other countries has led to evolution of new models of agriculture. The main objective of this ecological movement is based on principles of agroecology viz; a) local context (soil, weather, and available water) based cropping/farming systems and seed varieties/animal breeds, b) improving soil structure and fertility by organic means, c) preventive care to manage pests and diseases, d) effective use of locally available resources.

These sets of practices have evolved from reinterpreting the traditional farming practices with modern scientific learnings. As many believe this is continuation of the old traditional practices which are not relevant today but contemporary innovations with new science of ecological farming evolved at different nodes by farmers, civil society organisations and few agriculture scientists.

Various alternatives to the existing agriculture practices have emerged over the decades. At the core of it all, these have emerged out of a need for efficient farming practice that is local, resilient and adaptable agro-ecological farming practice.

Do Nothing (Natural) Farming: Natural farming is an ecological farming approach established by Masanobu Fukuoka (1913–2008), a Japanese farmer and philosopher, and popularised in his 1975 book The One-Straw Revolution. After working for about two decades on his farm he developed a system where there is no need of tillage, no chemical fertilisers, no chemical pesticides and no weeding.

Subash Palekar (Zero Budget) Natural Farming (SP/ ZBNF): Promoted by Sri Subash Palekar the ZBNF/SPNF is a model of agriculture which is largely based on four wheels practiced as Bijamrita (Seed Treatment using local cowdung and cow urine), Jiwamrita (applying inoculation made of local cowdung and cow urine without any fertilizers and pesticides), Mulching (activities to ensure favorable microclimate in the soil), and Waaphasa (soil aeration).

Organic Farming: This shuns chemical fertilisers and pesticides but the approach is similar to it. For example, nutrients required by the crops are supplied through various organic manures based on their nutrient contents. Similarly biological pesticides are used to 'kill' the insects instead of chemical pesticides. Modern organic farming also allows some biofertilisers and biopesticides which are industrially made.

Permaculture: Permaculture is a design approach to land management that adopts arrangements observed in flourishing natural ecosystems. It includes a set of ethics and design principles derived using whole systems thinking. It uses these principles in fields such as regenerative agriculture, rewilding, and community resilience.

Biodynamic agriculture: is a form of alternative agriculture very similar to organic farming, but it includes various esoteric concepts drawn from the ideas of Rudolf Steiner (1861–1925). Initially developed in 1924, it was the first of the organic agriculture movements. It treats soil fertility, plant growth, and livestock care as ecologically interrelated tasks, emphasizing spiritual and mystical perspectives.

Conservation Agriculture: As the ill effects of conventional agriculture particularly on soil structure with use of heavy machinery and cascading effects on soil biology and moisture holding capacity, a shift towards Conservation Agriculture has begun. Conservation Agriculture is a farming system that promotes minimum soil disturbance (i.e. no tillage),

maintenance of a permanent soil cover, and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production. In principle ploughing is mainly to reduce weeds and pest and diseases by exposing them to sun. However, in early nineteens most of the initiatives under conservation agriculture are captured by the herbicide selling companies and today most of the cases it goes without ploughing but using a herbicide use to manage weeds and rest.

NATURAL FARMING

Natural Farming is hence as the direction and process of transition towards a more local, resilient and adaptive agro-ecology based farming.

Natural Farming offers a solution to various problems, such as food insecurity, farmers' distress, and health problems arising due to pesticide and fertilizer residue in food and water, global warming, climate change and natural calamities. It also has the potential to generate employment, thereby stemming the migration of rural youth. Natural Farming, as the name suggests, is the art, practice and, increasingly, the science of working with nature to achieve much more with less.

Irrespective of the different farming models, at the core, all of these schools of thoughts have the following principles in common:

A. Using natural locally found products and inputs which the farmer can make on their own or buy from their local region
B. Increase cropping intensity through multiple cropping systems
C. Increasing soil organic matter
D. Increasing soil health particularly microbial population

What makes farming a sustainable production system?

Drawn from various schools of thought and various models here is the summary of what makes farming a sustainable production system. One can make choice on each of these and integrating more the elements better

a. **Natural Resource Management:** Sustainable use of natural resources is the main key to sustain farming as it is largely dependent on soil, water and biodiversity. Mention Forests and Commons are as part of farming systems.

1. **Water:** plants needs moisture and not water. Improving moisture holding capacity and making it available in critical stages in plant root zone is important. All practices from water harvesting, efficient application etc contributes towards this.

2. **Soil:** Soil not only holds plants and trees but provide nutrients for their growth. The physical properties like compaction, erosion, chemical properties like pH (acidity/alkalinity), EC (Salinity), biological properties like microbial diversity, presence of earthworms etc together contribute to sustainable production. Together all three need to be addressed.

3. **Seeds:** Any seed variety (traditional or improved) which has a value for cultivation-local soil suitability, fitting into the cropping patterns, resistant to locally common pest and diseases and value for use -utility value for the consumer or processor can be used.

4. **Restoring Ecosystem:** Agriculture is not the sum of the total practices, there is a need of transition to regenerative functions and ecological services particularly with respect to soil, water, biodiversity and other biological services are ensured here the role of land scape approach becomes important which includes commons (forest and pastures) in addition to farm lands.

b. **Land Utilisation:** as most of the farmers have small piece of land, effective planning and maximising the land use is important. Here local conditions in terms of soil type, water availability, weather place an important role in determining the choices.

1. **Cropping patterns:** More the number of crops, diverse the species low would be pest and disease problem. However, agronomic management is based on the needs in terms of time to be spent, optimal utilisation of resources and local demand. From growing intercrops to mixed crops there are various models designed to accommodate more than one crop in the farm during the same season. They are also based on meeting homenutritional needs to market needs. We can also use the vertical space effectively if plants and trees growing different heights and different duration can be put together. There is wide spread literature available in terms of best crop/tree combinations.

2. **Integrated farming systems:** for small and marginal farmers with small holdings income from crops alone may not be sufficient. In broadening the income sources adding on allied activities like poultry, small ruminants, dairy, fisheries etc. can help. These can also effectively use the crop residues.

c. **Intercultural operations:** during the season managing the crop growth and effectively managing the spaces between crop plants and trees becomes important as increased weed growth may smother the crops.

1. **Mulching:** however, the best practice would be to cover the soil completely using the dried/fresh biomass or cover crops like green gram, horse gram, velvette bean, etc. which are small leaved and short plant type or creepers. This reduces moisture loss from soil, prevents weed growth and also helps to harvest atmospheric humidity and helps plants to grow even in rainfed conditions.

d. **Pest and Disease Management**: Most of the chemicals are used here. So effective non pesticidal management is very important.

1. **Weed management**: Good cropping patterns can reduce the weed problem. Weed types also depends on the soil. Weeds can find economic use as well. Mechanical weeders also help in management of the weeds. The role of crop geometry (line sowing) as an important factor for weed management.

2. **Pest Management**: Pest incidence is based on the cropping patterns, production practices and weather conditions. Depending on the situation local resource based NPM practices are available
3. **Disease Management**: Disease is a symptom of underlying physiological problem often infectious. Again situation specific resource based NPM practices are available.

However they need effective Surveillance (farm level, village/regional level), diagnostic support whenever farmers face a problem.

What is essential to practice Natural Farming?

1. Knowledge of the practices (in such a way that the farmers have the space and power to make their own decision based on their contexts)

2. Technology that is beneficial now and for the next 50 years minimum
3. Scientific understanding of the biological systems and the natural processes happening in nature

Creating values beyond yield, inputs and products; which embraces diversity, and supports the systemic transition process

Core approaches to be looked into for practicing Natural Farming (These are covered in detail in the respective sessions):

1. **Water and Moisture Management**

- Cropping pattern must be based on the local water resource and weather parameters
- Rainwater harvesting practices such as grid block, trenches, ponds etc. must be adopted
- Harvest atmospheric moisture by increasing soil cover, designing cropping patterns for 365 days
- Increasing soil water and moisture holding capacity by increasing soil organic matter
- Improving water use efficiency through micro-irrigation systems, lifesaving irrigation plans, efficient cropping systems
- Monitoring weather and soil moisture

2. **Adaptive cropping systems**

- Cropping patterns based on soil types, water and weather parameters
- Increasing cropping intensity (horizontal and vertical) through crop rotations and inter/multiple/poly crops
- Designing farms taking an integrated farming systems approach
- Managing living roots and green cover for 365 days
- Staggered production system for fresh fruits and vegetables

3. **Sustainable Soil Nutrient Management**

Soil quality indexes such as the physical factors (soil structure, water holding capacity etc), chemical factors (EC, pH, Available nutrients etc) and Biological factors (Organic microbial diversity, soil fauna etc) are to be managed

- Prevent erosion
- Prevent compaction; minimising tilling, shift to animal drawn tools

- Manage soil salinity and pH; Organic amendments, cropping pattern changes, increasing soil organic matters
- Increasing soil organic matter; composting, mulching, manuring
- Biological nutrient management using home made bio-fertilisers, EMOs/IMOs

4. **Organic seed system**

- Identifying, conserving and documenting local diversity; mapping and characterisation
- Participatory varietal selection to establish value for cultivation and use: Diversity blocks, generating data on local performance, user preferences, seed catalogues etc.
- No GMOs to be used due to biosafety issues
- Organic seed hub; Manage parental lines, maintain breeding, training, capacity building on seed production, coordinating between conservators, breeders, seed producers and markets
- Institutionalising production and distribution through community seed banks, community seed enterprises, farmer service centres for local production and distribution
- Open source seed licensing; arrangements that facilitate and preserve freedom of access and use of plan genetic material, prohibit exclusive rights and apply to any subsequent derivatives of those materials
- Creating value for diversity by developing processing and value addition in production to increase use

5. **Integrating livestock to increase soil organic matters and for production of inputs**

6. **Non Pesticidal Management**

- Integrating management practices to prevent insects, diseases and weeds from reaching damaging stage or proportions
- A natural ecological balance will ensure that pests do not reach a critical number in the field that engages the yield
- Nature can restore ecological balance if it is not meddles with too much, hence no chemical pesticides at all

- Understanding the insect biology and crop ecology is important to take up right management practices - botanicals or microbials, farm made or commercial
- Pest surveillance : Farm level and village level surveillance to identify pests and disease using various traps to give alerts and advisories
- Simple tools such as flip charts, apps, manuals etc. for problem diagnosis
- Building local entrepreneurship for production and sale of bio-fertilisers and inputs
- Weekly advisories based on local surveillance

Soil Health Management

03. IMPORTANCE OF SOIL HEALTH AND PRESENT DAY CONCERNS WITH SOIL

Agriculture, globally as well as in India, has witnessed several technological advancements. However, today sustainability of agricultural production systems vis-à-vis the environment is a major concern. Soil and crop management practices affect the relationship between soil processes and agro-ecosystem function to a great extent, and thus affect the sustainability of agricultural production systems. Sustainable farming depends on the quality of soil, which provides water and essential nutrients to crops. Soil health management is a key component to the success of natural cropping systems management.

Soil health and present-day concerns with Soil

Soil is a fundamental and essential natural resource for the existence of all living organisms. Soil health or quality is defined as the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality and promote plant and animal health. Healthy soil is the foundation of productive, profitable and environment friendly agricultural systems. A healthy soil would ensure proper retention and release of water and nutrients, promote and sustain root growth, maintain soil biotic habitat, respond to management and resist degradation.

There are six major soil types in India- Alluvial soil, Red soil, Black soil, Laterite soil, Arid soil and Forest & mountain soil. Each soil type has its own characteristics in terms of physical and chemical properties, like Alluvial soil is highly fertile, with high phosphorus and potash content. Laterite soil is acidic in nature, while Black soil is rich in potash and magnesium, but poor in phosphorus. Red soil has high iron and potash content but lacks phosphate.

Intensive crop cultivation broadly using imbalanced fertilizer, high nutrient mining through monoculture, decline in organic matter status, decreased biodiversity, deficiencies of secondary and micronutrients, etc. have deteriorated the soil health across the country, resulting into declining crop productivity growth.

Overall, about 59 and 36 per cent of Indian soils are low and medium in available N, respectively. Similarly, soils of about 49 and 45 percent area are low and medium in available P, respectively; while soils of around 9 and 39 per cent area are low and medium in available

K, respectively. Among various soil characteristics that affect the availability and uptake of micronutrients, soil pH and organic carbon content are the two most important factors.

Analysis of more than two lakhs soil samples during 2011-2017 revealed huge variation in different types of micronutrients deficiency in India soils. On an average, 36.5, 23.4, 12.8, 11.0, 7.1 and 4.2% soils are deficient in zinc, boron, iron, molybdenum, manganese, and copper, respectively, across the country. Our soils are very low in organic matter content and thus have poor soil fertility. Organic carbon is an index of good soil health and application of organic manures helps in maintaining high organic carbon content of the soil.

Indiscriminate use of chemical fertilizers and pesticides posed a threat to the soil and environment. Rachel Carson in her book 'Silent Spring' has highlighted the adverse effect of synthetic pesticides. Many investigations have shown their adverse effects of change in soil nature, soil contamination, groundwater pollution, decrease in soil micro flora etc.

Pesticide consumption is increasing year by year (62,193 MT during 2021). Pesticides cause serious hazards to soil environment and human health because a lot of pesticides and their derivatives remain in the soil system for a considerable period. Most pesticides negatively affect the soil microbes, their diversity, composition, and biochemical processes. Pesticides cause imbalance of soil fertility which directly affects crop yield. The alteration in diversity and composition of the beneficial microbial community is unfavourable to plant growth and development either by reducing nutrient availability or by increasing disease incidence (Meena et al. 2020).

Fertilizer use has increased from 12.4 Kg/ha in 1969 to 137 Kg/ha in 2021 (About 11 times increase). However, increase in productivity is not proportionate, despite use of large quantities of agro-chemicals. Further, fertilizers subsidy provision was Rs 79,530 crore in 2021-22 Union Budget; Final figure was Rs 1.62 lakh crore; and it increased to Rs 2.25 lakh crore in 2022-23. In the 2023-24 Budget, the government has earmarked Rs 1.75 lakh crore for fertiliser subsidy, which has a cut of nearly Rs 50,000 crore. Increase in costs of fertilizers will further make the production systems unsustainable.

- Moreover, water is a major limiting resource, which has a significant effect on crop productivity.

- India – a water stressed country- has witnessed decline in per capita water availability from 5178 m^3/yr in 1951 to 1544 in 2011, and it is further expected to be 1140 m^3 by 2050.
- Agriculture uses 89% of groundwater, and the decreasing availability further stresses the production systems.
- Economic survey 2019 highlights that focus should be shifted from "land productivity" to "water productivity".
- Therefore, there is dire need to focus on sustainability of farming systems, and identify alternate farming systems with eco-friendly practices, which maintain appropriate supply of nutrients and water to crop plants.

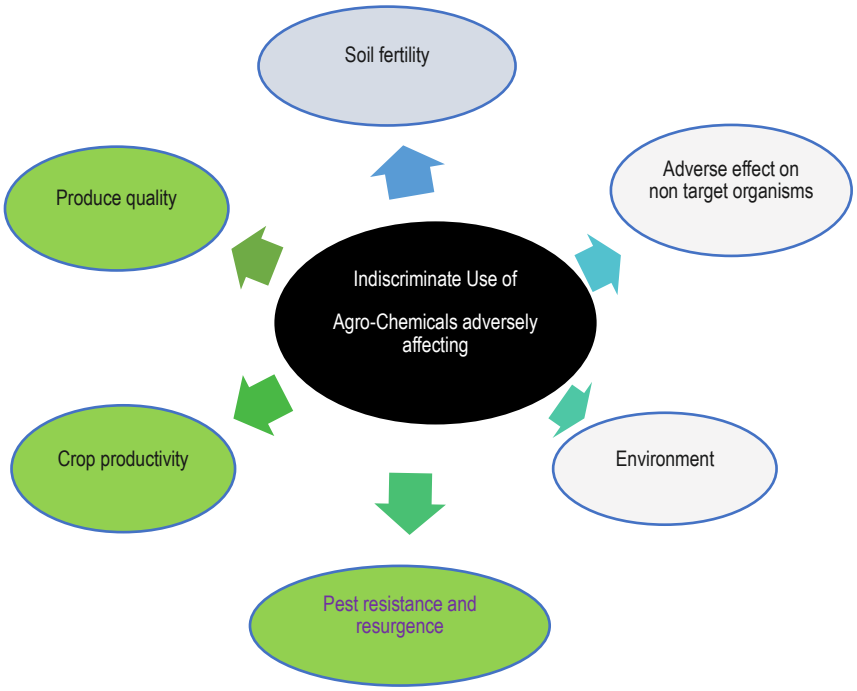


Figure: Adverse effects of indiscriminate use of agro-chemicals

1. AT FARMERS END

Ever increasing farmer distress: the conventional agriculture practice induces the farmer to rely heavily on synthetic fertilizers and pesticides leading to high costs of cultivation.

The green revolution increased agricultural production for many farmers in India and achieved significant gains in terms of food security. However, many of the small- farm holders in rain fed and resource poor areas did not benefit much from green revolution technology. Most of the small – farm holders who have been using chemical fertilizers and pesticides, many are caught in the debt trap due to the high cost of chemical inputs, lack of credit, poor access to markets, and lack of investible surplus, this has resulted in low profitability agriculture, leading the smallholders to drop out of the sector. The spate of suicides among farmers in recent years has been an unfortunate consequence.

Every year it is seen that farmers have to invest more money for cultivation. Reasons are high rate of seeds, water resources, fertilizers. These costs are gradually increasing, whereas the production levels are gradually decreasing.

2. AT CONSUMER END

Available land under cultivation is shrinking due to urbanization, soil degradation, and increasing desertification and the population is increasing. The COVID pandemic has also put our food systems under immense stress. As a result, large populations may face food scarcity. Over the years it has been observed that 20-30% of the nutrients are lacking in the food that humans are consuming. According to who reports 50% of diseases are occurring due to such food that humans are consuming. It has been reported that pesticides are one of the reasons for causing cancer in human beings. The existing practice of chemical agriculture is leaving chemical residues and reducing nutrient density in the food thereby creating additional health hazards.

Foods grown with agrochemicals affect the mediation of soil organisms in mobilising nutrients in right concentrations, forms and ratios. Such crops have the nutrition integrity compromised.

3. ENVIRONMENTAL CRISIS

(Agrochemical Pollution, Global Warming, Extreme Weather Events, Etc)

Soil degradation, water stress and loss of biodiversity: Use of synthetic chemicals in agriculture reduces life in the soil and essentially puts plant health at risk. It degrades soils leading to erosion, salinization, compaction, etc. It contaminates groundwater and other water dependent ecosystems, leading to biodiversity loss in the farmland and insect biodiversity. Also, prevailing agricultural practices, such as mono-cropping are contributing to crop biodiversity loss.

Global warming and climate justice: Temperature increases are happening at an alarming rate around the world. If this trend continues, the world will soon become warmer by 2^0 C. Global warming is exacerbating all the above effects. It has put children, women, and landless farm workers as the most vulnerable communities, the least responsible for the climate crisis, and the most affected, and they suffer the most and face gravest consequences. Governments have started responding to this situation and trying alternatives to conventional agriculture practices as 'business as usual' is not working any more.

04. AGRO-ECOLOGY & SOIL PROPERTIES INFLUENCING PLANT GROWTH

1. Cover crops

Covering soil with live crops is one of the key practices that build soil in less time by adding carbon to the soil, besides giving additional income from the crops. Live crops increase soil carbon in a short time through a phenomenon called rhizodeposition (releasing of photosynthates through the root hairs into soil). For all the living organisms, energy is obtained by consuming food. Plants are the primary producers of food (by means of photosynthesis) and every other organism derives energy by consuming food prepared by plants eventually. The food material (carbon substances) is prepared by plants by using CO_2 gas from the atmosphere. Around 40% of the food material is utilized for shoot development, around 30% is utilized for root development and the remaining 30% is released into the soil from the root hairs. This process is called **rhizodeposition**. These root exudates start the **soil food web** in the soil. The quantity of residues exuded from roots is more while the crop is in vegetative stage. A portion of these exudates, being rich in carbon also convert to soil organic carbon which contributes to

a) Improved soil biology
b) Better soil structure resulting in improved water holding capacity of the soil;
c) Better infiltration capacity of the soil;
d) And improved root ability of plant roots to easily grow deep in such soil.

For these benefits, soil should be ensured of living-roots throughout the year so that Soil organic carbon continuously increases. When these roots exudate from the root systems spreading into various depths, the depth of soil getting this carbon pumped in increases and soils quickly improve. The root exudates that are released it is estimated that the rate of soil organic carbon increase is 5-30 times faster in the soil compared to the addition of organic residues in the soil.

In order to ensure crop cover, strategies to fill fallow periods need to be done with the help of proven practices like PMDS (Pre-Monsoon Dry-Sowing) and Year-long crop cover.

PMDS (Pre Monsoon Dry Sowing)

- Diverse crop seeds pelletized with clay and bio stimulant to be sown with minimal moisture from rain or irrigation the seeds germinate and establish themselves.
- Provide a thick organic mulch.
- In this manner, it's possible to establish a crop cover with less resources.
- Foliar application of liquid bio stimulants ensures crop growth.
- Greater the seed diversity greater are the results for the development of organic carbon content in the soil.
- Leafy vegetables, vegetables, fodder, can be sowed in PMDS cropping.
- Some biomass may be used as cattle fodder, harvesting the above ground portion of the crop. Keeping the roots intact in the soil.
- Balanced biomass may be incorporated into the soil.

2. Crop diversity

Ensuring diversity while growing crops is very important for the following reasons:

a) Diverse food available for consumption
b) Different root depths of root systems of different crops improve the depth of Soil quickly
c) Crop losses due to specific insects, diseases is minimised
d) Pest build up in slowed down or stopped in fields with diverse crops
e) Productivity (yield) of whole land increases with increase in diversity.

Crop diversity increases the total yield (in terms of biomass) of the land. The experimental results say that diversity should be minimum from 4 different plant groups, and a minimum of 12 crop species at any given time.

Each crop has specific microbial associations with their roots in the soil. Ensuring diversity of crops ensures microbial diversity in the soil also. Above ground diversity reflects soil microbial diversity. Crop diversity should be planned taking into account the plant species that provide (i) income potential from various short to long duration crops (2)

organic residues in large amounts (3) fodder sources (4) protection to soil by covering it and holding the soil together for longer periods.

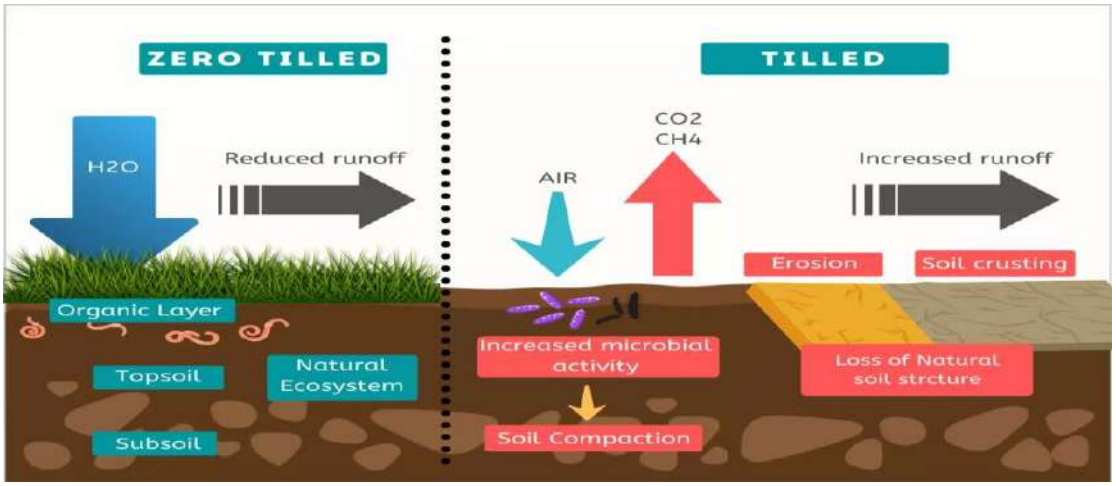
3. No/low tillage

Tillage is a practice that is done generally to loosen up the soil to absorb rainwater and allow seeds to grow roots deeper. But this practice harms the soils in many ways as follows:

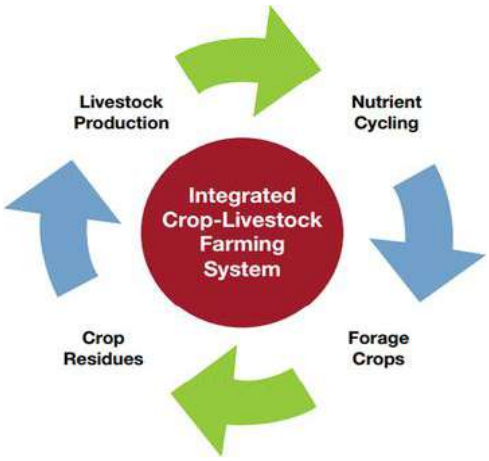
a) Very valuable soil carbon is escaped into the soil as a gas by means of oxidation Process
b) Soil structure is destroyed and soil becomes powdery leading to sealing of pore Spaces after rains leading to more compaction
c) Compact soils cannot support crop roots to grow deeper; and have less water Holding capacity to support crop growth
d) Soil biology is affected as soil carbon is getting reduced.

The following results will be obtained if a soil is not tilled.

a) Due to activity of crop roots, earthworm activity and other insects' activity, the tunnels created will become strong overtime if they are not destroyed by tillage
b) The tunnels allow lot of water to absorb into soil and reduce run off.
c) The tunnels will help crop roots to grow deeper very easily and – provides better anchorage to plants in times of floods, allows roots to access nutrients and water from deep layers. Deep summer ploughings cause a lot of oxidations of soil organic carbon. Every farmer is being encouraged to develop farm models that will have permanent trees integrated with crops and will not involve land preparation or intercultural operations that involve tillage every season.



4. Integrate animals



In nature, trees and animals depend on each other to grow. In NF practices, it is important that crop planning should include fodder crops, and also integrate animal (buffaloes or cows) by-products (such as dung and urine) to be used in the preparation of NF inputs (like Jeevamrit, Beejamrit, etc) in agriculture crop production. In situations where a PMDS (Pre-Monsoon Dry-Sowing) crop is being grown for green manuring purposes, allowing cattle to graze in the fields is much better than incorporating the crop in the soil. Cattle will eat healthy grown fodder. Incorporating PMDS crops in soil leads to loss of valuable carbon in plant matter up to 90% in the decomposition process.

5. Bio-stimulants

Bio stimulants are materials (other than fertilisers) that promote plant growth when applied in small quantities. Plants and animal by-products have some substances that are acting as bio stimulants. In NF, Beejamrit, Jeevamrit, etc are used in small quantities which are giving very good results. Bio stimulants are made up of a variety of biological substances, microorganisms, and compounds that can be applied directly to plants, seeds, or soil to improve a plant's Vigor, increase crop yields, and relieve plant stress. The use of bio stimulants can start in the seed germination phase and continue throughout the plant's life cycle. Bio stimulants work by enhancing the plant's ability to absorb nutrients so it can develop properly. When applied to soil, bio stimulants improve the soil's complementary microbes that help a plant's roots thrive and form a beneficial symbiotic relationship. Plants benefit from bio stimulants by creating higher yields, stronger growth, enhanced water absorption, better overall appearance, and an improved tolerance for heat, dry spells, pests, diseases, and transplanting shock, etc.

Normally in conventional agriculture, crop residues are seen as sources of plant nutrients and that's why they are composted and applied to soil; and also, FYM is seen that way and is applied in large quantities. But in NF, only small quantities are being used. Bio stimulants are all natural and biologically derived. Examples of bio stimulants – Beejamrit, Jeevamrit, Saptadhanyankura tonic, etc.

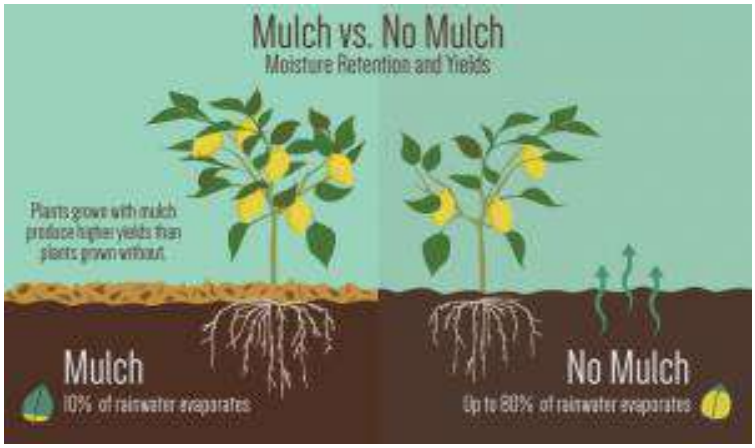
6. Addition of diverse organic residues

Besides a live crop, having organic residues spread on soil as a mulch is very beneficial.

Mulch provides the following benefits:

a) Avoids compaction of soil caused by beating action of rain
b) Protects soil from the heat of the sun and it helps retain more soil moisture, and provides better living conditions for the soil organisms.
c) The nutrients and water in the residues locked in the residues are gradually released into soil upon decomposition
d) During rains, presence of mulch on soil surface reduces the erosion of soil and reduces runoff of rainwater.

Applying 2-3 inches of (or around 2-3 tons/acre) crop residues as mulch is recommended as it is giving required benefits. Using rice husk has given bad feedback from farmers and is not recommended for use as mulch. Diversity of organic residues need to be maintained. It is important to note that the main advantage of adding organic matter is to improve soil biology and protect soil, and not as a source for providing nutrients.



7. No use of agrochemicals (fertilisers, insecticides, fungicides, weedicides, etc.)

Agrochemicals are the chemicals used in agriculture like fertilisers, insecticides, fungicides, weedicides, etc.

These chemicals work in a way to meet the temporary need for the crop without working along with nature and living things in the agriculture ecosystem. For example, fertilizers provide nutrients directly to plant by harming soil structure and soil biology;

pesticides try to kill all insects including beneficial ones and leave harmful chemical residues in food products, water and soil.

Soil properties Influencing Plant growth

Soil properties play a crucial role in influencing plant growth and development. Different soil characteristics directly or indirectly impact the availability of essential nutrients, water retention, root development, and overall plant health. Here's an overview of how various soil properties affect plant growth:

Soil Texture:

Soil texture refers to the relative proportions of sand, silt, and clay particles in the soil. Sandy soils have larger particles and drain quickly, often requiring more frequent irrigation. They have low water and nutrient retention. Clay soils have smaller particles, which leads to higher water retention but can also result in poor drainage and aeration. Loam soils, a mix of sand, silt, and clay, are considered ideal for plant growth due to their balanced water-holding capacity and drainage.

Soil Structure:

Soil structure refers to the arrangement of soil particles into aggregates. Good soil structure allows for proper root penetration, water movement, and air circulation. Compacted soils have poor structure, hindering root growth and water infiltration.

Soil pH:

Soil pH affects nutrient availability. Most plants prefer a pH between 6 and 7. Acidic soils (pH < 6) can limit the availability of essential nutrients like phosphorus, calcium, and magnesium. Alkaline soils (pH > 7) can lead to micronutrient deficiencies.

Nutrient Content:

Soil nutrients, including macronutrients (nitrogen, phosphorus, potassium) and micronutrients (iron, zinc, copper, etc.), are essential for plant growth. Soil fertility influences nutrient availability. Nutrient-rich soils promote healthy growth.

Organic Matter:

Organic matter improves soil structure, water-holding capacity, and nutrient retention. It serves as a source of slow-release nutrients and provides a favourable environment for beneficial microorganisms.

Water Retention and Drainage:

Adequate water retention is vital for plant hydration and nutrient uptake. Poor drainage can lead to waterlogged conditions, suffocating roots and causing root diseases.

Aeration:

Good soil aeration ensures the exchange of gases (oxygen and carbon dioxide) between the soil and the atmosphere. Oxygen is essential for root respiration. Compacted or waterlogged soils limit oxygen availability.

Cation Exchange Capacity (CEC):

CEC indicates a soil's ability to retain and exchange cations (positively charged ions) like calcium, magnesium, and potassium. Soils with higher CEC can hold more nutrients and release them to plants as needed.

Salinity and Sodicity:

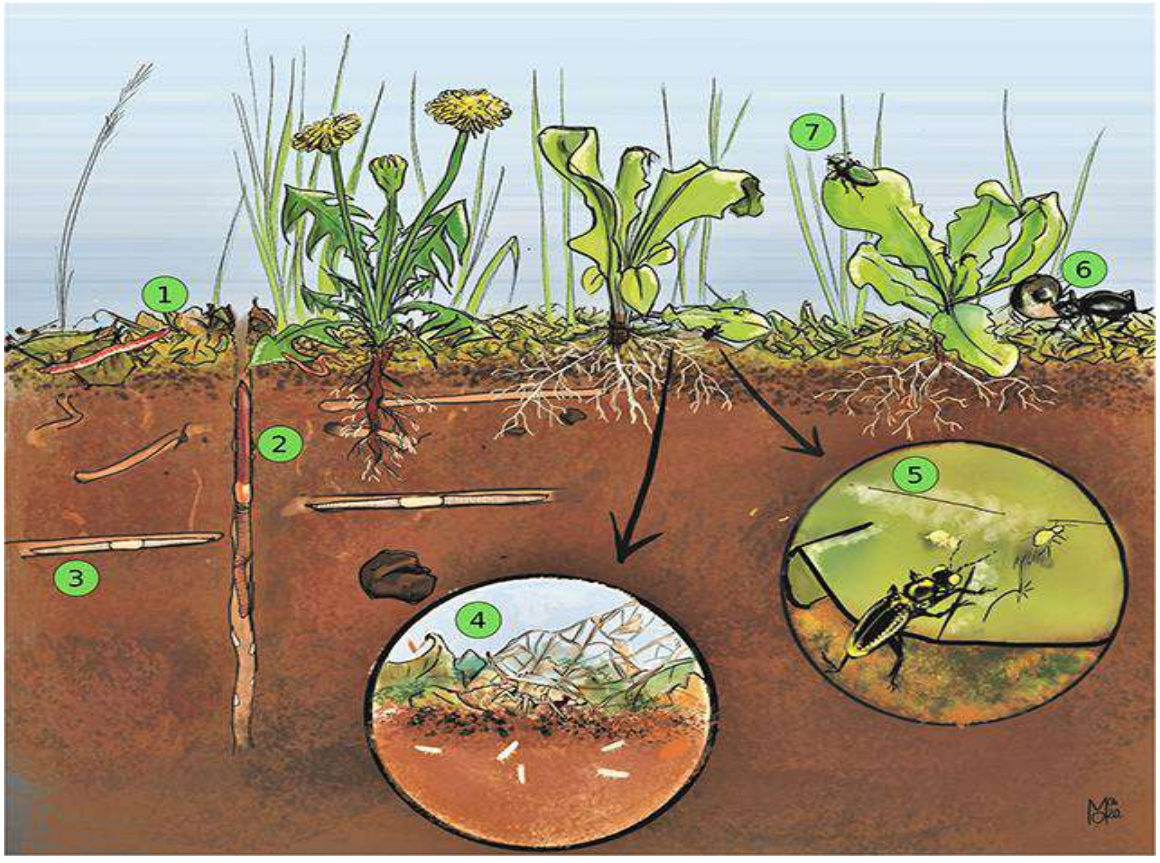
High salinity (salt content) can disrupt water uptake by plants and lead to osmotic stress. Sodicity (sodium dominance) can degrade soil structure, reducing root penetration and water movement.

Soil Compaction:

Compacted soils limit root growth and restrict water movement and air circulation. It can lead to poor drainage and increase susceptibility to erosion.

Microbial Activity:

Soil microorganisms contribute to nutrient cycling, organic matter decomposition, and disease suppression. Healthy soils with diverse microbial populations support vigorous plant growth.



SOIL PROPERTIES

Soil organic carbon, Soil Biology and Physical Environment

The major emphasis of different practices under natural farming is to enhance the soil organic matter (SOM) or soil organic carbon (SOC), and the population and activity of soil microbes and other soil fauna like earthworms and microarthropods. The increase in SOC and soil biological activity improve the nutrient availability to plants, soil structure, aeration and hydrothermal regime in the rhizosphere.

Soil organic matter (SOM) or soil organic carbon (SOC) is the key constituent which dictates soil physical condition, chemical properties including nutrient status and biological health of a soil. SOC is the prime indicator of soil health and index of the productivity of the soil. Normally, soil without any organic matter is considered as dirt which are tightly packed to restrict the infiltration of water, and are nonporous and non-permeable.

SOC creates a granular condition of soil which maintains favorable condition of aeration and permeability. It increases water holding capacity of soil and reduces surface runoff, erosion etc. SOM is food source for soil microorganisms. Highly decomposed organic matter (humus) provides a storehouse for the exchangeable and available cations, and acts as a buffering agent which checks rapid chemical changes in pH and soil reaction. Soil organisms, both animals (fauna/micro-fauna) and plants (flora/micro-flora), are important for maintaining the overall soil quality, fertility and stability of soil.

Soil organic matter helps soils hold onto water and nutrients and supports soil microbes that recycle nutrients. Soil microbes are intimately associated with biological and biochemical transformations occurring in soil. Management practices that reduce SOM/SOC in soils, or bypass biologically-mediated nutrient cycling also tend to reduce the size and complexity of soil communities.

According to the estimates by ICAR-NBSS&LUP (2017-18), there is huge variation in SOC stock across states. The SOC stock of Indian soils is 10 to 12% of the tropical regions and about 3% of the total carbon mass of the world.

Soil Biology

Healthy soil is the most important factor for sustainable farming. Plants growing in healthy soils are part of a rich ecosystem including numerous and diverse microorganisms in the soil. Soil Microbes perform various biogeochemical functions.

It has been long recognized that microbes play important roles in plant nutrition. However, the full range of microbes associated with plants and their potential to replace synthetic agricultural inputs has only recently started to be uncovered.

There is clear evidence that plants shape microbiome structures, most probably by root exudates, and also that bacteria have developed various adaptations to thrive in the rhizosphere. The mechanisms of these interactions and the processes driving the alterations in microbiomes are, however, largely unknown.

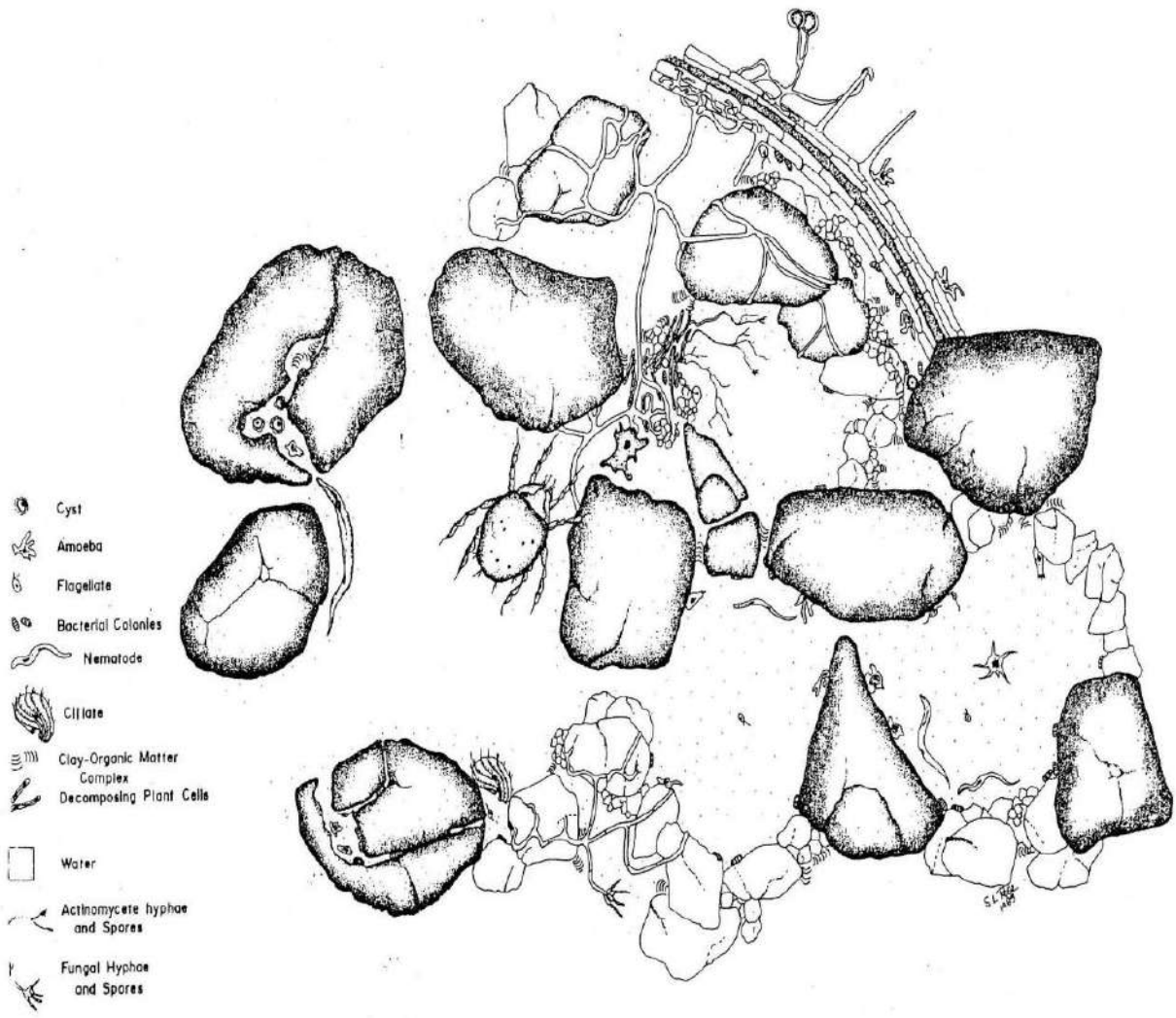
Soil microbiologists believe that healthy soil means living soil, which involves trillions upon trillions of living microorganisms consuming first organic matter, then each other, and releasing nutrients in the process.

Soil biological properties viz. microbial populations, enzymatic activity and soil bio-diversity are important indicators of soil quality, and they help in stimulating plant growth by influencing nutrient availability and soil hydro-thermal regime.

Soil microorganisms play an essential role in decomposing organic matter, cycling nutrients and fertilizing the soil.

Soil microbial activity that reflects microbiological processes of soil microorganisms (soil bacteria, actinomycetes, fungi, etc) is the potential indicator of soil quality, as plants rely on soil microorganisms to mineralize organic nutrients for growth and development. Soil microorganisms also process plant litter and residues into soil organic matter, a direct and stable reservoir of carbon and nitrogen that consists of living and dead organic materials subject to rapid biological decomposition. Soil microbes are also important for the development of healthy soil structure.

Soil bacterial species in plant rhizosphere which grow in, on, or around plant tissues and stimulate plant growth by a plethora of mechanisms.



Arbuscular Mycorrhizal Fungi (MF) colonise the root systems of plants. Plants offer photosynthetic sugars to MF, which in turn assist the plant by facilitating the uptake of mineral nutrients and water. In healthy soil, mycorrhizal fungi grow immensely which works like a sponge. It helps in improving soil aggregate stability, build soil carbon, improve water use efficiency and increase the efficiency of nitrogen, phosphorus and sulphur. To increase the mycorrhizal fungi, it needs to reduce/eliminate chemical use, reduce/eliminate tillage, reduce/eliminate synthetic fertilisers and living plant cover as long as possible. Cover crop also moderates soil temperature, which improves soil moisture condition and in turn helps in soil bacterial growth.

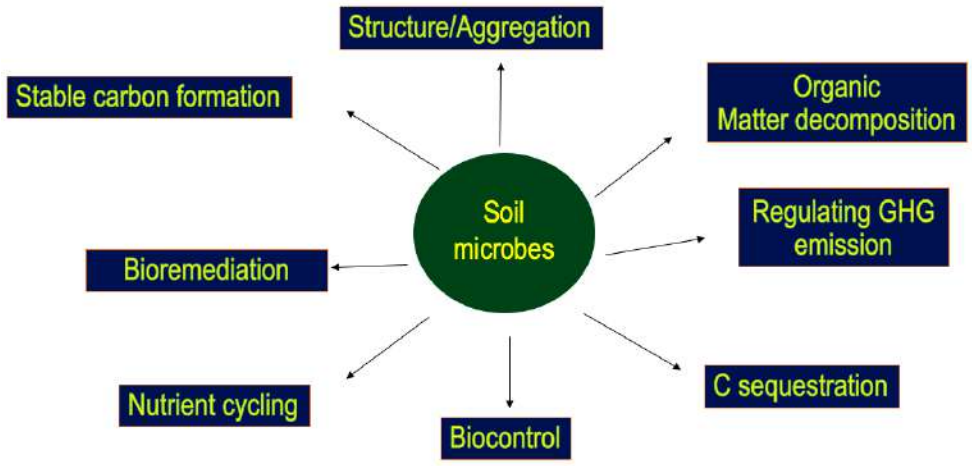


Figure showing role of soil microbes

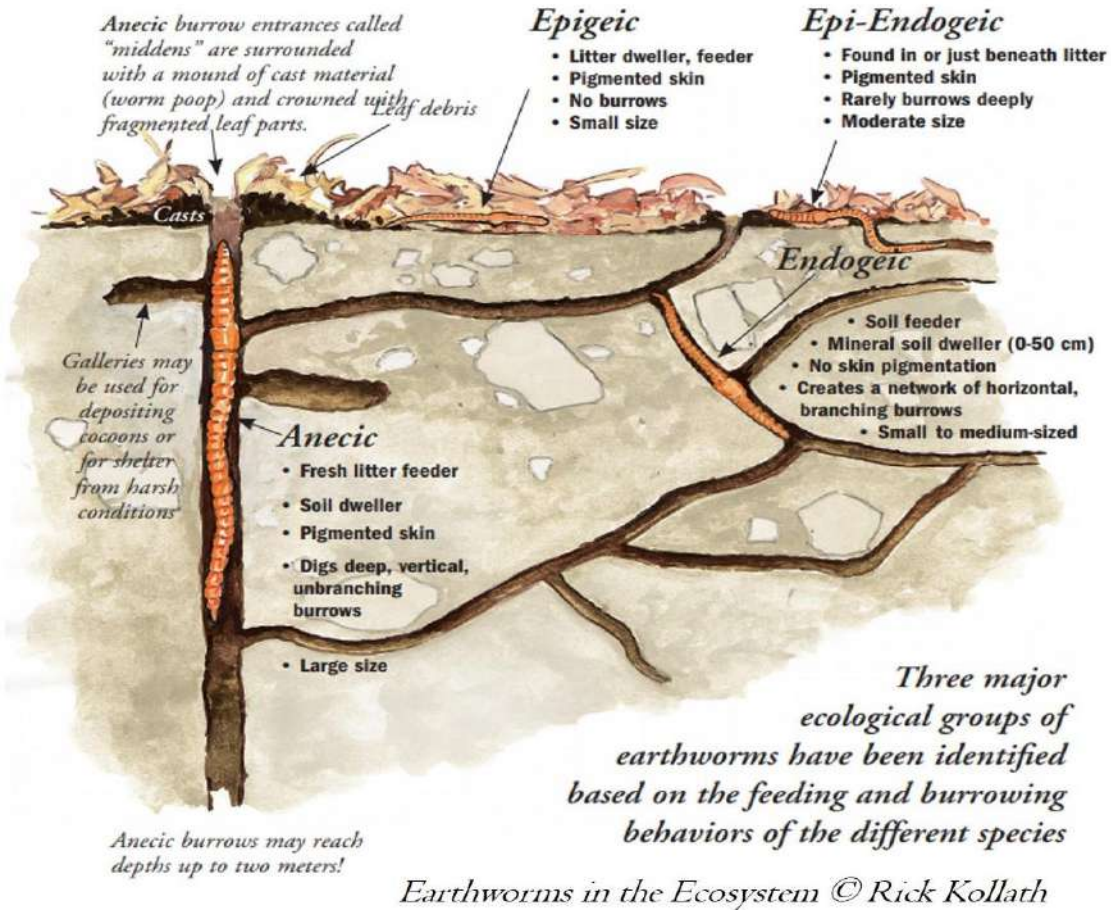
In healthy soil, these fungi together with the full coteries of soil microbes help in regeneration, resilience and revitalization of soil system making all needed nutrients available to the plants through fixation, decomposition, solubilization and mineralization. Thus, it also helps in building a soil carbon sponge, which absorbs water and makes it available to the plants. The application of chemical fertilisers, biocides, tilling of lands, etc. is detrimental to these soil microorganisms, and consequently roots of the plants act simply as straw sucking mainly those nutrients, which has been supplied externally in the forms of chemical fertilisers. Through biological processes, all the nutrients are made available to the plants through decomposition of root biomass of previous crops or mulches.

Changes in farming practices are foremost reflected in the changes in biological properties such as microbial populations and soil enzymatic activity. These occupy a pivotal role in reactions associated with organic matter decomposition and nutrient cycling. Soil enzymes have been suggested as one of the important indicator of soil quality, and for evaluating the degree of alteration and assessing the effect of different cropping systems on nutrient dynamics and soil quality.

Microbes provide crucial ecosystem services. The microbiota in the soils in which these grow provide nitrogen, phosphorus and other essential nutrients. Microbes in the oceans produce 50% of the oxygen we breathe, and remove roughly the same proportion of carbon dioxide from the atmosphere. They also remove up to 90% of methane from the world's oceans.

Soil fauna

Soil fauna is crucial to soil formation, litter decomposition, nutrient cycling, biotic regulation, and for promoting plant growth. Yet soil organisms like earthworms and micro-arthropods remain under-represented in soil processes. Earthworms are a major component of soil faunal communities in the natural farming ecosystem.



Source: https://kollathdesign.com/portfoliotype/natural-history-illustration/

Earthworms move the soil around and in the process create tunnels that alter soil in a beneficial way. Earthworm tunnels bring in oxygen, drain water and create space for plant roots. The natural feeding habits of earthworms involve ingestion of small amounts of soil through their bodies and then they excrete it in the form of earthworm casts, which improve soil fertility status.

Earthworms improve soil structure by dragging down organic matter, mixing soil and creating tunnels that improve drainage. Worm casts are rich in recycled plant nutrients, and can contain up to 40% more beneficial humus than the plough layer. Research has shown that

a fresh worm cast can hold as much as five times more accessible nitrogen, seven times more accessible phosphorous and 11 times more accessible potash than the surrounding top soils **(Farming Connect 2019).** Earthworms work throughout the soil from the surface to deep down in the soil profile. Their activity results in

- Improved nutrient availability - the casts they produce are rich in nutrients and when their bodies decompose, more nutrients are released to the soil;
- Improved drainage - their burrows allow movement of air and water through the soil; this is most noticeable in no till systems where movement of water through the soil can be much greater than in cultivated soil
- Improved soil structure – through improving the top soil by creating stable soil aggregates able to store moisture
- Improved productivity – as a result of all of the above

Earthworms affect the SOM dynamics. There is sharp increase of mineralization during digestion. Large amounts of mineral nutrients are present in fresh casts, which are reorganized in microbial biomass at the scale of days to weeks depending on soil properties. Also there is blocking of mineralization at the scale of months to years in the compact structure of ageing casts (i.e. older than 1–2 weeks), which help in Carbon sequestration.

Tillage, chemical fertilisation, and pesticide usage regularly influence earthworm populations. However, natural farming practices allow earthworms to proliferate. Cabbage intercropped with fenugreek, pea and coriander under Subhash Palekar Natural Farming (SPNF) found higher population count of earthworms (183.33 m^{-2}) in SPNF as compared to CF (41.67 m^{-2}) (cabbage as sole crop). The result showed that the application of cow urine and dung based inputs help in promoting earthworm activity in soil. Similarly earthworm cast weight was also higher in SPNF (57.23 gm^{-2}) than CF system (14.87±0.56 gm^{-2}) during the rainy season.

A systematic comparison between natural farming and non- natural farming fields conducted in Andhra Pradesh reveals that the natural farming fields host an average 232 earthworms per square metre compared with just 32 on non – natural farming fields.

Soil micro-arthropods include small invertebrate animals with an exoskeleton and segmented body that are visible to the human eye with some magnification for identification.

Among soil micro-arthropods, springtails (Collembola) and mites (Acari) play a primary role in the recycling of nutrients within terrestrial ecosystems. In particular, they are consumers of microbes such as bacteria and fungi. In fact, their feeding activity is better described as 'grazing'. Through this grazing they stimulate microbial activity and contribute to the mineralization of nitrogen and thereby to plant growth. As such they play an important role in soil fertility.

Soil microarthropods impact many soil processes that affect crop production. Most notably, microarthropods affect soil organic matter decomposition and nutrient cycling. They can also impact plant pathogen suppression and transmission, seed germination, root exudates, plant nutrient allocation and growth. Though soil mesofauna primarily affect crop production through their interactions with other factors in the soil environment, these indirect effects can add up to big impacts on crops.

(https://soilsmatter.wordpress.com/2023/06/01/how-do-soil-microarthropods-affect-crop-production/)

Studies shows that soil microarthropods have been found to be sensitive to changes in land management practices and are thus being used as indicators of soil quality. The abundance of soil microarthropods has been observed to be positively correlated with soil Carbon and Nitrogen.

Soil physical environment

It is essential to ensure good soil drainage, aeration, and optimum humidity for the growth of plants. Soils with reduced drainage may accumulate higher amounts of water than is needed and thus negatively affects plant growth. While insufficient soil moisture availability also adversely affect plant growth. Thus, it is important to maintain congenial soil physical environment.

Soil physical environment governs the ease of seed germination, root growth, soil aeration, soil hydrothermal regime, water retention and transmission in the rhizosphere. The soil and crop management practices affect the density and structure of soil and thus the physical properties which directly affect the plant growth namely soil water, soil air, soil temperature and soil hardness or penetration resistance.

Soil structure is a dynamic property which can be defined as “the shape, size and spatial arrangement of individual soil particles and clusters of particles (aggregates)”. Soil structure is generally characterized in terms of aggregate characteristics. Soil aggregates determine the air-water relationship and influence most of the soil physical properties and thus provide better environment for root development and plant growth. Moisture retention and availability depends upon the soil structure and pore geometry of soil.

Soil porosity and pore-size distribution depends upon the soil aggregation and thus the structure of soil. Soil structure includes the creation of secondary coarser pores and the formation of intra-aggregate finer pores. Structural degradation changes the pore size distribution and functionality, thus affecting soil air and water distribution and biological activity, it is essential to have a high proportion of pores with capacity to retain water available to plant roots.

Higher SOC and microbial diversity (fungal hyphae or bacteria) helps in the formation of porous spaces, thereby leading to increase in the absorption of water. Therefore, water adheres to the surface of particles or organic matters leading to water infiltration & increase in the holding capacity. Water transmission characteristics viz. infiltration rate and hydraulic conductivity, are affected by texture and structure. These will be higher, if the soil is highly porous, fractured or aggregated, than if it is highly compacted and dense. A significant relationship exist between hydraulic conductivity and water stable aggregates. Hydraulic conductivity not only depends on the pore volume but also continuity of conducting pores.

Natural farming practices enhance the soil microbial diversity and soil fauna, and thus lead to improved soil structure and porosity, which leads to better soil physical environment and thus improvement in soil-water-air relations.

06. SOIL FERTILITY

Natural Farming aims to improve the soil health through improving the soil biological activity by adding microbe inoculants and organic matter. The practices of Natural Farming include the addition of microbial cultures to enhance decomposition and nutrient recycling, use of local seeds, integration of crops, trees and livestock (mainly cows of native breeds), effective spacing of crops, contouring and bunds to conserve water, intensive mulching, extensive intercropping and crop rotations. Moreover, mulching has a huge positive effect on SOC content due to enhanced soil and water conservation, lower average and maximum soil temperatures under mulch than in unmulched soil surface, return of biomass to the soil, increase in soil biodiversity, and strengthening of the nutrient cycling mechanisms.

Natural farming has a lower – or even net positive - environmental and/or social impacts.

As mentioned in previous paras, natural farming practices improve SOC, microbial and soil faunal activity and thus enhance the nutrient cycling and availability to crop plants and maintain congenial environment in terms of soil moisture and aeration in the rhizosphere.

Soil management through natural farming practices contribute to building soil fertility and health. It increases water percolation, water retention, and clean and safe water runoff. It increase biodiversity and ecosystem health and resiliency; and it inverts the carbon emissions of our current agriculture to one of remarkably significant carbon sequestration thereby cleansing the atmosphere of legacy levels of CO_2.

The ability to reduce and derive appreciable amounts of nitrogen from the atmospheric reservoir and enrich the soil is confined to bacteria and Archaea. A number of bacterial species belonging to genera *Azospirillum*, *Alcaligenes*, *Arthrobacter*, *Acinetobacter*, *Bacillus*, *Burkholderia*, *Enterobacter*, *Erwinia*, *Flavobacterium*, *Pseudomonas*, *Rhizobium* and *Serratia* are associated with the plant rhizosphere and are able to exert a beneficial effect on plant growth. The important role is played by plants in selecting and enriching the types of bacteria by the constituents of their root exudates. Thus, the bacterial community in the rhizosphere develops depending on the nature and concentrations of organic constituents of exudates, and the corresponding ability of the bacteria to utilise these as sources of energy. Rhizospheric bacterial communities have efficient systems for uptake and catabolism of

organic compounds present in root exudates. Natural farming provides an unique opportunity to enhance utilisation of rhizobacteria in order to increase the crops productivity.

Ladha *et al.* (2016) constructed a top-down global N budget for maize, rice, and wheat for a 50-year period (1961 to 2010). They reported that non-symbiotic nitrogen fixation appears to be the major source for crop N uptake. An estimated 48% (737Tg) of crop N, equal to 29, 38, and 25 kg ha^{-1} yr^{-1} for maize, rice, and wheat, respectively, was contributed by sources other than fertilizer- or soil-N. Around 370 Tg or 24% of total N in the crop has been estimated to through Non-symbiotic nitrogen fixation, corresponding to 13, 22, and 13 kg ha^{-1} yr^{-1} for maize, rice, and wheat, respectively.

It is reported that Natural Farming is likely to reduce soil degradation and could provide yield benefits for low-input farmers. Nitrogen fixation, either by free-living nitrogen fixers in soil or symbiotic nitrogen fixers in legumes, is likely to provide the major portion of nitrogen available to crops. They also worked out maximum potential nitrogen fixation and release and reported that 52–80% of the national average nitrogen applied as fertilizer is expected to be supplied by biological fixation.

Phosphorus (P) is a major essential macronutrient for biological growth and development. Microorganisms offer a biological rescue system capable of solubilizing the insoluble inorganic P of soil and make it available to the plants. The ability of some microorganisms to convert insoluble phosphorus (P) to an accessible form, like orthophosphate, is an important trait in a rhizobacterium for increasing plant yields. The rhizospheric phosphate utilising bacteria are a promising source for plant growth promoting agents in natural farming.

The effect of *Jeevamrit*—cow-dung- and urine-based formulation—on soil chemical and microbial properties of the ZBNF field coupled with metagenomic analysis and the economics of ZBNF has been investigated. The percentage increase in soil properties, such as organic carbon, available phosphorus, and available potassium, was recorded up to 46%, 439%, and 142%, respectively, while micronutrients, such as Zn, Fe, Cu, and Mn, also increased up to 98%, 23%, 62%, and 55%, respectively, from 2017 to 2019. Whole genome metagenomic analysis revealed that Proteobacteria were dominantly present, and bacterial phyla including *Bacillus*, *Pseudomonas*, *Rhizobium,* and *Panibacillus*. On the other hand,

Ascomycota was the dominating fungal phyla present in the soil sample. Further, functional analysis showed a high representation of genes/enzymes involved in amino acids and carbohydrate metabolism contributing to soil fertility, plant growth, defense, and development.

Bio Formulations (Jeevamrit and Ghanjeevamrit)

There is a mention of fermented liquid natural manure in vrikshayurveda. The main bio-formulation that are applied in natural farming for soil health improvement are Jeevamrit and Ghanjeevamrit.

Jeevamrit

Jeevamrit is a fermented microbial culture. It provides nutrients, but most importantly, acts as a catalytic agent that promotes the activity of microorganisms in the soil to synthesize/ to make bio-available plant nutrients in situ, increases the population of native earthworms and protect against pathogens.

Natural Farming argues that the dung of indigenous cows/livestock and undisturbed soil from the field has a huge number of diverse microorganisms which help in increasing the bioavailability of nutrients to the plants. Soil is a complex ecosystem hosting bacteria, fungi, plants, and animals. Soil microbes metabolise recalcitrant forms of soil-borne nutrients to liberate these elements for plant nutrition. In natural ecosystems, most nutrients such as N, P, and S are bound in organic molecules and are therefore minimally bioavailable for plants. To access these nutrients, plants are dependent on the growth of soil microbes such as bacteria and fungi, which possess the metabolic machinery to depolymerize and mineralize organic forms of N, P, and S. have isolated many different bacterial genera such as *Citrobacter koseri, Enterobacter aerogenes, Escherichia coli, Klebsiella oxytoca, Klebsiella pneumoniae, Kluyvera spp., Morgarella morganii, Pasteurella spp., Providencia alcaligenes, Providencia stuartii*and *Pseudomonas spp.* from cow dung. It is also found that many cow dung microorganisms have shown natural ability to increase soil fertility through phosphate solubilization. isolated 219 bacterial strains from cow dung, among which 59 isolates displayed nematicidal activity against >90 percent of the tested nematodes. Cow dung has an antifungal substance that inhibits the growth of coprophilous fungi.

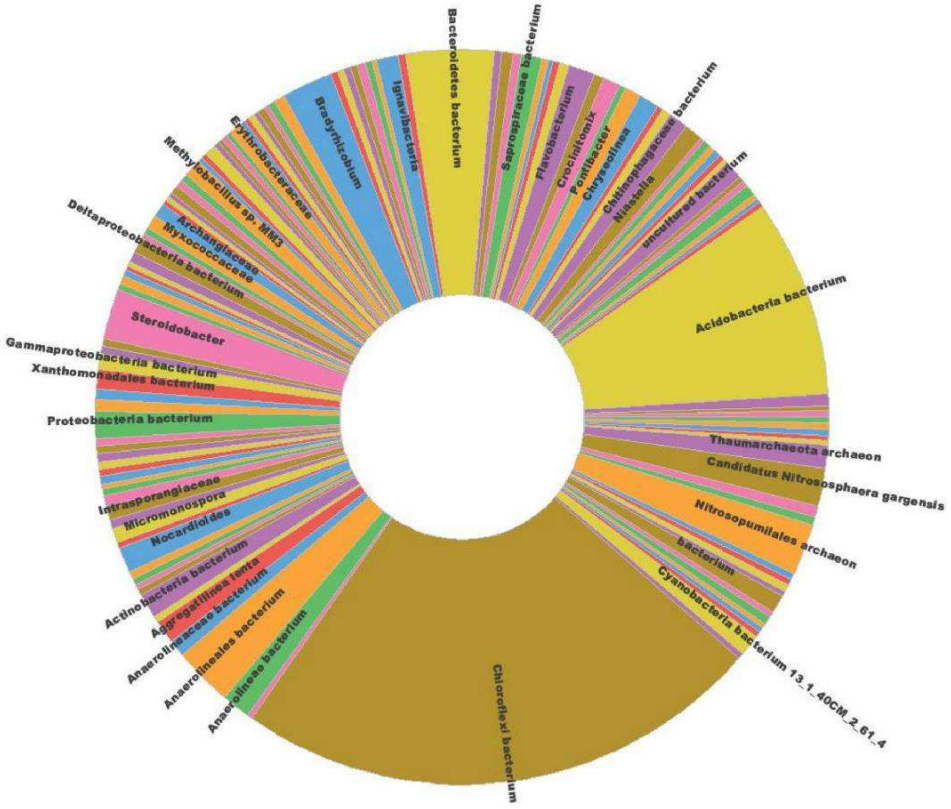
Jeevamrit acts as a biostimulant by promoting the activity of microorganisms in the soil and also the activity of phyllospheric microorganisms when sprayed on foliage. It acts like a primer for microbial activity, and also increases the population of native earthworms.

a. Preparation of jeevamrit: Put 200 litres of water in a barrel. Add 10 Kg fresh local cow dung. Add 5 to 10 litres of cow urine. Add 2 Kg of Jaggery (a local type of brown sugar). Add 2 Kg of pulses flour and a handful of soil from the bund of the farm. Stir the solution well and let it ferment for 48 hours in the shade. *Jeevamrit* is ready for application. 200 litres of *jeevamrit* is sufficient for one acre of land. During the 48-hour fermentation process, the aerobic and anaerobic bacteria present in the cow dung and urine multiply as they eat up organic ingredients (like pulse flour and jaggery). A handful of undisturbed soil acts as an inoculate of native species of microbes and organisms. *Jeevamrit* also helps to prevent fungal and bacterial plant diseases.

b. **Application of Jeevamrit**: This mixture should be applied every fortnight. It should be either sprayed directly on the crops or mixed with irrigation water. In the case of fruit plants, it should be applied on individual plants. The mixture can be stored for up to 15 days.

Ghanjeevamrit

It is the dry formulation of jeevamrit. Spread 200 kg of cow dung on ground uniformly in the form of a layer and add 20 litres of liquid jeevamrit on it and mix it. Now, make a heap of treated cow dung and cover it using a jute bag for 48 hours allowing it for fermentation then spread it on the floor, and dry in the sunlight. After drying is completed, store it in jute bags in the room. Air should be flowing. Ghanjeevamrit can be stored for 6 months. At the sowing period, use 200kg Ghanjeevamrit per acre. Again during the flowering period of the crop, add 50 kg of Ghanjeevamrit in between two crop lines on the soil per acre. It helps the soil to activate their available nutrients, microorganisms to make them available for the crop sown in that particular area. It increases the count of earthworms in soil which is beneficial for soil fertility. Ghana Jeevamrit has a large number of nutrients like nitrogen, phosphorus, calcium, and other micronutrients. This will ensure higher yield by enhancing the availability of nutrients through faster decomposition of bulky organic manures by boosting the microbial activity in the soil. Many of these formulations are rich in beneficial micro flora and can act as efficient plant growth promoters.



Microbial diversity under natural farming

Aacchadan (mulching)

Mulching is defined as covering of soil surface using either live crops or crop residues like straw (dead plant biomass).

It protects soil from direct exposure from sunlight, produces humus, conserves top-soil, increases water retention and transmission, moderates hydro-thermal regime, encourages soil fauna, and prevents weeds.

Mulching prevents the formation of hard crust after each rain. The use of blade harrows between rows or intercultural operations creates ‘dust mulch’ on the soil surface by breaking the continuity of capillary tubes of soil moisture and reduces evaporation losses.

Evidence suggests that crop residues are good sources of plant nutrients and can increase yield and water use efficiency, while decreasing weed pressure. Long-term studies of

the residue recycling have indicated improvements in physical, chemical and biological health of soil.

Three types of mulching have been suggested under natural farming:

- **Soil Mulch**: This protects topsoil during cultivation and does not destroy it by tilling. It promotes aeration and water retention in the soil. Therefore, deep ploughing should be avoided.
- **Straw Mulch:** Straw material usually refers to the dried biomass waste of previous crops. Any type of dry organic material will decompose and form humus through the activity of the soil biota which is activated by microbial cultures.
- **Live Mulch**: It is essential to develop multiple cropping patterns of monocotyledons and dicotyledons grown in the same field, to supply all essential elements to the soil and crops. Dicot groups such as pulses are nitrogen-fixing plants. Monocots such as rice and wheat supply other elements like potash, phosphate and sulphur.

The natural farming initiatives show promise for transformation at scale and open up a new frontier in thinking about agriculture with efficient utilisation of soil and water resources. Intensive irrigation and deep ploughing is not promoted in Natural Farming. This farming system also promotes soil aeration, minimal watering, intercropping and buds and topsoil mulching. Aacchadan, associated with natural farming which is mulching either by crop residues or live mulch through intercrops, does not allow soil evaporation and transpiration. Whapasa, is a condition where there is a presence of both air molecules and water molecules in the soil. This condition helps in reducing irrigation requirements and promotes water availability to the crops through soil capillary actions. The drought conditions can be mitigated through Intercropping and Aachhadan. This intercropping and Aachhadan conditions enhance the activities of soil earthworms from top to bottom soils and vice-versa.

As per the Centre for Study of Science, Technology and Policy (CSTEP) report based on a study conducted in Andhra Pradesh in 2020, natural farming requires 50 to 60 percent less water and electricity when compared to conventional farming practices.

Natural farming practices also prevent over-extraction of groundwater, enable aquifer recharge, and eventually contribute to increasing water table levels.

Soil Aeration (Whapasa)

Soil aeration, a result of jeevamrit and achadan- represents water management through improved soil structure and humus content. It increases water availability, water use efficiency, and increases resilience to drought. The advocates of natural farming counter the over-reliance on irrigation in green revolution farming.

Whapasa is the condition, wherein both air molecules and water molecules are present in the soil. Thus, irrigating only at noon, in alternate furrows, may fulfil the moisture requirement of the crops, a significant decline in need for irrigation in natural farming. The ***whapasa*** principle of Natural Farming increases soil aeration and maintains air and soil moisture in equal proportion around plant root zone (rhizosphere). Under irrigated and high rainfall conditions, the excess water makes it very difficult for the roots to get the air that they need, causing them to decay. Thus the ***whapasa*** condition avoids the occurrence of soil and root borne disease.

Soil and water conservation practices

Biological measures (agronomic/agricultural and agroforestry) of soil and water conservation reduce the impact of raindrops through the covering of soil surface and increasing infiltration rate and water absorption capacity of the soil resulting in reduced runoff and soil loss through erosion. These measures are cheaper, sustainable, and may be more effective than structural measures.

Important agronomic measures favouring soil and water conservation are described below:

Green manuring: Green undecomposed material used as manure is called green manure. It is obtained in two ways: by growing green manure crops or by collecting green leaf (along with twigs) from plants grown in wastelands, field bunds and forest. Green manuring usually belongs to the leguminous family and is incorporated into the soil after sufficient growth. The plants that are grown for green manure are known as green manure crops. The most important green manure crops are sunn hemp, dhaincha, pillipesara, cluster beans and Sesbania rostrata.

Contour farming: Contour farming is the most common agronomic measures for soil and water conservation in hilly agro-ecosystems and sloppy lands. All the agricultural operations viz. ploughing, sowing, inter-culture, etc. are practised along the contour line. The ridges and

furrows formed across the slope build a continual series of small barriers to the flowing water which reduces the velocity of runoff and thus reduces soil erosion and nutrient loss. It conserves soil moisture in low rainfall areas due to increased infiltration rate, whereas in high rainfall areas, it reduces the soil loss. In both situations, it reduces soil erosion, conserves soil fertility and moisture and thus improves overall crop productivity. The effectiveness of this practice depends upon rainfall intensity, soil type and topography of a particular locality.

Choice of crops: The selection of the right crop is crucial for soil and water conservation. The crop should be selected according to the intensity and critical period of rainfall, market demand, climate and resources of the farmer. The crop with good biomass, canopy cover, and extensive root system protects the soil from the erosive impact of rainfall and creates an obstruction to runoff and thereby reduces soil and nutrient loss. Row or tall-growing crops such as sorghum, maize, pearl millet, etc. are erosion permitting crops which expose the soil and induce the erosion process. Whereas, close growing or erosion resistant crops with dense canopy cover and vigorous root system viz. cowpea, green gram, black gram, groundnut, etc. are the most suitable crops for reducing soil erosion. To increase the crop canopy density, the seed rate should always be on the higher side.

Crop rotation: Crop rotation is the practice of growing different types of crops in succession on the same field to get benefits for soil and crop systems. Beneficial effects include lower incidence of weeds, insects, and plant diseases, as well as improvements of soil physical, chemical, and biological properties. Monocropping results in exhaustion of soil nutrients and deplete soil fertility. The inclusion of legume crops in crop rotation reduces soil erosion, restores soil fertility, conserves soil and water and helps supplement atmospheric nitrogen to the soil. Further, the incorporation of crop residue improves organic matter content, soil health and reduces water requirement. A suitable rotation with high canopy cover crops helps in sustaining soil fertility, suppresses weed growth, decreases pests and disease infestation, increases input use efficiency and system productivity while reducing the soil erosion.

Intercropping/Mixed cropping: Cultivation of combination of different types of crops with different canopy and maturity time simultaneously. It reduces demand of a particular type of plant nutrients and increases availability of different types of crop produce on a regular basis to augment farmers income.

Intercropping: Cultivation of two or more crops simultaneously in the same field with definite or alternate row pattern is known as intercropping. It may be classified as row, strip, and relay intercropping as per the crops, soil type, topography and climatic conditions. Intercropping involves both time-based and spatial dimensions. Erosion permitting and resisting crops should be intercropped with each other. The crops should have different rooting patterns. Intercropping provides better coverage on the soil surface, reduces the direct impact of raindrops and protects soil from erosion.

Cover crops: The close-growing crops having high canopy density are grown for protection of soil against erosion, known as cover crops. Legume crops have better biomass to protect soil than row crops. The effectiveness of cover crops depends on crop geometry and development of canopy for interception of raindrops which helps in reducing the exposure of soil surface for erosion. The legumes provide better cover and better protection to land against runoff and soil loss as compared to cultivated fallow and sorghum crops. The most effective cover crops are cowpea, green gram, black gram, groundnut, etc.

Strip cropping: Growing alternate strips of erosion permitting and erosion resistant crops with a deep root system and high canopy density in the same field is known as strip cropping. This practice reduces the runoff velocity and checks erosion processes and nutrients loss from the field. The erosion resistant crops protects soil from beating action of raindrops, reduces runoff velocity and thereby increased time of concentration which results in a higher volume of soil moisture and increased crop production. Strip cropping is practised for controlling the run-off and erosion and thereby maintaining soil fertility. In natural farming our five layer model is an example of this type of cropping.

Agroforestry: Agroforestry indicates land use systems and technologies, in which woody perennials such as trees, shrubs, palms etc., are effectively combined on the same land-management unit as agricultural crops and/or animals, either in some form of spatial arrangement or in a temporal sequence. In agroforestry systems, there are ecological and economical interactions among different components.

Reduced Tillage: Excessive tillage is harmful to soil health in a number of ways. Tillage increases oxygen in the soil, stimulating microbial activity, and results in the decomposition of organic matter. Tillage also disrupts soil aggregates, exposing particles of organic matter that had been physically protected within aggregates to microbial consumption. Inversion

tillage also reduces the soil coverage provided by crop residues, leaving soil more exposed to erosion.

Tillage can also disrupt the hyphal network of mycorrhizal fungi, which can lead to their decline over time. When not managed carefully, most inversion and non inversion tillage methods compact the subsoil, creating a plow pan, which restricts root growth and access to water and nutrients in the subsoil. Excessive wheel and foot traffic can compact the surface soil, reducing macro porosity and impeding root growth.

Application of bio formulations through micro irrigation

Micro irrigation practices can be integrated under natural farming to reduce the labour cost and further increasing application efficiency. Ingredients for preparing natural inputs like cow dung and cow urine are collected in a tank situated within the gaushala. After automatic filtration, these are used for preparing natural farming inputs like jeevamrit and are applied to the crops through micro-irrigation without the involvement of human labour. A number of innovative farmers have designed and developed systems for flood and drip irrigation of Natural Farming Bio-formulations. These designs involve creation of filtration and percolation chambers for removing waste and particulate matter residue from the liquid formulations. Then with ingeniously designed pump and mixing systems, these are operable with minimum labour interventions.

Cropping Systems

07. CONVERSION FROM CONVENTIONAL FARMING TO NATURAL FARMING

The transition from conventional to Natural Farming requires numerous changes. One of the biggest changes is in the mindset of the farmer. Conventional approaches often involve the use of quick-fix remedies that unfortunately, rarely address the cause of the problem. Transitioning farmers generally spend too much time worrying about replacing synthetic inputs with inputs derived from naturally occurring sources. Natural Farming system relies on sound practices focused on preventive strategies. Since there are often few natural remedies available to natural farming producers for certain problems, prevention is the key element in natural farming. Here are a few steps which a farmer should follow when making the transition to natural farming.

Training and Awareness on Natural Farming

Natural Farming systems are knowledge based. New entrants and transitional producers must become familiar with sound and sustainable agricultural practices. Transitional producers should be prepared to read appropriate information, conduct their own trials and participate in training programmes, seminars, etc.

Visit to Nearby Demonstrations (Govt. KVK, SAU or Progressive/ Champion Farmers' Field) to gain practical knowledge the transitional farmers should be prepared to visit Natural Farming fields of nearby Krishi Vigyan Kendra, Agricultural universities or progressive natural farmers' field and collect all relevant information and photographs related to farm operation, yield, products, certification, processing information, etc.

Start with at least one acre or part of the field

Transitional producers should start Natural farming in at least one acre area or some part of their field and conduct their own trials based on trainings received and exposure visits. Successful natural farmers continuously try new and/ or innovative natural practices. Natural practices such as multiple cropping, cover cropping, intercropping and use of various soil and pest management bio inputs need to be evaluated regularly.

Start increasing the reliance on natural produce for self-consumption. Slowly expand to neighbour hood markets and distant markets. Although, the demand for natural products is continuously growing, ensure reliable market for the natural products while expanding the area under the natural farming.

Converting Whole Farm into Natural Farming

To convert whole farm, various steps to be taken should include realistic time frames. Farmers have to identify their strengths and weaknesses. All necessary tools to begin the transition, such as mechanical weeding equipments, composting equipments, additional handling equipments dedicated to the natural products and processing equipments should be procured.

Arrange Cow or Cattle for Natural Farming

Cow is the basis of natural farming. Dung and urine are essential for preparing bio formulants for maintaining the soil fertility and natural insect repellents. Procure cow or cattle, if not available on the farm. Also appropriate changes in the cow shed should be made for easy collection and storage of urine. Attend trainings on On-farm Input preparation based on dung, urine and green leaves.

Increase Crop diversity and add trees

Management of an appropriate habitat for sustenance of different life forms is an essential component of natural farming. This can be achieved by ensuring crop diversity and by maintaining a wide variety of trees and bushes as per climatic suitability. These trees and bushes will not only ensure the nutrients from air and deep soil layers to surface layer but also attract the birds and predators, friendly insects by providing them food and shelter. There may be some loss of productivity due to shading effect of the trees, but that loss can be compensated with reduced pest problems and reduced cost of cultivation. In a 10 acre farm in the plains, it is suggested to plant at least five to six neem trees *(Azadirachta indica),* one to two tamarind *(Tamarindus indica) trees,* two cluster fig *(Ficus glumerata),* eight to ten *ber (Zizyphus Sp)* bushes, one to two *aonla (Emblica officinalis) trees,* one to two drumstick trees and 10-15 wild bushes.

On the wet farms there should be five to six neem trees, one to two wood apples, one to two star fruit, eight to ten guava or soursop, three to four drumstick, one to two fig and 10-15 bushes of mulberry, star gooseberry, curry leaf etc. On the dry farms there must be at least five to six neem, one to two bel fruit, eight to ten *ber* or custard apple, one to two *aonla,* one to two drumstick and 10-15 bushes of *Vitex negundo, Cassia auriculata* etc.

In hilly areas, *Alnus nepalensis* is considered to be wonder tree as it fixes good amount of nitrogen. It is being promoted in a cropping system mode particularly in north-eastern India. Bushes of *Prunus*, oak *(Quercus glauca), Pinus* species along the farm boundary and yarrow *(Achillea millifolium),* buck wheat *(Fagopyrum esculentum),* lupin *(Lupinus sativus),* Himalayan stinging nettle (*Urtica parviflora),* marigold, etc., in between the plots invite a lot of predators and attract a large number of pests.

Fruit orchards also need to maintain adequate diversity with at least 3-5 types of fruit plants and few non-fruit trees. Plot bunds (about 1.5m wide) should be planted with *Glyricidia,* perennial *Sesbania (Sesbania grandiflora), Leucaena leucocephala, Cassia siamea,* etc. The internal hedgerow should consist of perennial pigeon pea, Crotalaria, seasonal *Sesbania,* etc. Lops from these trees will provide enough quantity of biomass for various purposes.

In between *Glyricidia/ Sesbania* rows insert few plants of pesticidal value such *as Adathoda vasaca, Vitax nigundo, Calotropis, Datura alba, Jatropha curcas, Ipomea (Besharam),* etc. Surrounding the farm or garden, there should be hedgerows or a live fence of coppiced or pollarded, multipurpose, deep-rooted trees and shrubs and medicinal herbs. Ecological diversity is an essential component of any successful organic farming system.
Trees on utility space can be allowed to grow fully. Trees and bushes on farm bunds should be placed randomly at sufficient distance and pruned at repeated intervals. *Glyricidia* plants should be planted at close spacing on all major bunds and all around the farm. They will act not only as biological fence but also provide valuable biomass.

Crop Diversity and Crop Rotation

The objective should be to have the entire farm area covered by crops for as long as possible during the year. Mixed cropping is the outstanding feature of natural farming in which variety of crops are grown simultaneously or at different time on the same land. Mixed cropping increases photosynthesis. It avoids competition for nutrients because different crops draw their nutrients from different depths of the soil. The legume crops fix atmospheric nitrogen and make available for companion or succeeding crops. Deep rooted plants draw nutrient from deeper layer of soil and bring them to the surface of soil through their leaf fall. So, the nutrients leached down to lower strata are further brought back to upper layer by these

deep-rooted plants. Farmers should select the crops combination according to their needs and season.

Companion crops should be selected carefully, for e.g., maize gets along well with beans and cucumber, tomatoes go well with onions and marigold. On the other hand, beans and onions do not grow well with each other.

Entire farm should have at least 8-10 types of crops at all the times. Each field/ plot should have at least 2-4 types of crops out of which one should be legume. In case if only one crop is taken in one plot, then adjacent plots should have different crops.

Crop rotation is the backbone of natural farming practices. To keep the soil healthy and to allow the natural microbial systems working crop rotation is must. Crop rotation is the succession of different crops cultivated on same land. Follow 3-4 years rotation plan. All high nutrient demanding crops should follow legume dominated crop combination. Rotation of pest host and non pest host crops help in controlling soil borne diseases and pest. It also helps in controlling weeds. Crop rotation is good for improving productivity and fertility of the soil. Crop rotations help in improving soil structure through different types of root system. Legumes should be used frequently in rotation with cereal and vegetable crops. Green manure crops should also find place while planning the rotations. Some important benefits of crop rotations are:

- Soil structure is improved through different types of roots,
- Pest build up is avoided, and
- Rotations help against the build-up of weeds.

Preparation of Bio Inputs

If needed attend training programs on bio input preparations. Gain skill and expertise in preparation and use of bio inputs for soil fertility management and pest and disease management.

Seeds/ Planting Material Treatment

Use of disease-free seed stock is one of the best options in pest and disease. Farmers should be aware and use different methods for this purpose, such as:

- Hot water treatment at 53° C for 20-30 min.
- Cow urine or cow urine-termite mound soil paste.

- Beejamrut
- Asafoetida 250 gm in one lit. of water for 10 kg seed.
- Turmeric rhizome powder mixed with cow urine.
- Panchgavya extract

Soil Enrichment

During conversion period, soil fertility can be improved and maintained initially through use of natural inputs like well decomposed compost and green manure in appropriate quantities. Well- fed healthy soil rich in microflora and microfauna takes care of the crop nutrient requirement.

Lopping from Glyricidia and other plants grown on bunds, animal dung and urine and crop residue should form the major source for nutrients. Changing crop rotations and multiple crops ensure better utilization of resources.

Application of liquid manure (for soil enrichment) is essential to maintain the activity of microorganisms and other life forms in the soil. 3-4 applications of liquid manure is essential for all types of crops. Cow urine & Panchgavya are excellent growth promoters when used as foliar spray. 3-5 sprays after 25-30 days of sowing ensure good productivity.

Pest Management

As synthetic chemicals are prohibited, the pest management is done by cultural or agronomic, mechanical, biological or by naturally accepted botanical extracts. Get acquainted and trained in neem, urine based formulations, fermented butter milk, dashparni extract, mixed leaves extract, chilli-garlic extract, etc.

Follow Mulching and Moisture Conservation

A mulch is natural spread layer of plant residues or other materials on the surface of the soil. Natural mulches are from natural origin materials which can decompose naturally like agricultural wastes which are used as mulch such as grasses, weed plants, wheat or paddy straw, plant leaves and saw dust etc. It decays over time, and increases the water holding capacity of soil. It also provides the soil with nutrients as it breaks down. It also improves water use efficiency indirectly. A mulch layer restricts the weed growth by obstructing light penetration to the soil surface.

Increase biomass production for mulch material by incorporating trees, cover crops, green manure crops into crop rotation, etc.

Follow Good Agricultural Practices

Include the following good practices while starting and expanding the areas under natural farming:

- Crop rotation
- Cover Crops
- Multiple cropping
- Natural Methods for Disease and Pest Management
- Agroforestry Practices
- Soil preparation, sowing, manuring, irrigation, weeding, harvesting, and storage are the some more steps of good agriculture practices.

Post-Harvest Management

Post-harvest management is a system of handling, storing, and transporting agricultural commodities after harvest. During the post-harvest period, handlers and producers focus on preserving quality, quantity, and the safety of the commodities.

Material used for packaging should be eco-friendly. Unnecessary packaging material should be avoided. Recycling and reusable systems should be used. Packaging material should be biodegradable. Material used for packaging should not contaminate the food.

Products integrity should be maintained during storage and transportation of natural products. Natural products must be protected from co-mingling with non-natural products and must be protected all times from the materials and substances not permitted for use in natural farming. The farmers taking up natural farming should be aware and if need be get trained in these aspects.

Maintain Written and Photo Documentation

Record keeping is one of the most important requirements in natural farming. Farmers are expected to keep all detailed information and photographs regarding farm operation, yield, products and processing. Once the record keeping requirements are understood, the reporting procedure established, the paper work becomes regular. This will help in certification process documentation.

Steps for Farmers journey from Conventional to natural farming

1) Desire for conversion from chemical to natural farming is articulated by farmer after being sensitized through NF training program or awareness from various means. The farmer and their family thoroughly understand the NF principles as well as the do and don'ts. The economic benefits of NF vs conventional methods are to be fully understood as well the risks if the package is not applied completely and carefully.
2) Farmer individually or in group conducts self-assessment of existing practices and develop a short term action plan or what he/ she wants to do.
3) Identify Knowledge requirements and gaps and how to overcome the gaps and updation of knowledge.
4) Review of available tools and equipment's and requirements for NF including use of desi breed of animals.
5) Identification of potential resource persons (farmers, KVK scientists, line departments etc) as per the crops and associated requirements for pest and disease management.
6) Conduct soil health assessment including soil testing and plan for improving soil nutrients to have a baseline information, particularly for Organic Carbon.
7) Identify friends and neighbor's who are practicing NF or interested to convert to NF. Regular interactions with such like-minded persons to share knowledge.
8) Establishes or modifies the farm including space and methods conducive for NF, e.g. cow shed, dung and urine collection, preparations of inputs for nutrient and pest management etc.
9) Conduct NF trials on crops, fruits and vegetables in first season in small area of upto one acre and observation of the learnings through continuous sharing with other farmers, scientists etc.
10) Failures and successes to be documented carefully of what went right or wrong during the first season. Plan for the next season in terms of expanding area and selection of crops.
11) If possible apply for certification individually or in a group.
12) After meeting the home needs, marketing of Natural Farming products to be done directly to friends and other nearby interested persons and encourage them to visit the farm. Apply concepts like FAMILY FARMER, Visit the natural farm to harvest the crops etc. in the short run. Gradually upscale as much as possible the marketing of the products directly to consumers.
13) Organise visits to farms of well performing NF and also invite them to your farm.
14) Over a period of two to three years (4 to 6 seasons) based on experience the entire land of the farmer can be converted to NF. The availability of Natural materials, labour, market experience etc and past experiences to be considered as part of the upscaling plan and course corrections made from time to time.

08. CROP DIVERSITY AND CROPPING SYSTEM

Cropping systems refer to the comprehensive integration of crops, crop rotations, and management strategies applied over time and space on specific agricultural lands. While the conventional focus was on maximizing output, Natural farming is increasingly oriented towards promoting environmentally sustainable cropping practices. Across the globe, diverse cropping systems are implemented, including Multiple Cropping, Double Cropping, Triple Cropping, Relay Cropping, Ratoon Cropping, and Intercropping, each tailored to specific agroecological conditions and sustainable farming principles.

A cropping system is a defined assemblage of crops and the sequence in which they are cultivated over time within a specific area of land.

- It involves either growing a single crop consistently on the same land each year or rotating different crops in a systematic pattern.
- The system is location-specific and adapts to changes in environment and geography.
- The primary goal of any cropping system is to optimize the return on investment by effectively utilizing available resources, including solar energy, water, and land.
- The key components of a cropping system include management strategies, planting geometry, and seed genetics.
- It is a dynamic agricultural strategy that responds to local conditions and seeks to maximize productivity while ensuring sustainable resource management.
- Thoughtfully integrating crop varieties and rotations enhances agricultural resilience and maintains long-term land viability for future generations.

CROPPING SYSTEM - TYPES

1. Multiple Cropping:

Multiple cropping is a farming practice where two or more crops are grown simultaneously on the same piece of land. For example, cultivating wheat and gram together on the same field.

This practice is prevalent in various regions, especially on small farms, where farmers aim to produce food for household consumption with limited resources.

Multiple cropping offers several advantages:

- Increased Yields: Growing multiple crops together ensures efficient utilization of available resources, such as sunlight, water, and nutrients. This leads to increased overall crop yields compared to growing a single crop.
- Risk Diversification: Planting multiple crops provides a buffer against potential risks and crop failure. If one crop is affected by pests, diseases, or adverse weather conditions, the other crop(s) can still thrive, reducing the impact on the farmer's livelihood.
- Efficient Land Use: Multiple cropping optimizes land use by making the most of the growing season. Once one crop is harvested, another is already growing, maximizing productivity from the same plot of land.
- Improved Soil Health: Different crops have varying nutrient demands and root structures. Multiple cropping helps in maintaining soil fertility as various crops utilize and contribute different nutrients to the soil.
- Household Food Security: For small-scale farmers, multiple cropping ensures a diverse and steady supply of food for their households throughout the year, reducing the reliance on a single crop for sustenance.
- Income Generation: By diversifying their crops, farmers can spread the sales of produce throughout the year, allowing for a steady income stream and potentially capturing higher market prices.
- Sustainability: The practice of multiple cropping aligns with sustainable agricultural principles by promoting biodiversity and reducing the reliance on chemical inputs.

However, multiple cropping also comes with some challenges:

- Management Complexity: Cultivating multiple crops requires careful planning, monitoring, and management to optimize crop combinations and resource use.
- Pest and Disease Management: Growing different crops together may attract a broader range of pests and diseases, necessitating effective pest control strategies.

- Crop Selection: Farmers need to select compatible crops that complement each other in terms of growth rate, resource requirements, and market demand.

2. Mono Cropping

Monocropping is the agricultural technique of producing a single crop year after year on the same ground without rotating through other crops or growing many crops on the same land, which is known as polyculture.

Three widely produced crops that are frequently grown using monocropping methods include paddy, wheat, maize and soybean.

Monocropping has catastrophic impacts on the environment and it also raises the possibility of contracting infections and pests.

3. Sequential Cropping:

Sequential cropping involves the practice of growing two or more crops in succession on the same field within a single growing season.

Once the previous crop is harvested, the subsequent crop is planted, making efficient use of the available growing time and resources. For example, in regions with prolonged and shorter rainy seasons, farmers may plant maize during the prolonged rains and pulses during the shorter rainy season, ensuring optimal utilization of the available water resources.

In some areas with extended wet seasons, it is possible to grow two major crops in succession or one main crop followed by a cover crop to enhance soil health and fertility. The feasibility of growing two crops in succession also depends on the presence of two distinct rainy seasons or sufficient moisture in the soil to support the growth of both crops.

Unlike intercropping, where multiple crops are grown together in the same field simultaneously, sequential cropping focuses on maximizing crop intensification solely in the spatial dimension. There is no competition between crops, and farmers manage one crop at a time in the field.

Benefits of Sequential Cropping:

These are similar to multiple cropping:

- Optimal Resource Utilization: Sequential cropping enables farmers to efficiently use available resources, such as water, nutrients, and sunlight, by ensuring continuous crop growth throughout the growing season.
- Improved Soil Health: Planting different crops in succession can help improve soil health as each crop contributes different nutrients and organic matter to the soil.
- Risk Diversification: By growing multiple crops in succession, farmers can reduce the risk of complete crop failure. If one crop is affected by pests or adverse weather, the subsequent crop may still succeed.
- Enhanced Crop Productivity: Sequential cropping can lead to higher overall crop productivity as the land is productively utilized throughout the growing season.
- Sustainable Farming: By maximizing crop intensification without intercrop competition, sequential cropping promotes sustainable agricultural practices.

Challenges of Sequential Cropping:

- Labor and Management: Managing successive crops may require more labor and attention to ensure timely planting, irrigation, and harvesting.
- Crop Selection: Careful selection of crop combinations is essential to ensure that subsequent crops are well-suited to the local climate and growing conditions.

4. Relay Cropping:

Relay cropping is a unique farming practice where a second crop is planted before the previous one has been harvested, allowing both crops to share a portion of the growing season. Examples of relay cropping include planting rice (or wheat) alongside Black gram, onions, lady's fingers and maize simultaneously.

This approach reduces risks associated with relying solely on a single crop, as farmers can simultaneously grow multiple crops in the same field.

Benefits of Relay Cropping:

- **Risk Reduction**: By cultivating multiple crops at the same time, relay cropping provides a safety net against potential losses due to crop failure or adverse weather conditions. If one crop faces challenges, the other may still thrive, safeguarding the farmer's overall harvest.

- **Insect Control**: The distribution of crops in relay cropping can help control the spread of pests and diseases. Insects that prefer one crop may be deterred or disrupted by the presence of a different crop, reducing their impact on the entire planting.

- **Improved Labor Efficiency**: Relay cropping optimizes labor distribution as farmers can efficiently manage multiple crops concurrently. This approach ensures better utilization of labor throughout the growing season.

- **Soil Nutrient Enhancement**: Certain relay cropping combinations, especially those involving legumes like peas or beans, contribute nitrogen to the soil through nitrogen fixation. This natural nitrogen enrichment benefits subsequent crops, promoting soil health and fertility.

Challenges of Relay Cropping:

- **Crop Selection**: Selecting compatible crops that can coexist harmoniously in the same field is critical for successful relay cropping. Some crops may compete excessively for resources, leading to reduced yields.

- **Management Complexity**: Managing multiple crops with different growth rates and requirements can be more challenging and require careful planning and attention.

- **Timing**: Proper timing is essential in relay cropping to ensure that one crop is ready for harvest before the other requires the full use of the field. Poor timing may lead to resource competition and reduced yields.

5. Ratoon Cropping

Ratoon cropping is a method of farming in which the remnants of one crop that has previously been harvested are used to cultivate a second crop. As new plants emerge from the harvested crop's stubble, the practice is also known as "stubble cropping."

As production and quality decline after each cycle, ratooning cannot be employed indefinitely. For instance, it is possible for sugarcane to have two or three ratooning crops before new planting is required.

6. Intercropping

Intercropping is a method of increasing agricultural productivity by planting two or more crops simultaneously on a specific plot of land in a specific row pattern. Small farmers who depend on rain for higher production are more likely to use it.

This procedure has a specific row pattern, such as 1:1 or 1:2, which means that the primary crop is in the first row and the other crops are in the second or third row. These crops are blended in this technique despite having different nutrient needs. It guarantees the best possible use of the nutrients given. Additionally, it stops pests and diseases from spreading to every plant involved in a particular crop. This method is detailed in the later section.

Cropping System - Factors to Consider for Crop Choice:

- **Profitability**: One of the central considerations in any cropping system is the potential profitability of a crop. Farmers must assess market demand, pricing trends, and production costs to determine which crops offer the best economic returns.
- **Adaptability**: The adaptability of a crop to changing environmental conditions is crucial. Climate variability, soil types, and water availability can fluctuate, and selecting crops that can withstand such changes is essential for a sustainable and resilient cropping system.
- **Disease Resistance**: Crop choice must take into account the crop's susceptibility to prevalent diseases in the region. Opting for disease-resistant varieties can reduce the risk of yield losses and minimize the need for costly pesticide applications.
- **Technology Requirements**: Some crops may require specific technologies for successful growth, harvesting, and post-harvest handling. Farmers need to consider the availability and affordability of these technologies when deciding whether to incorporate a particular crop into their system.

- **Environmental Conditions**: The current environmental conditions on the farm, including temperature, rainfall, and growing season, play a critical role in crop selection. Crops that are well-suited to the local environment are more likely to thrive and produce higher yields.
- **Integration with Production System**: Crop choice should be in harmony with other components of the production system, such as livestock integration, crop rotations, and agroforestry practices. An integrated approach can enhance resource utilization and ecological sustainability.
- **Crop Diversity**: Promoting crop diversity is essential for reducing risks associated with market fluctuations, climate uncertainties, and pest outbreaks. Diversifying the crop portfolio can spread risk and provide greater resilience to the overall cropping system.
- **Market Demand**: Understanding market demand and consumer preferences is vital in determining the viability of a crop. Farmers should align their crop choices with market trends and explore niche markets for specialty crops with higher value.
- **Input Availability**: The availability of seeds, manures and other inputs should be considered when selecting crops. A crop that requires inputs in short supply or with limited accessibility may not be a practical choice.
- **Government Policies and Incentives**: Farmers should be aware of government policies, subsidies, and incentives related to specific crops. Supportive policies can influence crop choices and provide additional benefits for farmers.

Inter cropping

Intercropping is a type of multiple cropping that involves growing two or more crops in close proximity. The most common goal of intercropping is to increase yield on a given plot of land by utilising resources that would otherwise go unused by a single crop. Planting a deep-rooted crop with a shallow-rooted crop, or a tall crop with a shorter crop that requires partial shade, are examples of intercropping strategies. There are numerous types of intercropping, all of which vary the temporal and spatial mixture to some extent: mixed intercropping, row cropping, relay cropping, and so on.

What is Intercropping?

- Intercropping is a method of increasing agricultural productivity by planting two or more crops simultaneously on a specific plot of land in a specific row pattern.
- The primary goal of this type of cropping is to make use of the space between two rows of main crop and produce more grain per unit area.
- Small farmers who depend on rain for higher production are more likely to use it.
- This procedure has a specific row pattern, such as 1:1 or 1:2, which means that the primary crop is in the first row and the other crops are in the second or third row.
- These crops are blended in this technique despite having different nutrient needs. It guarantees the best possible use of the nutrients given.
- Additionally, it stops pests and diseases from spreading to every plant involved in a particular crop.

Principles of Intercropping

- Crops grown in tandem should have complementary rather than competitive effects.
- The subsidiary crop should be of shorter duration and faster-growing habits to take advantage of the main crop's early slow-growing period, and it should be harvested when the main crop begins to grow.
- Agronomic practices for the component crops should be similar.
- Erect growing crops should be intercropped with cover crops such as pulses to reduce or control soil erosion and weed population. This also aids in reducing water evaporation from the soil's surface.
- The root depths of the component crops should be different so that they do not compete for nutrients, water, and root respiration.
- A standard plant population of the main crop should be maintained, whereas the plant population of subsidiary crops can be increased or decreased depending on the situation.
- Component crops infested with similar pest and disease pathogens and parasites should not be chosen.
- The planting method and management should be simple, less time-consuming, less cumbersome, economical, and profitable in order to be widely adopted.

Intercropping - Prerequisites

- Each crop needs enough space when two or more are growing together in order to increase cooperation and reduce competition.

- Although there may be some variation in the amount of temporal and spatial overlap between the two crops, both conditions must be satisfied for a cropping system to be considered an intercrop.
- Therefore, four factors must be taken into account:
- Spatial Arrangement: The appropriate spatial arrangement maximizes the complementarity between the component crops and improves the physiological effects of the intercropping system in a particular environment.
- However, in order for an intercropping arrangement to be favorable and be used by the farmer, it must meet several criteria.
- Density: Each crop in the mixture has its seeding rate reduced from its maximum rate in order to maximize plant density.
- Both crops wouldn't produce well if planted at full rates due to severe crowding.
- The crops will have a better chance of producing well within the mixture by having lower seeding rates for each.
- Maturity Dates: Intercrops with varied maturity dates or development phases are planted to take advantage of fluctuations in peak nutrient, water, and sunlight requirements.
- The competition between two crops is reduced when one crop matures before the other. Crops having various maturation dates can also help separate and delay the harvesting of grain commodities.
- Plant Architecture: Plant architecture is the practice of allowing one crop to receive sunlight that the other crops in the mix would not otherwise receive.
- A classic illustration would be a canopy of widely spaced corn plants growing over a ground cover of beans and pumpkins.

Intercropping - Types

Intercropping is defined by a specific arrangement of plants that serve as the foundation for its classification. Intercropping types include row, strip, parallel, synergistic, relay, multi-storey, alley, etc.

Strip Intercropping

- The term "strip cropping" refers to the practice of cropping different cultures in strips.
- To prevent soil erosion, it is a common practice on sloped terrain.
- Strip cropping in agriculture also applies to even terrains.

- The strips are sufficiently narrow to generate agronomic interactions between neighboring crops.
- Strip width is therefore essential to the design and operation of this cropping pattern. The strips are frequently changed from year to year.
- Basically, strip cropping agriculture is utilized to either enhance the growth of primary species or improve soil health.

Parallel Cropping

- Parallel cropping is the practice of growing crops that have different natural behaviors but no competition.
- An example of parallel cropping is wheat and mustard. After planting wheat, farmers typically broadcast mustard in the same field.
- It makes greater use of resources like light, nutrients, and moisture.
- The productivity of the system is hampered by inefficient moisture usage and competition between the various root systems of the crops cultivated together.

Synergistic Cropping

- Synergistic cropping is when two crops are grown on a unit area at the same time and produce more as a whole than they would if they were grown separately on a unit area basis.
- The concept of synergistic cropping first emerged in the 1980s.
- This technique is based on agronomic approaches primarily targeted at improving soil fertility.
- As a result, the overall health of the soil-microorganism-plant system is focused, rather than on production alone.

Multi-storey Cropping

- Multi Storey Cropping is the process of cultivation of more than two crops at once on the same plot of land with varying heights.
- Examples: coconut, pepper, cocoa, and pineapple.
- The crops are cultivated together on the land, utilising land, water, and space in the most effective and inexpensive ways possible.
- Plantings having an overstory of trees or shrubs and an understory of specialised or agronomic crops or pastures are referred to as multi-story crops.

- There is enough space between trees to allow forage or crops in the understory to receive enough sunlight.
- Multi Storey cropping is sometimes known as "Forest Farming."
- Native forest tree canopies would be controlled to permit the cultivation of such crops or forage.

Relay Intercropping

- Relay cropping is a type of cropping arrangement in which one crop is seeded into a standing second crop well before the second crop is harvested.
- Growing Rice-Cauliflower-Onion-Summer gourds is an example for relay intercropping.
- Relay cropping has the potential to resolve a number of conflicts, including inefficient use of available resources, disagreements over sowing time, Fertilizer application, and soil degradation.
- Relay cropping is a complex set of resource-efficient technologies capable of improving soil quality, increasing net return, increasing land equivalent ratio, and controlling weed and pest infestation.
- Relay planting has less risk because it does not require relying just on one crop.
- Relay cropping is also known as overlapping cropping.

Alley Cropping

- Alley cropping is one of several practices that deal with trees and crops growing on the same plot of land.
- Alley cropping is a method of growing trees or shrubs and agricultural crops in alternate rows.
- Trees are frequently pruned to reduce the shading of agricultural crops. Alley cropping can help with nutrient cycling and erosion control as well.
- Alley cropping can thus be regarded as re-creating a savanna's structure in an agroforestry system with many canopy layers, including an overstory of nut trees, a mid-layer of fruiting small trees and shrubs, and a groundcover of annual crops or perennial grass groundcover.

Row Intercropping

- Plants are arranged in rows in this case, as the name suggests. Cereals and legumes such as corn and beans are a common and beneficial combination.

- Row ratios can range from single to multiple rows.
- Row cropping provides additional nitrogen fixation by legumes in symbiosis with bacteria of the Rhizobium genus.

Temporal Intercropping

- The combined plants in this intercropping method require different maturing times.
- When the fast-growing plant is harvested, the slow-growing plant is given more room to grow.

Mixed Intercropping

- The practice of intercropping entails sowing different species (two or more) in the same terrain with no distinct arrangement in rows or in the same rows.
- In this case, the sowing and harvesting seasons coincide.
- Mixed cropping protects the primary culture from winds, frosts, droughts, and other extreme weather conditions.

Trap Cropping

- The intercropping technique, as the name implies, aids in pest trapping to protect the main culture. Among the most common trapping plants are mustard and marigold.
- The basic concept is to attract insects or fungi to the sacrificial secondary crops, protecting the cash crop.
- Blue Hubbard squash is said to be effective against squash bugs, squash vine borers, and spotted and striped cucumber beetles.
- Trap intercropping allows for pesticide savings by requiring no or only partial chemical application to trapping areas.

Border Cropping

- Border crops are thorny or tough plants that grow around cash crops or along field edges.
- Bordes crops are used as barriers to keep the main species safe from winds and invasions.
- As a result, sorghum is grown next to cotton and safflower next to chickpea.

Repellant Intercropping

- Farmers use pest-repellant plants as a sustainable pest-management technique when using this intercropping method.
- It is based on the repellant effect of specific species, which protects the cash crop.

- The repellant keeps insects away from their host plant, as in the case of planting leeks to keep bean flies away from beans.

Push-Pull Cropping

- For the sake of the cash crop, the intercropping practice combines both trap and repellent plants.
- While trap species attract (or pull) pests, repellant species repel them. Growing Napier grass (to pull) and Desmodium legume (to push) to protect corn from stem boring corn larvae is an example of this technique.

Intercropping - Advantages

- Increased Profit: Even when the first crop is unsuccessful, secondary crops offer higher yields and guarantee profit.
- Ergonomic Usage of Land: Contrary to monocropping, when gaps between rows are left empty, planting species in between rows allows for a more efficient use of the soil.
- Protection of the Cash Crop: Intercropping serves a variety of purposes, including warding off or trapping pests, luring in beneficial insects, and providing shade from excessive sunlight or wind. Pest management lowers the number of chemicals used, saving money.
- Prevention of Soil Erosion and Crust: Particularly, the roots of plants in alley intercropping and between rows reduce erosion.
- Added Nutrients for the Main Crop: Because the leguminous family is recognized for fixing nitrogen, it supplies nitrogen to the nearby species.
- Reduced Need for Fertilizers: Intercropping cultures reduce the need to use synthetic fertilizers by improving soil fertility.
- Efficient Use of Natural Resources: More efficient use of natural resources like water and solar energy as they are distributed to secondary crops as well.
- Improved Weed Management: In intercropping, beneficial plants rather than weeds fill the empty spaces between the rows.
- Enhanced Biodiversity and Ecological Stability: The environment benefits from the increased growth of agricultural species.

Intercropping - Limitations

- Unsuitable for Mechanized Farming: Intercropping is not always suitable for a mechanized agricultural system.
- Time-consuming: It calls for more focus and, as a result, more intensive, skilled management.
- Labour Expenses: Planting, weeding, and harvesting are less efficient, which may increase labor expenses for these tasks.
- Requires Effective Planning: Effective planning is crucial and includes things like careful cultivar selection, appropriate spacing, etc.
- No Effective Reuse: A larger amount of fertilizer or irrigation water cannot be used effectively since the component crops respond differently to these inputs.

Differences between Intercropping and Mixed Cropping

Mixed Cropping	Intercropping
When two or even more crops are planted and grown simultaneously on the same piece of land, the practice is known as mixed cropping.	Contrarily, intercropping is a type of growing crop in which two different product types are grown and farmed on the same piece of land in a specific pattern.
The objective of mixed cropping is to reduce the possibility of crop failure.	The objective of intercropping is to boost the crop's production.
When mixed cropping is employed, the seeds are properly mixed and assimilated into the soil.	Contrarily, intercropping doesn't require any pre-seeding mixing.
In mixed cropping, the seeds are not sown in sequence.	In the case of intercropping, seeds are sown in several rows in a precise sequence.
In mixed cropping, crops compete with one another.	Contrarily, in intercropping, there is no competition between the crops.
Every crop has a similar life cycle and maturation period.	The length of the maturation period and the life cycle of each crop vary greatly.
In mixed cropping, the entire lot receives the same application of fertilizer, pesticide, and insecticide.	Contrarily, intercropping uses different insecticides and fertilizers for every harvest.

Cropping patterns in natural farming, can be tailored to optimize the principles of minimal intervention, biodiversity, and ecological harmony. Here's how cropping patterns can be approached in natural farming while considering these two methods of planting:

1. Line Sowing:

Line sowing involves planting seeds in straight rows or lines. This method provides more organized spacing between plants and allows for easier management.

2. Broadcasting:

Broadcasting involves scattering seeds across a planting area without specific arrangement. This method mimics natural seed dispersal and is suited for more densely planted crops.

What Is Crop Diversification?

Addition of other crops or cropping systems to agricultural production on a particular farm taking into account the different returns from value- added crops with complementary marketing opportunities.

Why Is It Important? Particularly At Present Times

Lowering your risk by diversifying the crops and productions systems like poultry, goatery, piggery, dairy etc.; also acts as an insurance.

Cropping System: Cropping pattern used on a farm and their interactions with farm resources, other farm enterprises and available technology which determines their makeup.

Cropping Pattern: Yearly Sequence and Special Arrangement of Crops and Fallows in An Area

- Mono Cropping
- Multi Cropping: (E.G. Inter Cropping, Mixed Cropping)

Diverse farming systems are a set of methods and tools developed to produce food sustainability by leveraging ecological diversity at plot, field and landscape scales. It basically depends on diverse cultural practices and governance structures to support the locally adapted management system by supporting the integration of nature, human ecologies and environment. Diverse cropping systems allow critical ecosystem services like pollination and pest control to be generated and regenerated within the agro ecosystem.

Around 583 crops are cultivated in India and around 500 species of ethnic uncultivated greens which are simply collected and consumed. Diversified crop system is successful when agro-ecological principles are synergies in agroforestry. It is not that diverse cropping system is a recent concept in India. Several indigenous cropping systems are available to India which is given in below table. Most of these cropping systems are location specific and row sowing is done and vegetables are mostly cultivated for family consumption.

S.No	Indigenous Cropping System	Place	State
1	Hangadi Kheti	Udaipur	Rajasthan
2	Rammol	Kachchh	Gujrat
3	Kurwa	Rajmahal Plateau	Jharkhand
4	Olya/Chat	Dewas	Madhya Pradesh
5	Sat-Gajara	Hoshangabad	Madhya Pradesh
6	Misa Chasa	Koraput	Odisha
7	Baradhanya	Pune	Maharashtra
8	Pata	Wardha	Maharashtra
9	Navadhanya	Anantapur	Andhra Pradesh
10	Akkadi Salu	Raichur And Kolar	Karnataka
11	Poonam Kuthu	Wayanad	Kerala
12	Puradiyakrishi	Idukki	Kerala
13	Punam Krishi	Idukki	Kerala

Why Diverse Cropping System

- It requires one time sowing when there is monsoon and due to different maturity time of each crop gives multiple harvest. The crop harvest starts from September- October and continues up to February.

- The soil is covered with crop till February. So it is not exposed to sun for 9 to 10 months. There is heavy leaf litter leading to improving soil quality over time by retaining moisture and maintaining soil temperature.
- Crops are designed in a multi-tiered canopy to harvest the maximum sunshine for each crop.
- Monsoon rainfall is not used in single rain fed crops but in multiple crops.
- Since, no chemical is used there is frequent, and high population visitors of pollinators.
- In this type of cropping system we take care of all the three aspects of soils: soil chemistry, soil physics and soil biology.
- Diverse cropping system helps in maintaining bulk density, porosity, infiltration rate, moisture holding capacity, aeration, erosion, and surface runoff, hence, improves physical property of soil.

What is Navadhanya Cropping Systems?

> It is an intercropping system in dryland agriculture. It has evolved to sustain crops in erratic rainfall, trapping erratic rainfall and utilising 100% to crops. The farmers used the system as the net of erratic rainfall in drought prone areas for protecting at least 2/3rd of the crops in their fields. Source: http://www.ecosecretz.com/2017/09/navadh

Main Crop: Groundnut/ Millets/ Sunflower Etc. Harvested In <100 Days (3 Months).
1st Intercrop Row: Harvested In 4 Months.
2nd Intercrop Row: Harvested In 6 Months.
Border Crop: Millets on border rows.

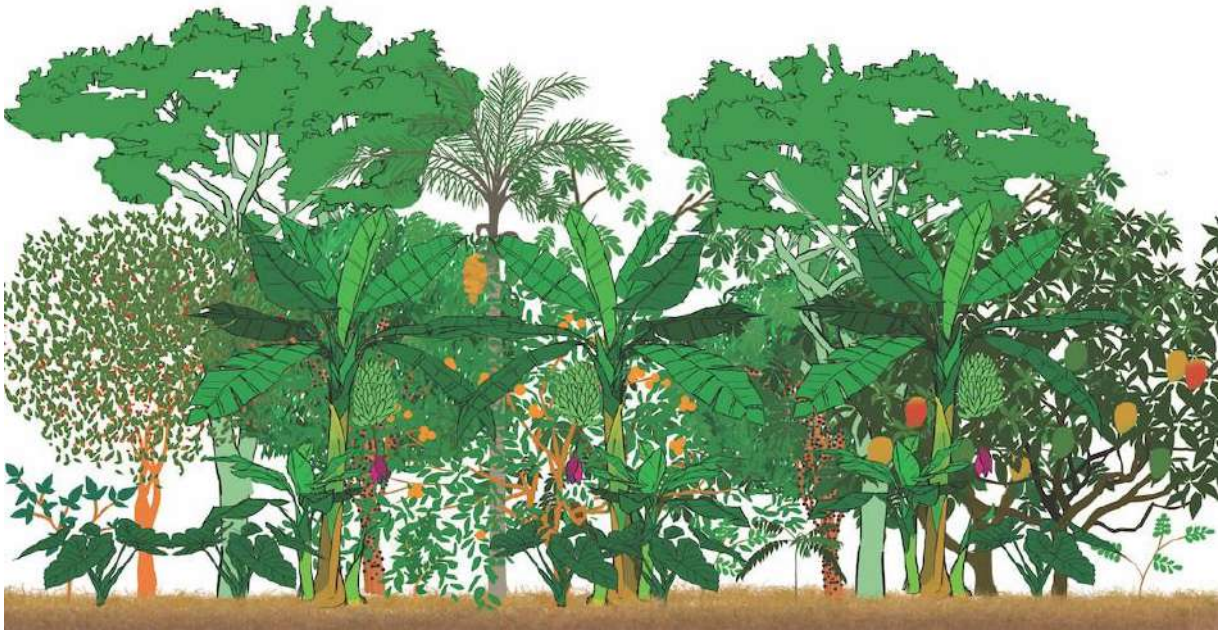
Limited Crops: Mixed within the rows along with the first 3 -- small proportions – a diverse array of crops for self-consumption or sale.

Additional Crops: Leafy vegetables, vegetables and others – very small niches mainly for household consumption.

09. AGROFORESTRY

Agroforestry is any sustainable land-use system that maintains or increases total yields by combining food crops (annuals) with tree crops (perennials) and livestock on the same unit of land, either alternately or at the same time, using management practices that suit the social and cultural characteristics of the local people and the economic and ecological conditions of the area.

Agroforestry is not a new concept. Communities for generations have been cultivating varieties of crops and plants, mostly for domestic use. To this day, the communities that grow their food which includes millets, vegetables, fruits, pulses, and other crops, are ensuring the nutrition security of the family and the local community. Agroforestry in its different forms has been found worldwide in different agro climatic zones ensuring better management and resource utilisation. The system, coupled with natural farming practices, generates substantial income for the farmers while regenerating the degraded soil and channelizing restoration of natural resources.



i) Objectives:

1. To utilise the available farm resources properly
2. To maximise per unit production of food, crop & other produce
3. To optimize biological and physiological resources

4. To maintain the ecological balance
5. To check soil erosion, conserve soil and moisture, and increase the soil fertility

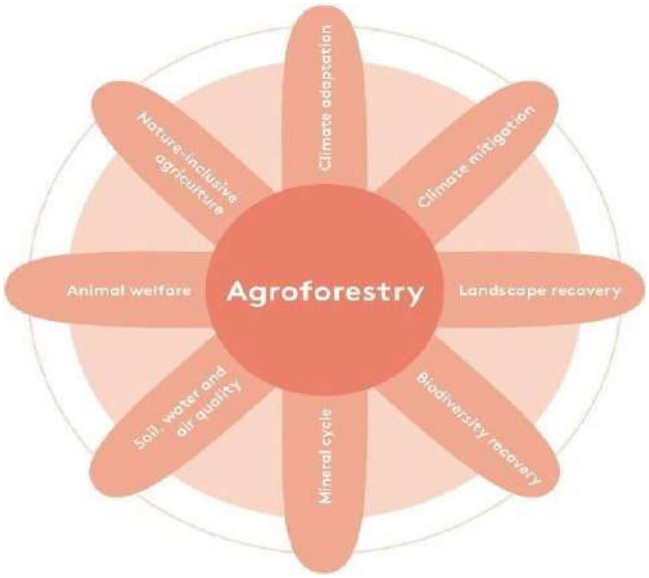


Image Source: louis bolk Institute

ii) Why Agroforestry?

Agroforestry has proved to be an increasingly sustainable solution for climate change mitigation and adaptation, environmental problems, degrading landscapes, and scarcity of groundwater. It provides food security to a hot and hungry world. It can ensure the regeneration of the natural ecosystem systems (i.e. CO2 sinks, improving groundwater levels. etc.), ensure higher productivity/ income for both farmers and herders, can provide constant income/ and new jobs for generations. It can stimulate and sustain rural development. It can ensure the full restoration of our natural biodiversity and higher productivity/ land-use efficiency per hectare compared to an agricultural system based on chemicals and monoculture. From large-scale agro farms to small subsistence farms and kitchen gardens agroforestry guarantees higher returns on investment, increases assets in the hands of farmers, and all-year harvest for households.

Smart system planning in regenerative agroforestry will increase the reliability of yields and provide additional income streams. Regenerative Agroforestry not only secures and generates more income for farmers but also has the potential to save money that can then be invested towards solving the problem of climate change.

iii) What is Agroforestry?

The agroforestry system incorporates the elements of layer model farming, mixed farming, and regenerative agriculture. The farm systems involve a fully mixed cropping approach and not an individual plant approach (monoculture). The mix-crop forest system approach takes advantage of the symbiotic plant relationship among varieties of plants/ root systems. It ensures plant densification, stratification, accumulation and growth acceleration and natural plant succession. The farm ensures constant plant cover (green/ dry mulching). They apply a dynamic process with changing structures over time (4-dimensional planting).

Reproduction is the key to upscaling agroforestry quickly and economically feasible without huge investments. At least 99.9% of the farm inputs are generated on the farm. No chemical fertilisers or pesticides are used on the farm. The farm operates a circular ecosystem with zero waste, returning more to nature than taking out. The farm uses decomposed plants on one side, and animal dung and urine, etc. on the other side.

iv) Types of Agroforestry

Depending on the agro climatic zones and landscape, different types of agroforestry are followed. Most of them fall into the following categories:

1. Alley Cropping
2. Forest Farming
3. Riparian Buffers
4. Silvi-pasture
5. Windbreaks
6. Food Forest

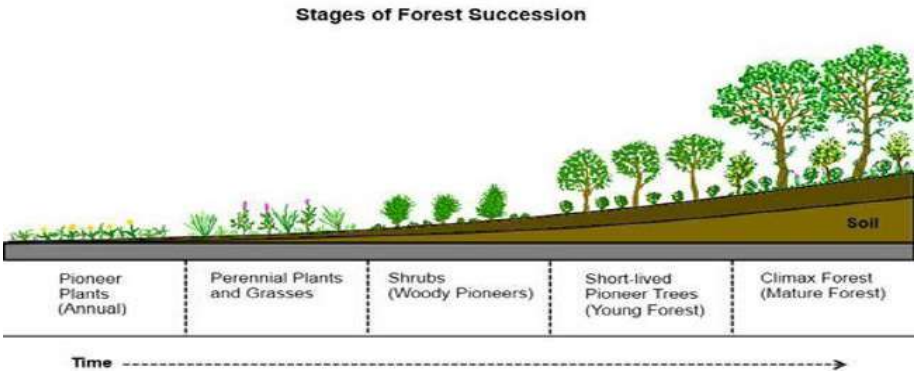


Image Source: deepgreenpermaculture.com

A) **Environmental benefits of Regenerative Agroforestry**

1. Reduction of pressure on natural forests.
2. More efficient recycling of nutrients by deep-rooted trees on the site
3. Better protection of ecological systems
4. Reduction of surface runoff, nutrient leaching, and soil erosion through impeding effect of tree roots and stems on these processes
5. Improvement of microclimates, such as lowering of soil surface temperature and reduction of the evaporation of soil moisture through a combination of mulching and shading
6. Increment in soil nutrients through addition and decomposition of litterfall.
7. Improvement of soil structure by constantly adding organic matter from decomposed litter.

B) Economic benefits of Regenerative Agroforestry

1. Increment in the outputs of food, fuel wood, fodder, fertiliser, and timber
2. Reduction in the incidence of total crop failure, which is common to single cropping or monoculture systems
3. Increase farm income levels due to improved and sustained productivity.

C) Social benefits of Regenerative Agroforestry

1. Improvement in rural living standards from sustained employment and higher income
2. Improvement in nutrition and health due to increased quality and diversity of food output
3. Stabilization and improvement of communities by eliminating the need to shift sites of farm activities.

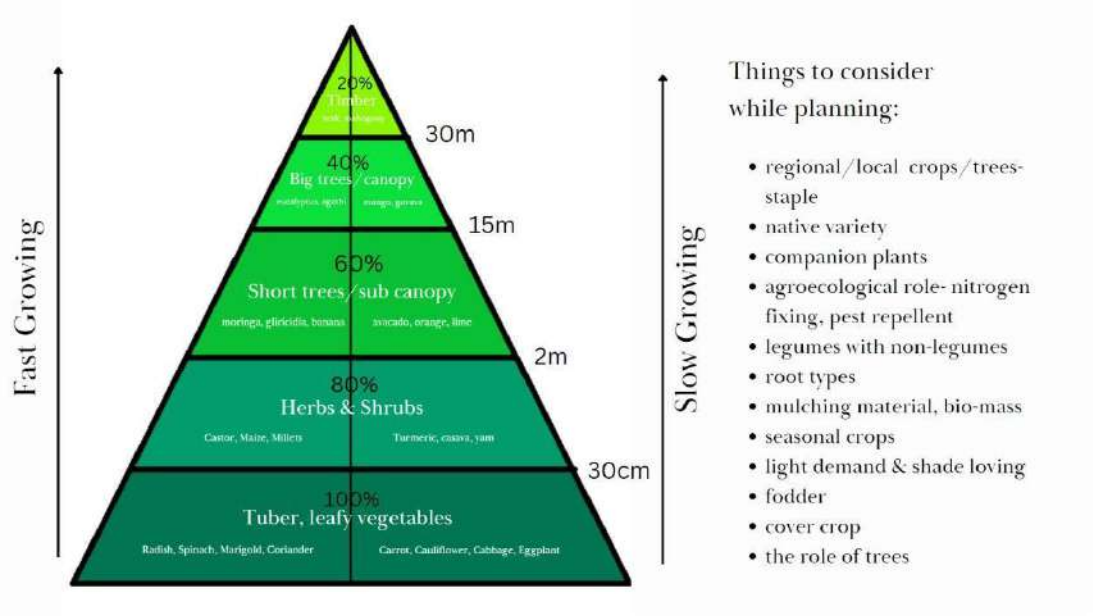
Limitations & Opportunity of Agroforestry System

1. High Labour Input - Employment generation
2. A different approach in different landscape
3. A longer period is required for trees to grow to maturity and acquire an economic value

4. Knowledge (know-how) - The agroforestry system requires a better understanding of each player's role within the ecosystem and the synergy it forms within. It requires an understanding of the soil, native flora and fauna, and crops/ plants/ trees' behaviour
5. Resource, capital - The development of an agroforestry system initially requires an investment, mostly one-time in nature.

How to design Agroforestry Farms?

i. Selection of land
ii. Selection of plants & trees - The selection of trees must be native/ local crops/ trees-staple, native variety, considering whether they are companion plants. The agroecological role- nitrogen fixing, pest repellent, legumes with non-legumes, root types, mulching material, biomass, seasonal crops, light demand & shade loving, Fodder, cover crop, the role of trees
iii. Measurement Water channel, Source of water catchment
iv. Live fencing
v. Land preparation (Beds and trenches)
vi. Plantation



Agroforestry for Ecosystem Services

Regulates

- **Air Quality** - The combination of trees, shrubs, herbs, and other timber-based trees creates a microclimate, which supports the ecosystem's growth and purifies the neighbouring environment.
- **Climate** - One of the most popular solutions for climate change mitigation, the agroforestry system has a high potential to store the extra carbon we have in the environment.
- **Water Runoff** - The live soil created through the agroforestry system has a high percolation level, thus holding water longer and reducing water runoffs.
- **Soil Erosion** - the root system is interconnected and forms a strong connection, a web beneath the ground that holds soil. The trees are mainly responsible for holding soil and protecting farmlands from erosion.
- **Natural Hazards** - The live fencing in the agroforestry systems is designed to protect the farms from natural hazards.
- **Pollination** - Multi-layer crops are the best conductors for pollination and crosspollination.

Supporting

- **Nutrient Cycle** - The system is designed so that each player, i.e., soil, water, air and crops/ trees develops a synergy between them and provides nutrition to each other in a circular model.
- **Water Cycling** - High water percolation in the agroforestry system recharge groundwater faster. The live root system and live soil provide water to plants, evaporating to form raindrops, thus creating a conducive environment to form rain clouds.
- **Soil Formation** - The natural farming methods regenerate the degraded soil. The presence of biomass in the soil, crop residue, mulching, and application of organic manure helps build soil.
- **Photosynthesis**

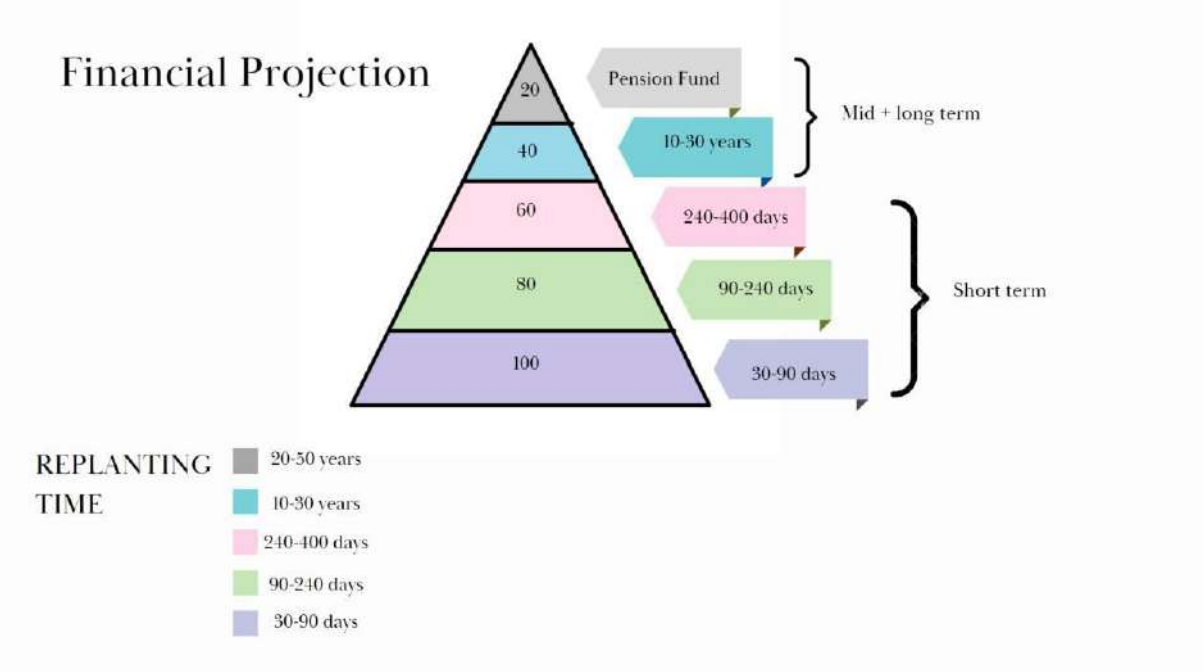
Provisional

- Food
- Fiber

- Biomass
- Fresh Water
- Natural Medicine

Cultural

- Ethical values
- Recreation
- Ecotourism



Conclusion:

Agroforestry is a vital tool for climate mitigation and adaptation; it fights poverty and hunger, increases biodiversity and is a solution for environmental problems, degrading landscape, and groundwater scarcity. It provides food security to a hot and hungry world and can strengthen women's control over resources, thus contributing to poverty alleviation. It provides innumerable benefits especially in the Natural Farming System including mulching.

For agroforestry to reach its full potential, barriers need to be addressed at all levels: 1) finding ways to adequately identify, classify, and report on agroforestry projects, 2) increasing finance to agroforestry projects, and 3) increasing knowledge and cooperation among key stakeholders, including supporting more demand-driven, participatory research and knowledge exchange.

Integration of Livestock Systems

10. INTEGRATION OF LIVESTOCK IN NATURAL FARMING – PERSPECTIVE, PRINCIPLES AND PRACTICES

"Integrating animal husbandry into crop producing farms is one of the principles of Natural Farming."

What do we mean by Livestock? What image is formed when we use the term?

Livestock is commonly defined as domesticated animals raised in an agricultural setting to produce labor and commodities such as meat, eggs, milk, fur, leather, wool, etc. The term is used interchangeably for animal, bred for consumption and farm ruminants such as Cattle and Goats.

What is Animal Husbandry then?

Animal husbandry is the branch of agriculture concerned with animals that are raised for meat, fibre, milk, or other products. It includes day-to-day care, selective breeding and raising of livestock.

Why is there a need for the integration of animals into the farms?

Integrating animals into a farm helps create a closed or semi-closed system where energy and nutrients are recycled as shown in Figure 1. Animals can convert non-edible biomass (e.g., grass, straw, kitchen waste) into food and other services while increasing soil fertility with their manure.

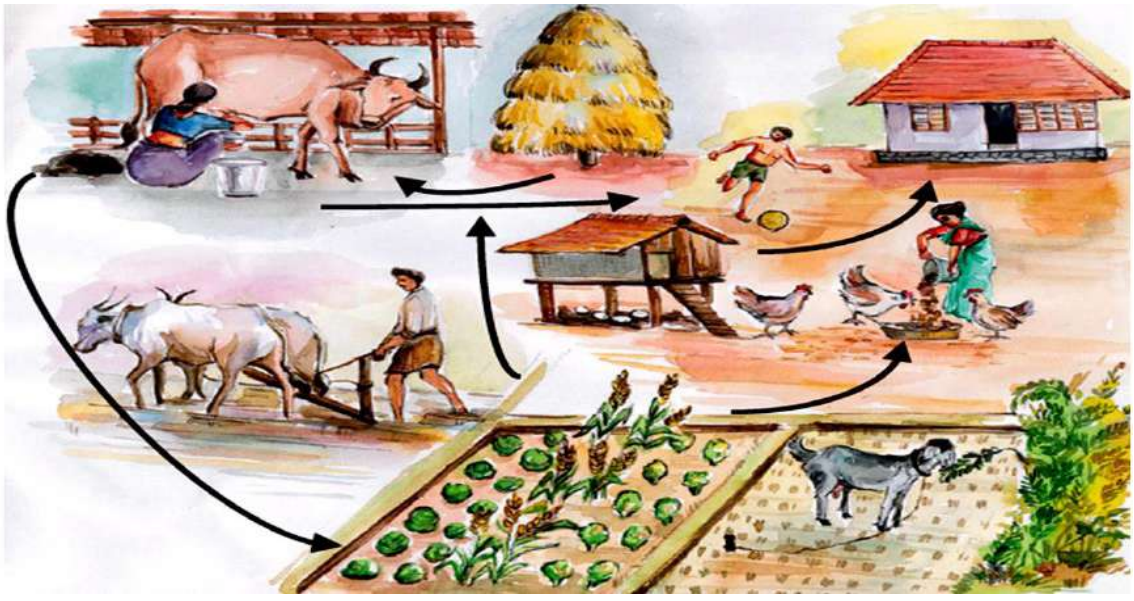


Figure 1: Animals integrated into the farm, showing the flow of fodder, dung, services and products.

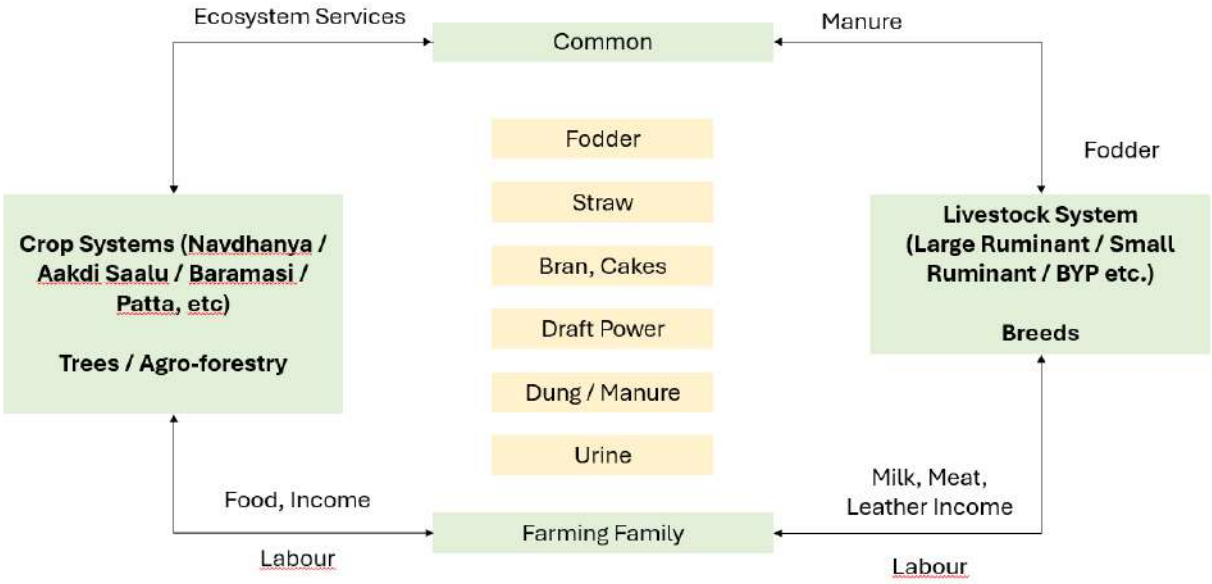


Figure 2: Interlinkage between Crop and Livestock production system

Let's understand it in detail using the Figure 2 that showcases the interlinkage between multi-cropping system and livestock which are as follows:

1. Livestock provides manure in different forms to the land for increasing microbial activities generating soil fertility.
2. Recycling of by-products such as straw acts as fodder for livestock & kitchen waste goes into the kitchen garden/ Compost.
3. Raw material generated from livestock like cow-urine helps in the preparation of herbal concoctions/ bio-pesticides used to control pest & disease in crops.
4. Livestock serves as a draught power for tillage and transport.
5. Multi-cropping system generates diverse fodder that is good for the animals.
6. Yields such as milk or eggs can be used for sale or self consumption.
7. Open grazing of Livestock in forests leads to management of weeds & enhancing soil fertility rejuvenating the common land.

Does that mean, other species of Livestock can contribute to NF?

In Indian conditions, dung and urine of desi / indigenous cows perform best as bio-formuations. The reason behind this is they eat a lot of diverse kinds of vegetation which increases the number of microbes in the cow dung and cow urine. However, due to several years of cross-breeding program, indigenous cattle breeds are being diluted. National Bureau

of Animal Genetic Resources has identified, characterized and registered nearly 50 cattle breeds in the country from different agro-climatic zones.

However, in the absence of indigenous cows, buffalo and other animals can also be used for natural farming.

1. Role of Bullock in Natural Farming

With the increasing use of heavy farm machineries in the mono cropping system, use of bullock has been reduced in Indian agriculture. However, still more than 40% of energy used in agriculture contributes to Draught Animal Power. They are mainly kept for milk. The raw materials like dung and urine can still be used for the preparation of concoctions such as *jeevamrita, beejamrita* and others that are useful for Natural Farming. Buffalo also helps in promoting a diverse mix-cropping/ multi-cropping system which is one of the important principles of natural farming.

A lot of such evidences are recorded through case studies documented by RRA Network and WASSAN under the project TIGRESS (Transforming India's Green Revolution by Research and Empowerment for Sustainable Food Supply) carried out in 14 agroecology zone in 10 states found that traditional mix-cropping followed by the farmers use Bullock. Some of them are widely known as *Aakdi Saalu* in Karnataka, *Navadhanya* in Andhra Pradesh, *Sangdi Kheti* in Tribal region of Rajasthan or *Patta Padhhati* in Vidarbha Region of Maharashtra.

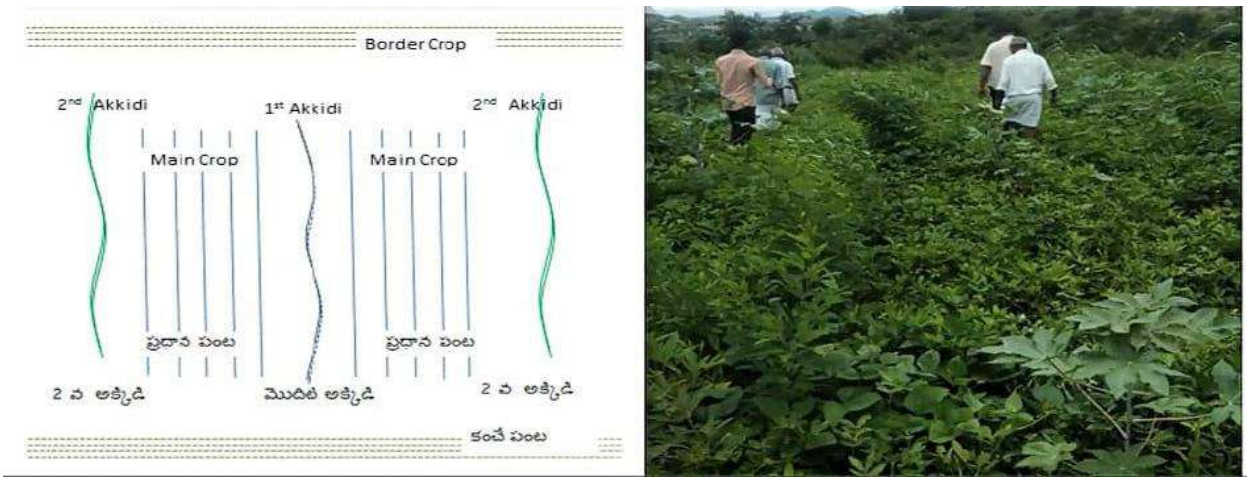


Figure 3: A Navadhanya field in Andhra Pradesh and its mix-cropping design

Big ruminants like bullocks also helps in providing mobile hybrid energy solutions for effective and efficient use of water. Some of these technologies are Mobile Solar Pump to provide critical irrigation to multiple farms.

2. Intensive Ecological Farm with Desi Poultry

This is yet another enterprise model of multilayer farming using Desi Poultry tried in backyard land integrated with production of desi/ indigenous poultry.

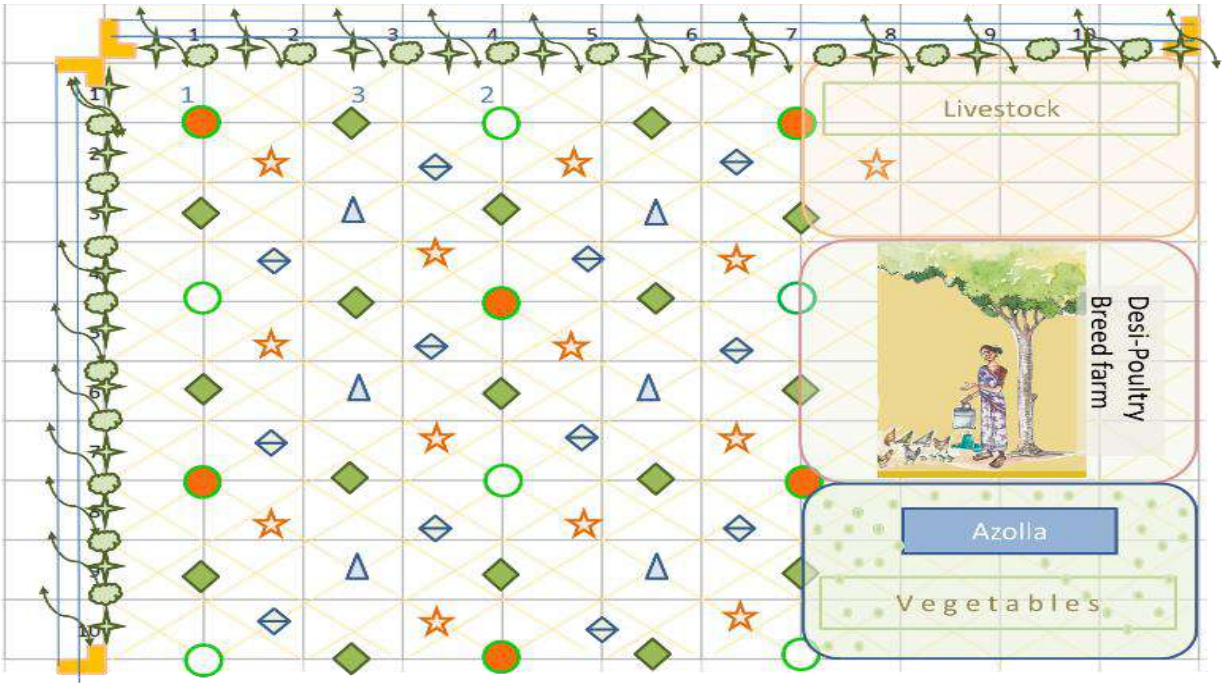


Figure 4: Design of the integrated model of desi poultry

The 0.5 ac of land in Figure 4 shows the design of multi-layer farming with Desi Poultry whereby grains, vegetables and fruits are grown without chemical pesticide and fertilizers by using poultry litter. Further, poultry serve as a natural predator for the insects that attack crops. The fodder requirement of desi poultry is fulfilled through a foraging system (relying on food provided by nature through the gathering of plants and small animals, birds, and insects; scavenging animals killed by other predators; and hunting) & green fodder like Azola without having industrial feed. The entire land is fenced using wire covered with dark color sarees to protect it from wild animals.

Figure 5: Benefits of Integrated model of multi-layer farming with Desi Poultry

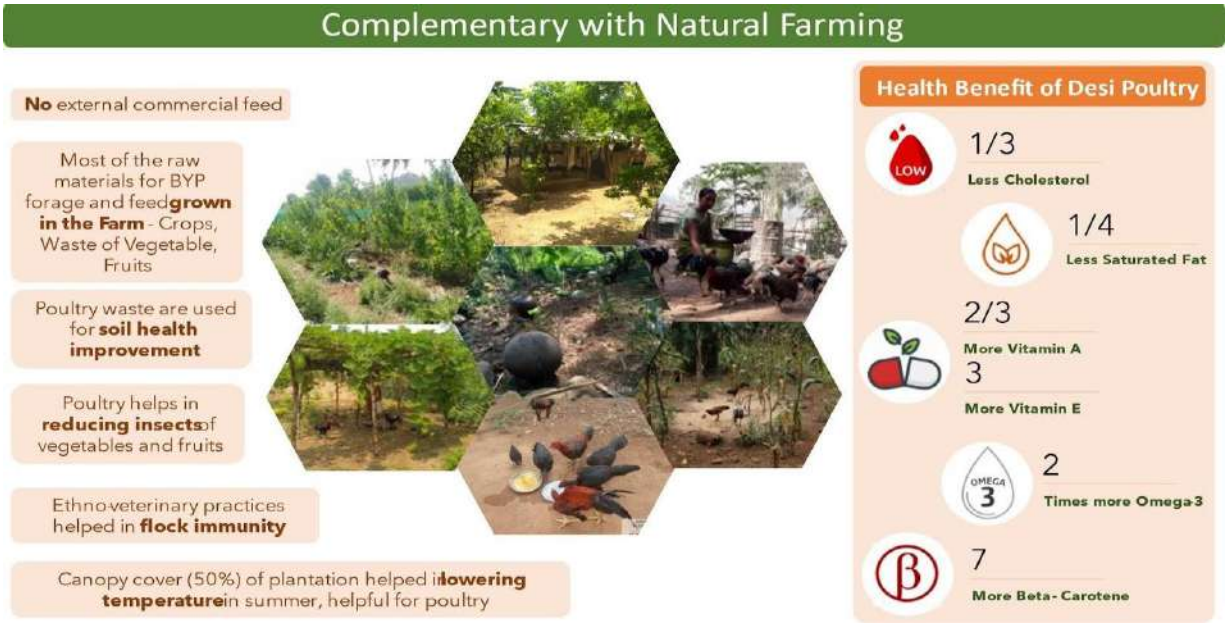


Figure 6: Health benefits of Desi Poultry drawn up from this model

KEY FEATURES OF THE INTENSIVE ECOLOGICAL FARMS ARE AS FOLLOWS

- Tried in half acre to 0.5 ac farm
- Grow Vegetable crops
- 5-layer intensive fruit and other trees, and grass
- About 50 hen units can be placed- foraging system for food
- 3 to 4 ram lambs (grazing)

- 2 Dairy animals
- Low irrigation through drips
- Fenced properly for protection
- With a night shelter for poultry
- Investment of about Rs.2.00 lakhs over period
- Returns start from 6 months
- Reach about Rs.0.75 to Rs.1.00 lakh by 2nd year
- Pays back in 4 years-time

11. FODDER & FEED MANAGEMENT

What is fodder and forage?

Fodders crops are cultivated plant species that are utilized as livestock feed. Fodder refers mostly to the crops which are harvested and used for stall feeding.

Forage can be defined as the vegetative matter, fresh or preserved, utilized as feed for animals. It includes grasses, legumes, crucifers and other crops cultivated and used in the form of hay, pasture, fodder and silage.

What is the present scenario of fodder in the country?

Based on the recent data of 2022, India is facing a net shortfall of 35.6% green fodder, 10.5% dry crop leftovers, and 44% concentrate feed ingredients. The option for increasing land area under fodder cultivation is very limited. Hence, it is a big challenge to utilize the available meagre land wisely with its fullest potential to produce the fodders for the animals.

How the deficit of fodder can be achieved?

Few of the possible ways includes adopting suitable multi-cropping systems, incorporation of fodder crops in food and other cash crop-based cropping systems on rotational basis, production of fodder on degraded lands by adopting fodder-based agro forestry systems and exploring other options of green fodder like azolla. The cropping system with forage crops provides a potential alternative to overcome the fodder problem as it utilizes the resources more efficiently. Some of the successful models are as follows:

1. Intensive Ecological Farm with Desi Poultry: The model has been explained in details in the Livestock session under Image 1.4. This was first piloted by RRA Network in 7 states which was influenced from the training of Namakkal KVK in Tamil Nadu. It was further scaled up by the Department of Animal Husbandry, Govt of Andhra Pradesh in the tribal areas.

2. Regeneration of Commons & Fallows for Fodder Security: Since Livestock is integral part of natural farming, it is important to sustain livestock in the village in order to transform a village into natural farming village. Though commons are shrinking, it is high time to protect, conserve and regenerate commons.

Beside commons, current fallows can also contribute towards fodder security for the animals in the village. Another such example is from the drought experiencing Anantapur district of Andhra Pradesh. WASSAN worked with communities in Ayyavaripally village, a dairy dependent village which became fodder surplus in 2 years reviving all the fallow lands in the village; moving from Rs.17 lakhs deficit to meeting all its requirements.

This *was carried out by villages communities through*

1. Mapping of Fallow lands.
2. Estimating Fodder deficits (fodder budgets).
3. Tie-up between Dairy farmers with fodder deficits with fallow landowners.
4. Promoting fodder crops like Jowar, Bajra, Field beans, Cowpea, Maize & Horse gram in the fallow lands during the rainy season (Kharif) using Pre-Monsoon dry sowing (PMDS). (In the rainfed and unirrigated region, the beejamritha treated seeds are broadcasted in the field before the onset of monsoon. Beejamritha helps in combating unpredicted and less rain for Kharif crop and also protects seeds from being eaten by birds. The seeds germinate whenever first rain happens for which farmer need not wait. It helps in avoiding repeat sowing due to monsoon failure/delay.) The fodder crop combination is shown in Table 1.

6. Integrating fodder crops in *Navdhanya* multi-cropping system, Andhra Pradesh.

CROP COMBINATION			
Sl.No	**Type of seed**	**Units**	**Seed per Acre**
1	Jowar	Kgs	3
2	Bajra	Kgs	3
3	Horsegram	Kgs	4

4	Cowpea	Kgs	2
5	Field beans	Kgs	2
6	Maize	Kgs	4
7	Ragi	Kgs	1
8	Stylosanthes hamata	Kgs	1
	Total		**20**

Table 1 Fodder crop combination in fallow land.

3. Penning of animals on agricultural fields

In several places, particularly in drylands, penning of animal on agricultural field is a traditional practice followed by farmers. Penning with migratory herds of sheep, cow, camel is practiced which is the low-cost method of improving soil health. Penning reduces lots of labor of farmers family and high labor intensity is one of the bottlenecks for conversion towards natural farming.

A study carried out by CRIDA highlights farmers adopted penning achieved higher yield than those who didn't. Similarly, a recent study carried out by Centre for Pastoralism (CFP), Watershed Support Services and Activities Network (WASSAN) and Centre for Peoples Collective (CPC) found that in deccan plateau farmers who invites pastoralist to pen his animals for 7 - 10 days have drastically reduced usage of chemical fertilizers. Therefore, other species of animals not only desi cow contributes to promotion of natural farming.

Penning of animals in agricultural field in Gujarat.

4. Open Grazing Vs Stall feeding to animals

Keeping animals means providing fodder throughout the year. Either it can be produced on the farm using multi-cropping system or in fallows or grazing in an agricultural land or grass or tree crops used for cutting.

While grazing requires less labour than stall feeding, land & appropriate measures are taken to monitor the animal to keep it away from other crops. It is usually the most favorable option concerning health & welfare of the animal. Interestingly, studies in Gujarat & Rajasthan, have proven that pastoral communities producing milk mostly relay on grazing of their animals.

Shed keeping however has an advantage that the dung can be easily collected, stored, or composted and applied to the crops. Whether grazing or stall feeding is the most suitable option, mainly depend on the agro-climatic conditions, the cropping system, and the availability of land. **A combination of stall feeding and grazing in a fenced area may be an ideal combination of high productivity and animal friendly husbandry.** In extensive grass lands of semi-arid areas, however, grazing may be the only suitable option.

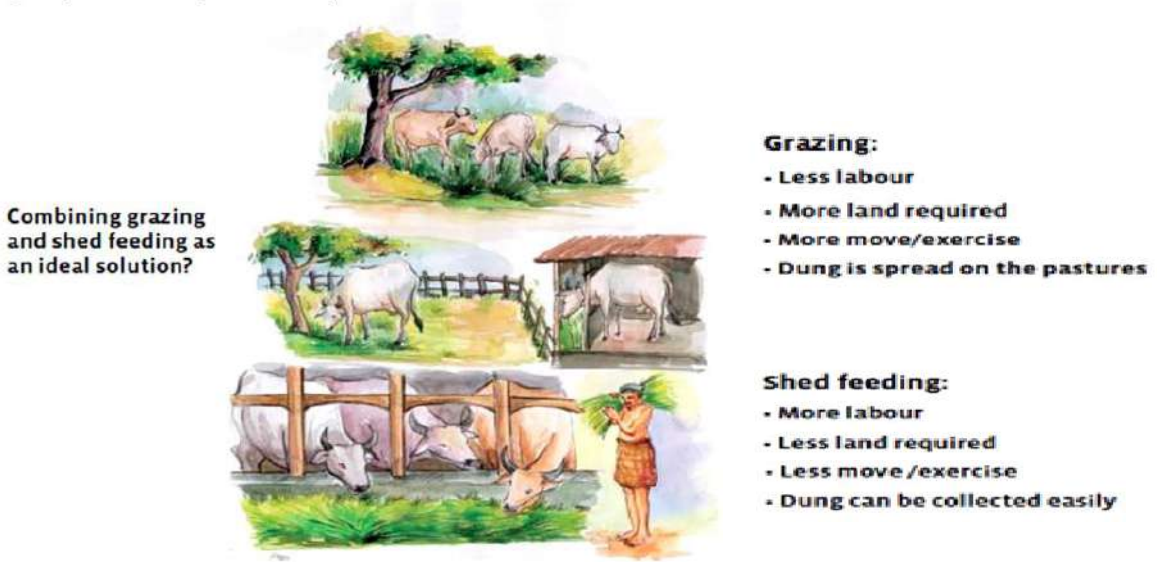


Figure : The pros and cons of Grazing and stall feeding,
and the combination of both as a promising option**.**

5. Alternative source of fodder production, Azolla: Azolla is a free- floating, fast growing aquatic-fern. Its nutritional value is well recognized, indicating that it is a good source of protein, practically all the amino acids for animals as well as micro nutrients like calcium, magnesium, potassium and vitamins. It is a unique supplement for variety of animals including ruminants, chicken, pigs, and fish. It holds the promise of providing a sustainable

feed for livestock & can be easily digested. Azolla can be used to replace 15-20% of commercial feed.

Key Learning:

Natural farming strategy: Integration of Livestock with multi-cropping system	
Requirement	**Strategy**
• Enhance biological activity in Soil	Practice multi-cropping system of diverse crops, deep and shallow rooted.
• Input support to enhance microbial activity	Integrate farm animal suitable for the region. Optimum utilization of the available resources in preparation of stimulants.
• Meet the requirement of fodder for livestock	Adoption of traditional practices like peening or grazing or foraging. Fodder production in fallows or multi- cropping system or Azolla.
• Recycling of nutrients	Integrate farm system suitable for the region.

Seed & Planting material

12. SEED SYSTEM FOR NATURAL FARMING

Seed systems for natural farming are based on the principles of resilience, sustainability, and farmer empowerment.

1. **Resilience**: Seed systems are designed to be resilient to climate change, including biotic and abiotic stress. This is achieved by using a variety of seed sources, including farmer-saved seeds, community-based seed banks, and OP varieties from public sector Institutions.
2. **Sustainability**: This is achieved by using seed varieties that are adapted to local conditions and responsive to NF.
3. **Gender responsive**: This is achieved by providing farmers with access to high-quality seeds, training on seed selection and management, and support for seed production.

Some of the key features of seed systems for natural farming:

Diversity: Natural farming seed systems emphasize diversity. Diversity helps to ensure that farmers have access to the seeds they need to adapt to changing conditions and pests.

Adaptation: Natural farming seed systems are adapted to local conditions. This means using seed varieties that are suited to the climate, soil, and resistant to pests. Adaptation helps to ensure that farmers get the best possible yields from their crops.

Sustainability: Natural farming seed systems are sustainable.

Benefits of using seed systems for natural farming:

Improved soil health: Natural farming seed systems can help to improve soil health by using seed varieties that are adapted to low-input farming practices.

Reduced environmental impact: Natural farming seed systems can help to reduce the environmental impact of agriculture by using seed varieties that do not require high inputs of fertilizers or pesticides.

Increased farmer income: Natural farming seed systems can help to increase farmer income by providing farmers with access to seeds and by helping them to produce more food.

What is GOOD seed.

Seed source: Good quality seeds should be obtained from a reputable source. Traditional cultivars can be obtained from custodian farmers, seed banks, FPOs, etc

The source should also be able to provide you with information about Value in Cultivation and Use (VCU) such as suitable soils, season, resistant/ susceptible to pests/ diseases; and its uses. (VCU Systematic documentation of plant characteristics and its expression under specific agronomic condition along with its uses is defined as Value for Cultivation and Use.)

Classification of seeds

Traditional cultivars: Heirloom varieties are a type of open-pollinated crops that have been passed down through generations of farmers. They are often prized for their unique flavor, nutritional value, and adaptability to local conditions.

OP varieties: Open-pollinated: Heirloom varieties are open-pollinated, which means that they are pollinated by natural means, such as wind, insects, or birds. This type of pollination allows for more genetic diversity in plants, which can lead to a number of benefits, such as increased resistance to pests and diseases, improved adaptation to local conditions, and increased flavor and nutrition.

Hybrids: Crossing two different types of the same plant creates hybrids. This results in a plant with the desired traits of both parents. Hybrids cannot re sued as they get segregated in F2 generation.

Genetically Modified crops: Inserting a gene from another organism into the plant's DNA creates genetically Modified crops.

Except Hybrids and GM crops, Traditional cultivars and OP varieties are suitable under Natural farming.

Basic Principles of Producing Quality Seeds:

Open Pollinated varieties:

1. Production plan
    a. Need assessment: The first step is to assess the need by taking in to consideration demand, value for cultivation and use.
    b. Demand for a particular crop variety: It is also important to consider the demand for a particular crop variety.

2. Site selection: Seed multiplication plot/ site should be in the same climatic area for which the variety has been developed. Dry humid climate with moderate humidity and sufficient moisture during the critical stage is ideal for seed production.

3. Credible source: The sources can be formal and informal.
    I. Formal sources such as State Agriculture Universities, ICAR –research station, NBPGR, International Institutions such as ICRISAT, IRRI, etc.
    II. Informal Sources:
        a. Custodian farmers
        b. Community Seed banks
        c. NGOs.
        d. Seed Networks, etc.

4. Seed procurement is an important part of seed production. Breeder/ Foundation seeds should be procured in advance from known sources such as State Agricultural Universities, ICAR institutions, and farmers' breeders. To obtain foundation/ breeder seeds from agricultural universities, it is mandatory to place a seed indent one year before the seed requirement.

5. Land selection for seed multiplication/In situ conservation. The seed production plot or site should be in the same climate as the variety was developed for. Heavy rains, high temperatures, and lack of soil moisture can all lead to poor quality seed. A dry climate with moderate humidity and rainfall during the growing season is ideal for seed production.

    The selected plot for seed production should be free of volunteer and weed plants. Crop rotation can be used to avoid volunteer plants. The field should also be free of soil-borne pathogens and insect pests, as well as salinity and alkalinity.

6. The sowing method, spacing, and seed rate vary depending on the crop. To get higher yields and better seed quality, it is important to keep the soil fertile and the moisture level in the soil at a desirable level during the crop growth period. Irrigation is necessary at the seed development stage in many cereal crops to obtain good quality seed. Soil fertility management, Pest management and Water management are similar to crop production practices under Natural Farming.

7. Seed quality management practices
    a. Isolation: Good quality seeds should be produced in isolation from other varieties of the same crop. This is to prevent cross-pollination, which can lead to contamination of the seed. The isolation distance will vary depending the crop. Self-pollinated crops required less isolation distance then cross pollinated crops.

    b. Rouging: is the process of removing unwanted plants from a crop. This is done to maintain the genetic purity of the seed. Unwanted plants can include plants that are not of the desired variety, plants that are diseased, or plants that are damaged.

8. Harvesting: Moisture content is an important factor to consider in deciding when to harvest seeds. In general, Indian farmers and seed producers decide when to harvest by checking the morphology of the crop. For example, in tomatoes, the first picking of fruits usually has the highest germination percentage. In okra, pods collected from the 3rd to 6th nodes typically have the best seed quality.

9. Processing: Good quality seeds should be processed to remove impurities, half-filled seeds, and other defects. This is done to ensure that the seed is of a high standard, ensure physical purity of the seeds including free from weed seeds, admixture, inert matter, etc.

Importance of traditional cultivars for Natural Farming

Traditional cultivars are crop varieties that have been developed and grown over many generations by farmers, are often well adapted to local conditions and can be more resistant to pests and diseases than modern varieties and have more value in use. The revival of traditional cultivars is an important part of natural farming as these cultivars are well-suited for natural farming because they are often more resilient and require less inputs than modern varieties.

PRA Tools for mapping status of traditional cultivars.

Mapping- 4 cell analysis.

Participatory tools to be used for mapping the seed diversity

METHOD	PURPOSE
Dialogue with village elders	Obtain information on crop diversity on time line
Focus Group discussion	Collecting the specific information related to crop/variety/landrace etc
Transact walk	Observing existing crops/varieties/ diversity, etc
Crop and varietal diversity matrix	To identify unique, common and rare varieties
Simple ranking	Understand the choices between set of crops/varieties
Matrix ranking	Compare the varieties of same crop
Social seed network analysis	Used to map the flow o seeds
Four cell analysis	To identify, common, unique and rate var.

FOUR CELL ANALYSIS

When to use the tool

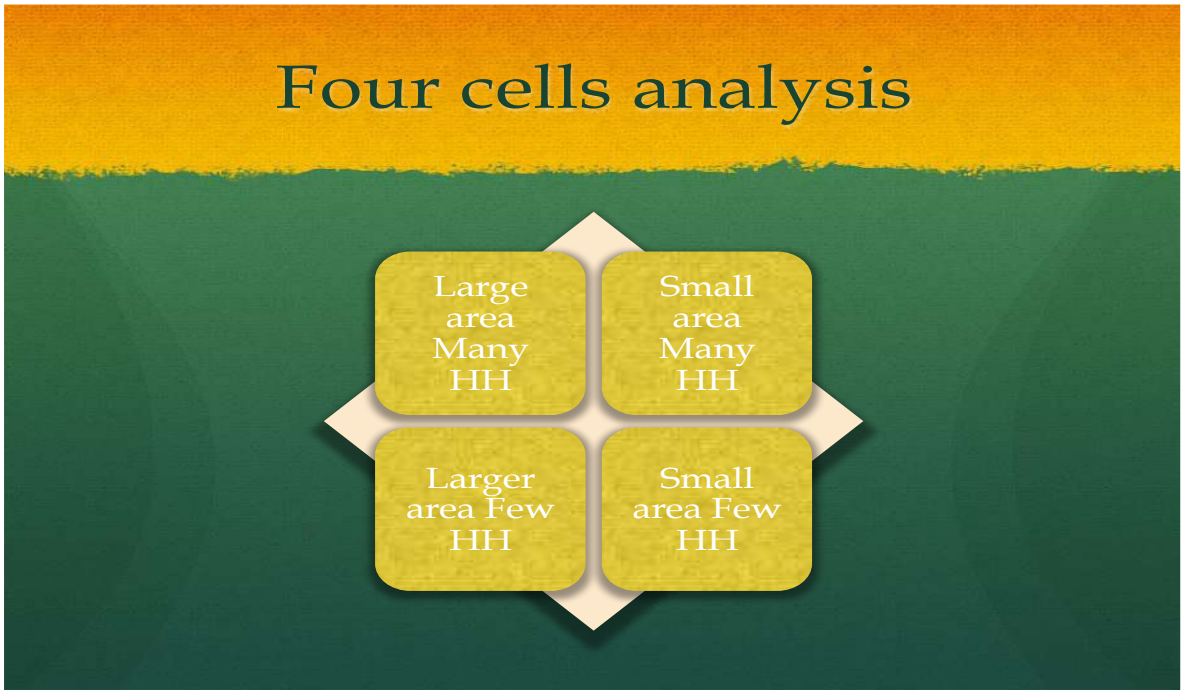
- The tool helps in identifying unique, common and rare varieties or crop species cultivated in a community
- It documents the reasons why crop species or varieties are in a dynamic stage within a community
- It further facilitates the identification of the interventions for the conservation of a crop species or variety within a specific community.

Materials: Four cell analyses can be done on the ground with real samples of the varieties/ crops, or on a large piece of paper with cards

Methodology

Step 1: Invite farmers and ask them to bring samples of each variety that they are growing.

Step 2: Make a large cross on the ground and distinguish the four categories



Step 3: The meaning of the four squares are visualized by drawing different numbers of houses and large or small fields

Step 4: The following questions are asked to the participants to get information on varieties crop species (name, specific traits, origin)

- What varieties/ crops are cultivated in **large areas** by **many** households?
- What varieties/ crops are cultivated in **large areas** by **few** households?
- What varieties/ crops are cultivated in **small areas by many** households?
- What varieties/ crops are cultivated in **small areas by few** households

Step 5: The participating group discusses the result, with special focus on the varieties to be grown in small areas and held by few households; these are the threatened varieties. The group discusses actions to increase cultivation.

The four-cell analysis method can be used to identify rare cultivars that have the potential to be revived based on the VCU of the cultivars. It takes into account factors such as the taste, nutritional value, and adaptability of the cultivar.

The identified cultivars can be conserved. It can be in situ conservation or Ex-situ conservation.

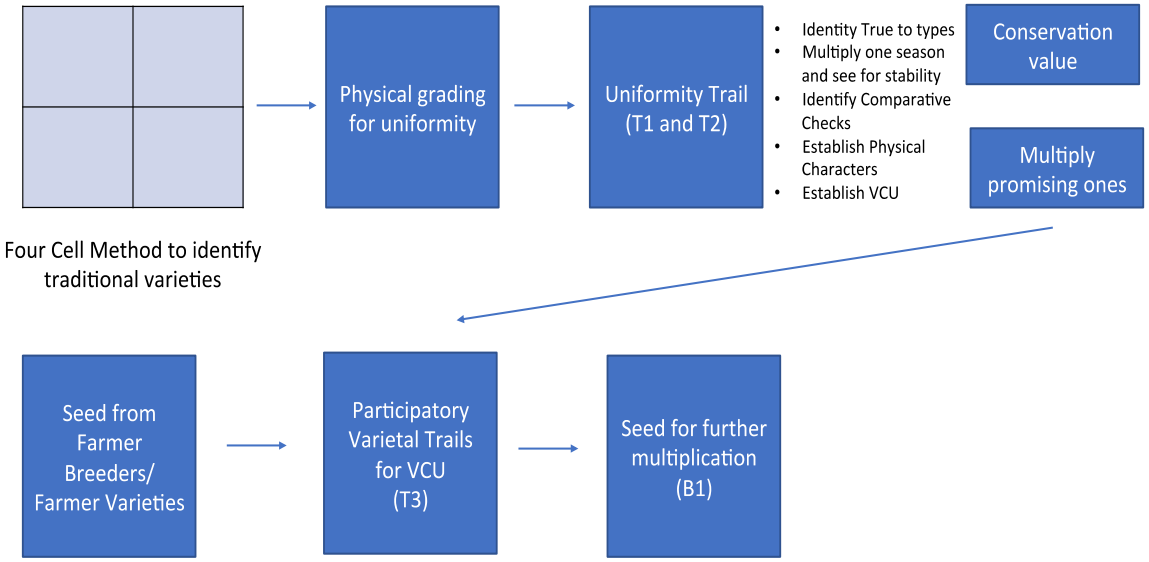
- In situ conservation is the preservation of plant genetic resources in their natural habitat. This can be done through a variety of methods, such as establishing protected areas, managing traditional farming practices, and supporting local seed banks.
- Ex situ conservation is the preservation of plant genetic resources outside of their natural habitat. This is typically done in seed banks, which are facilities that store seeds under controlled conditions.
- **Some of the method of multiplication of traditional cultivars are**

  Cultivar Evaluation Trials.

  Cultivar evaluation trials are conducted to compare the performance of different crop varieties under a specific set of conditions. The goal of these trials is to identify the varieties that are best suited for a particular environment and use.

  The best-performing crop varieties can be evaluated by farmers based on their preferred traits, and then multiplied and supplied to farmers through community-based organizations (CBOs) or farmer producer organizations (FPOs).

Traditional and Farmers Varieties



Crop Production system

13. CROP PRODUCTION TECHNOLOGIES

Land preparation

The goal of land preparation is to create the ideal soil environment that will facilitate the development of growing plants. Tillage refers to the mechanical manipulation of the soil using tools and implements in order to improve soil conditions for better seed germination and subsequent crop growth. Conservation tillage is a unique type of soil cultivation used in natural farming systems. It involves leaving crop residue from the previous year on fields before and after the next crop is planted, which has the added benefit of reducing soil erosion and runoff as well as carbon sequestration.

Major advantages of conservation tillage include

- Enhances soil water infiltration, minimising nitrate and water runoff as well as erosion.
- Enhances soil surface stability against wind erosion and the discharge of dust and other airborne particles.
- Less nutrient leaching since there is more soil organic matter to supply binding sites.
- Reduces evaporation and boosts soil moisture retention, increasing harvests in years of drought.
- Reduces the vehicle traffic in the field level, which lowers the cost of fossil fuel and lowers the emissions of carbon into the atmosphere.
- Decreases the loss of applied chemicals, including insecticides.
- Due to higher soil organic matter levels that result in less leaching, higher infiltration rates with more surface residue result in less runoff moisture retention capacity.

Crop and variety selection

The selection of crop and varieties plays an important role in crop production and it is consider as non-monetary inputs. The selection of crop and variety should be based on the available resources and must withstand under the biotic and abiotic stress. For instance, cultivars of sorghum that are resistant to shoot fly infestation are chosen for cultivation in areas where sorghum is grown. We have to select flood tolerant cultivars where flood is common issues during the monsoon.

A) Seasonality Based

- Crops grown in the Kharif season include rice, maize, sorghum, bajra, ragi, and small millets.
- Crops grown during the Rabi season include wheat, barley, oats, chickpeas, sorghum, potatoes, rapeseed, and mustard.
- Crops grown throughout the summer include sesame, black gram, and green gram.

B) Considering Rainfall

- 10-20 cm/month for at least 3 months - bajra, tiny millets
- 30 cm/month for at least 3 months - rice
- 20–30 cm/month for at least 3 months- maize/black gramme
- Monthly rainfall of 5 to 10 cm favours grass
- Less than 5 cm is unsuitable for crop production.

C) Depending on the length of the growing season

- 20 weeks - Single crop
- 20–30 weeks - Single crop plus Inter crop
- 30 weeks - Sequential planting of two crops

D) Based on Irrigation Facilities/Water

It is decided whether a single crop (late release of water) or a double crop (early release of water) can be cultivated in a year based on the water release in the canal. Crops are chosen based on their water needs and the availability of water from a river, canal, or ground water source. For instance, various crops need the following amount of water to grow; Rice 1100-1150 mm, sorghum 400-450 mm, blackgram-250-300mm, cotton 550-650 mm, banana 2000-2200 mm.

Choice of varieties

The needs of the specific area must be taken into consideration when choosing a variety.

Treatment of seeds

In order to lessen, control, or repel disease organisms, insects, or other pests that attack seeds or seedlings growing there from, seeds may be treated by mixing, coating, soaking in nutrient, hormone, or growth regulator solutions, or by wetting and drying them.

When seeds are treated, pests are also kept in check during storage and after planting or sowing.

The seed treatment is done for the following purposes:

- To ward off or fend off birds and vermin
- To provide nutrients to plants
- To provide resistance against pathogens
- To end the dormancy of seeds
- To promote tolerance for drought
- To promote early emergence and a greater germination percentage
- To make mechanised sowing easier

Beejamritham seed treatment

Beejamrita, an organic liquid manure, is used to treat the seeds of several crops. It is a potent treatment that guards the seed from numerous bacterial and fungal illnesses. Before sowing/ planting, seeds, plants, seedlings, or any other planting material can be treated with Beejamrutha. It is beneficial in preventing fungus growth on young roots. It is the second pillar of natural farming with. It is made via a fermentation method using components found on the farm itself.

Procedure: Gather the seeds in a cotton cloth. Before applying the solution to the seeds, stir the solution once more in a circular motion. Place the bundle of seeds there after dipping it in the Beejamrita solution until it is completely submerged. After that, take the seed bundle out and let it dry in a shaded place. Avoid rain and harsh sunlight on it.

(OR)

Use bijamrita as a seed treatment by coating, combining, or mixing seeds of any crop by hand. After they have dried thoroughly, use the seeds for sowing.

Sowing

It is the act of putting plant propagules (such as seeds, seedlings, cuttings, rhizomes, clones, tubers, etc.) in the ground to become plants.

Methods of Sowing

(a) Broadcasting - Broadcasting is the act of scattering or distributing seeds on the ground. The simple, rapid, and inexpensive way of seeding is broadcasting. Uneven distribution,

incorrect seed placement, less soil cover, and compaction are problems with broadcasting. Germination, seedling vigour, and establishment are not uniform due to the fact that all of the seeds are not sown in the same density and depth. It works well for crops with small, closely spaced seeds.

(b) Dibbling: Using a planter, a dibbler, or frequently by hand, seeds are inserted into a hole or pit that has been dug at a specific depth (2-3cm) and with a predetermined spacing. Compared to broadcasting, dibbling is more time-consuming, expensive, and labour-intensive. But this method reduces the seed rate and also ensures the good germination and also vigorous seedling growth.

(c) Sowing behind the country plough is an activity in which a person working behind a plough sows seeds into the furrow either constantly or at the necessary intervals. The soil sealing the furrow prevents the seeds in the prior furrow from germinating when the plough cuts the next adjacent furrow. The depth of the plough furrow can be changed to alter the depth of sowing.

(d) Drilling: This technique involves placing seeds at a precise depth before compacting the soil around them. Seed drills are used for this purpose. Rows of seeds are constantly drilled or drilled at regular intervals. Although it takes more effort, money, and time, it keeps the population density per unit area constant.

(e) Planting – It entails firmly burying seeds or seed material in the ground.

CROP GEOMETRY

In a crop field, it refers to the way that plants are distributed throughout the surface or the form of the space that each plant has access to. Seeds should be planted with the right space. If the plant density per unit area increases, the yield per plant steadily declines.

SYSTEM OF ROOT INTENSIFICATION

It started in 1980s as System of Rice Intensification in Medagaskar. It spread to India and more than 70 other countries. In India it started in 2000-2001 through ex-scientists, various Civil Society Organisations and State Rural Livelihood Missions under NRLM, MORD. The principles were successfully demonstrated in various crops. Principles of System of Root Intensification are as follows:

1. Young age seedlings
2. Use of organic manures and fertilizers/plant protection measures
3. Use of Weeders for aerating soil and incorporating weeders
4. Alternet Wetting and Drying
5. Proper spacing of seedlings
6. Priming and Treatment of seeds/seedlings

INTERCROPPING

Intercropping is the simultaneous cultivation of two or more different crops on the same plot of land at the same time. The principal crop is appropriately mixed with the additional plant density of the related crop, which must be in a distinct row arrangement and have its recommended maximum plant population. The goal is to increase crop production per unit area by raising plant population pressure and intensifying cropping in both the temporal and spatial dimensions. Compared to solo cropping, it uses growth resources more effectively. Both legumes and non-legumes are typically grown. The benefits of intercropping are as follows:

a. Increased revenue from the companion crop
b. Companion crops may provide subsistence income if the main crop is harmed by unfavourable conditions like drought, flood, epidemics, etc.
c. By fixing nitrogen, legumes cultivated as companion crops always help the main crop and also draw moisture from deeper soil layers.
d. Effective labour utilisation by increasing the number of man days available for employment
e. Quick-growing companion crops always reduce the damaging weeds thriving in the intervals between the main crops
f. More effective use of the nutrients, water, light, and space needed for growth
g. A decrease in the frequency of disease and insect attacks
h. A decrease in erosion losses.
i. Generates money just prior to the long-duration main crop's harvest.

Intercropping can produce successful results if an appropriate companion crop is chosen to grow alongside the primary crop. Knowing the prerequisites of the companion crops, such as soil and water requirement, competition for space, sunshine, and air, crop

duration, yielding potential, time of sowing and harvesting, is crucial before putting any intercrop with the main crops, such as sugarcane, maize, sorghum, or bajra. On the basis of the aforementioned knowledge, some appropriate combinations are:

Principal Crop	***Intercrop***
Sugarcane	*Wheat, cowpea, soybean, moong, sunflower*
Sorghum	*Cowpea, soybean, moong, urd, arhar*
Maize	*Cowpea, soybean, urd, arhar, castor*
Bajra	*Cowpea, soybean, urd, arhar, castor*
Cotton	*Soybean, groundnut*
Potato	*Wheat, radish*

WEED MANAGEMENT

Weeds are unwanted and unattractive plants that negatively impact human welfare by interfering with the use of land and water resources. They may alternatively be called "plants in the wrong place." Weeds constitute a significant challenge in non-cropped areas such industrial sites, road/rail lines, air fields, landscape plantings, water tanks and water ways, etc. because they compete with the desirable and helpful plants in crop lands, woods, aquatic systems, etc.

Weed control measures include weed prevention, eradication, and control through controlled use, invasion restriction, growth suppression, seed prevention, and total elimination. So, one part of weed management is weed control. (This is discussed in detail in a separate session.)

BIOLOGICAL CONTROL

Biocontrol is the employment of living creatures to reduce a pest population's abundance, which makes it less harmful than it would otherwise be. Biological control refers to the use of live organisms, or bioagents, such as insects, pathogens, herbivorous fish, snails, or even competitive plants, to manage weeds. Weeds cannot be completely eliminated with the biological control method, although their population can be decreased. Not all weed varieties can be controlled with this strategy. The best targets for biological control are introduced weeds.

Examples:

- Hyacinth moths, *Neconchetina eichhorniae,* are used to manage *Eichhornia crassipes*.

- The larvae of the lantana moth *Crocidosema lantana* dig into the flower stalks, consume the blooms, and control lantana camara.
- *Melanagromyza cuscutae* is used in controlling Cuscuta species.

IRRIGATION MANAGEMENT

Irrigation is the artificial application of water intended to make up for the insufficient soil moisture that does not fully fulfil the needs of growing crops.To increase the production of agricultural and horticultural crops, irrigation is simply the practise of supplemental natural precipitation. The art and science of irrigation management involves applying water from a source to an agricultural field.

There are three different irrigation techniques: Surface irrigation, subsurface irrigation, and pressurized irrigation (drip and sprinkler irrigation).

Surface irrigation

The phrase "surface irrigation" describes water delivery methods that use an overland, gravity-fed water flow to water crops. It includes various methods of irrigation like flooding, check basin method, ring basin method and border strip method etc.

Subsurface irrigation

Through a system of subsurface perforated or open jointed pipes, water is supplied underneath the surface of the land. These pipelines allow water to flow under pressure, and the water exits through open joints. To ensure that they do not interfere with the crop, pipes should not be any shallower than 40 cm. Losses from evaporation are decreased. The procedure is costly due to the high cost of the installation and the pipes. To prevent the perforation from being clogged, the water utilised should be of high quality.

Pressurized irrigation

Both drip irrigation and sprinkler irrigation are pressurised irrigation techniques that apply water through a network of tubes using pressure devices. Pressurised irrigation systems use a network of pipes to pressurise water that is then carefully applied to the plants under pressure. Surface irrigation methods are less efficient in applying irrigation water to crops than pressurised irrigation systems. This method offers better agricultural distribution, better time control, less land wastage for irrigation layout, less labour demand, and better use of scarce water resources.

Mulching in irrigation management

Mulching is a widespread practise that involves spreading materials such as crop residues, agricultural leftovers, livestock manure, etc. over the soil surface in the field before or shortly after planting. Mulching is primarily used to reduce evaporation or water erosion, raise soil temperature, increase the capacity of the soil to hold water, and control weeds. Mulching encourages plant growth, increases crop yields, reduces water losses and also controls weeds.

Nutrient Management

A common framework for approaching nutrient management is known as the "Four Rs":

- Right amount - the proper rate of application
- Right source - applying the proper type
- Right placement - using the appropriate method for application
- Right timing - applying at the correct time in the lifecycle of the system

Crop rotation, cover crops, decreased tillage, and the use of compost are some of the techniques used in organic agriculture systems to increase soil fertility. Less carbon is lost to the atmosphere due to reduced tillage, which results in more soil organic carbon. This prevents soil from becoming inverted and exposed to air. A few industrial fertilisers, including de-oiled cakes, bone meal, biofertilizers, and a variety of mineral powders, including rock phosphate and green sand, a potassium-rich type of potash that occurs naturally. Lime and sulphur are examples of natural pH supplements that can be used when the pH has to be changed.

Panchagavya

An organic compound called panchagavya has the ability to support plant growth and enhance immunity. Cow dung, cow urine, milk, curd, jaggery, ghee, bananas, tender coconuts, and water are the nine ingredients that make up panchagavya. It's application enhances the formation of new leaf and canopy formation. The primary benefit of Panchagavya is its ability to successfully raise all crop growth and yield parameters when the land is transformed from an inorganic to an organic cultural system starting in the first year. It extends the shelf life of the cultivated product while also enhancing their flavour.

Jeevamrutha

It is an inexpensive, fermented, microbial preparation that enhances soil mineralization while enriching the soil and promoting the proliferation of microorganisms. It is one of the major inputs in the natural farming. It also provides resistance to pests and diseases, encourages the activity of beneficial organisms, and increases the amount of organic carbon in the soil.

Composting

Composting is an aerobic process that breaks down organic wastes into solid wastes that can be recycled. Compost created during the process of decomposing organic matter, is a beneficial fertiliser for plants and majorly used in nutrient management for organic agriculture.

Green Manuring

Green manuring is the process of growing leguminous and other plants in the field, and incorporating into the soil when they reach the 50% flowering stage. *Crotalaria juncea, Sesbania bispinosa, Phaseoulus trilobus, and Sesbania rostrata* are the most significant green manure crops.

Greenleaf manuring

Green leaf manuring is the application of green leaves and twigs of trees, shrubs, and plants that have been collected from elsewhere. The primary sources of green leaf manure are forest tree leaves. Another source of green leaf manure is vegetation that grows in wasteland, field bunds, etc. Neem, mahua, wild indigo, Glyricidia, Karanji (*Pongamia glabra*), calotropis, *Sesbania grandiflora*, subabul, and other shrubs are significant plant species suitable for producing green leaf manure.

Organic manuring benefits

Micronutrients are provided to plants by organic manures. The physical characteristics of the soil, its ability to store water, its hydraulic conductivity, and its capacity for infiltration are all improved by the application of organic manures. The carbon dioxide that is released during decomposition reacts with water to form carbonic acid, which is used as nutrient provider. Organic manures promote soil fertility by increasing nutrient availability and providing energy (food) for bacteria. Green manures also have the benefit of fixing atmospheric nitrogen, which reduces the need for nitrogen in crop production. They also take

nutrients from deeper soil layers and concentrate them on the soil's surface for use by future crops.

Plant protection Measures

This is discussed in detail in other sessions.

CROP ROTATION

Crop rotation is the practise of growing various crops in succession on a plot of land over a set period of time with the goal of maximising return on investment while minimising damage to the fertility of the soil. Because it is such an effective tool for reducing soil illnesses, insect pests, weed issues, and for developing healthy soils, crop rotation is necessary in natural farming.

General recommendation for practicing crop rotation

- Plant a crop that requires lots of nitrogen after a crop of legumes.
- After a legume, in the second or third year, plant less nitrogen-demanding crops.
- Plant annual crops for a single season in a specific site.
- Avoid planting a crop after a closely related species.
- Make use of crop successions that encourage healthier crops.
- Use crop rotations to keep weeds under control.
- As part of the rotation, try to cultivate a crop with deep roots.
- Plant some crops that will produce a lot of residue.

Harvesting and processing

Harvesting should be done based on the duration of the crop, maturity symptoms. Typically, the grain is harvested 10 to 15 days after it reaches physiological maturity. The grain has a certain moisture content and unique physical features as it reaches maturity. The length of the growing cycles, which varies depending on the crop and variety, and the level of grain maturity are used to identify the best time to harvest.

The grain should be harvested when its moisture level is between 15% and 20%. Clearly, the risk of losses from moulds, insects, and germination increases with the grain's moisture content at harvest. The risk of losses owing to grain breaking or from attacks by birds, rats and other pests, however, increases the longer the grain is left in the field (for further drying of the product).

The harvested crop parts are dried, threshed, and the grains are segregated for storage after the crops are harvested. To boost the income, the right processing techniques are used based on the crop's characteristics.

14. WEED MANAGEMENT IN NATURAL FARMING

Need of Weed Management in Natural Farming

Weeds are essential and are used as living or dead mulch layers in natural farming. However, Weeds are the most important biotic constraints to increase agricultural productivity and farmers' income in both developing and developed countries. It is also a major constraint to increase agricultural productivity and farmers' income, particularly in developing countries like India. In general, weeds cause the highest potential yield loss to crops along with pathogens (fungi, bacteria, etc.) and animal pests (insects, rodents, nematodes, mites, birds, etc.). In India, reduction in crop yield was estimated as 31.5% (22.7% in winter and 36.5% in summer and rainy seasons) by weeds. Actual economic losses were high in the case of rice (USD 4420 million) followed by wheat (USD 3376 million) and soybean (USD 1559 million). Thus, annual total actual economic loss of about USD 11 billion was estimated due to weeds alone in 10 major crops of India viz. groundnut (35.8%), soybean (31.4%), greengram (30.8%), pearlmillet (27.6%), maize (25.3%), sorghum (25.1%), sesame (23.7%), mustard (21.4%), direct-seeded rice (21.4%), wheat (18.6%) and transplanted rice (13.8%). Yield losses in crops due to weeds depend on several factors such as weed emergence time, weed density, type of weeds and crops, etc. Left uncontrolled, weeds can result in 100% yield loss. Weeds compete with crops for sunlight, water, nutrients and space. In addition, they harbor insects and pathogens, which attack crop plants. Furthermore, they destroy native habitats, threatening native plants and animals.

Weeding is completely restricted in natural farming; therefore, yield and economic losses are higher in natural farming when compared to modern agriculture. Hence it is essential to follow suitable weed management practices without affecting the concepts of natural farming to boost the crop productivity.

Methods of Weed Management

To achieve higher yield and income by managing weeds in natural farming, some of the suitable weed management practices are discussed below. However, none of the single method is effective for all weeds and to manage weeds effectively and sustainably in the long run, it is essential to integrate possible weed management practices for natural farming.

1. Use of Weed Free Seeds

Use clean seed that is free from weed seeds for sowing purpose. Inspect seed, necessary stocks for the presence of weed seeds, tubers, rhizomes, weed seedlings etc. The cropped area, bunds, irrigation channels etc. should be kept clean or free of weeds. Keep threshing yard and manure pits free from weeds.

2. Selection of Variety

Careful selection of crop varieties is essential to limit weeds problems and to satisfy market needs. Any crop variety that is able to quickly shade the soil between the rows is able to grow more rapidly than the weeds will have an advantage.

3. Crop Rotation

Crop rotation involves alternating different crops in a systematic sequence on the same land. It is an important strategy for developing a sound long term weed control program. Weeds tend to thrive with crops of similar growth requirements as their own and cultural practices designed to contribute to the crop may also benefit the growth and development of weeds. Monoculture, that is growing the same crop in the same field year after year, results in a build-up of weed species that are adapted to the growing conditions of the crop. When diverse crops are used in a rotation, weed germination and growth cycles are disrupted by variations in cultural practices associated with each crop (tillage, planting dates, crop competition, etc).

Within a rotation, crop choice will determine both the current and the potential future weed problems that a grower will face. Traditionally, potato (*Solanum tuberosum* L.) is included in the rotation to reduce weed problems before a less competitive crop was grown. For an organic grower, crop choice is complicated further by the need to consider soil fertility levels within the cropping sequence and to include fertility building periods in the rotation. Variations in crop and weed responses to soil nutrient levels can also play an important part in weed management. The inclusion of a fallow period in rotation will reduce perennial weeds. It is best to alternate legumes with grasses, spring planted crops with fall planted crops, row crops with close planted crops and heavy feeders with light feeders.

4. Planting Patterns

Crop population, spatial arrangement, and the choice of cultivar (variety) can affect weed growth. For example, studies have shown that narrow row widths and a higher seeding density will reduce the biomass of later-emerging weeds by reducing the amount of light available for weeds located below the crop canopy. Similarly, fast growing cultivars can have a competitive edge over the weeds.

5. Intercropping

Intercropping involves growing a smother crop between rows of the main crop. Intercrops are able to suppress weeds and minimize soil erosion. When legumes are included as intercrop, it fixes atmospheric nitrogen in the soil and enhances soil fertility. However, the use of intercropping as a strategy for weed control should be approached carefully. The intercrops can greatly reduce the yields of the main crop if competition for water or nutrients occurs.

6. Cover Crops

Rapid development and dense ground covering by the crop will suppress weeds. The inclusion of cover crops such as rye, red, clover, buckwheat and oilseed radish or over wintering crops like winter wheat or forages in the cropping system can suppress weed growth. Highly competitive crops may be grown as short duration 'smother' crops within the rotation. Additionally, cover crop residues on the soil surface will suppress weeds by shading and cooling the soil. When choosing a cover crop, consideration should always be given to how the cover crop will affect the succeeding crop. In addition, decomposing cover crop residues may release allelochemicals that inhibit the germination and development of weed seeds.

7. Mulching

Mulching or covering the soil surface can prevent weed seed germination by blocking light transmission preventing seed germination. Mulches physically suppress weed seeds emergence. There are many forms of mulches available. The following two are suitable for natural farming.

a. *Living mulch* : Living mulch is usually a plant species that grows densely and low to the ground such as clover. Living mulches can be planted before or after a crop is

established. It is important to kill ad till in, or manage living mulch so that it does not compete with the actual crop. A living mulch of *Portulaca oleracea* from broadcast before transplanting broccoli suppressed weeds without affecting crop yield. Often, the primary purpose of living mulch is to improve soil structure, aid fertility or reduce pest problems and weed suppression may be merely an added benefit.

b. *Organic mulches* : Materials such as straw, bark, and composted material can provide effective weed control. Producing the material on the farm is recommended since the cost of purchased mulches can be prohibitive, depending on the amount needed to suppress weed emergence. An effective but labor-intensive system uses newspaper and straw. Two layers of newspaper are placed on the ground, followed by a layer of hay. It is important to make sure the hay does not contain any weeds seeds. Organic mulches have the advantage of being biodegradable. Cut rye grass mulch spread between planted rows of tomatoes and peppers was more economic than cultivation. Fresh bark of conifers and oak as well as rapeseed straw gave good control of weeds when they were laid as mulches under the trees in apples orchards.

8. Field Scouting

It involves the systematic collection of weed and crop data from the field (weed distribution, growth stage, population, crop stage etc.). The information is used, in the short term, to make immediate weed management decisions to reduce or avoid economic crop loss. In the long term, field scouting is important in evaluating the success or failure of weed management programs and for making sound decisions in the future.

9. Water Management

Effective water management is a key to controlling weeds in a vegetable operation. Buried drip irrigation minimizes weed growth in natural farming. Drip tape buried below the surface of the planting bed can provide moisture to the crop and minimize the amount of moisture that is available to weeds closer to the surface. If properly managed, this technique can provide significant weed control during dry period.

10. Allelopathy

Allelopathy is the direct or indirect chemical effect of one plant on the germination, growth or development of neighboring plants. It is now commonly regarded as component of biological control. Species of both crops and weeds exhibit this ability. Allelopathic crops

include barley, rye, annual ryegrass, buckwheat, oats, sorghum, sudan sorghum hybrids, alfalfa, wheat, red clover, and sunflower. Vegetables, such as horseradish, carrot and radish, release particularly powerful allelopathic chemicals from their roots. Suggestions have been made that allelochemicals and other natural products or their derivatives could form the basis of bio herbicides. However, it is unclear whether the application of natural weed killing chemicals would be acceptable to the organic standard authorities.

MECHANICAL WEED CONTROL

The mechanical methods include tillage, hoeing, hand weeding, sickling, mowing, burning, floods, mulching, and digging.

Tillage

Weeds are killed by tillage because it removes them from the soil. By damaging the pruning of the roots and stems, it may harm plants by lowering their ability to compete or regenerate. Also, weeds are buried by tillage.

Hoeing

The best and most popular weeding instrument for ages has been the hoe. It is still a really helpful tool for getting results quickly and affordably, though. For row crops, it is an addition to the cultivator. Hoeing can totally eradicate weed growth, making it especially more effective on annuals and biennials.

Weeding by hand

It is accomplished physically by pulling weeds out by hand or by using tools called khurpis, which resemble sickles. It is most likely the earliest method of weed control, and it is still a useful and effective way to get rid of weeds in both cropped and uncropped regions.

Mowing and sickling

In order to starve the subsurface sections of weeds and hinder seed formation, sickling is also done by hand with the aid of a sickle. It is common in muddy places where only the tall weed growth is sickled, leaving the soil's root system to retain the soil and avoid soil erosion. The majority of the time, machines are used to mow lawns and the sides of roadways.

Burning

Using fire or burning is frequently a cost-effective and useful way to get rid of weeds. It is employed in conditions when cultivation and other conventional procedures are impractical to (a) get rid of vegetation (b) destroy adult weeds' dry tops, and (c) kill green weed development.

Flooding

Against weed species that are susceptible to prolonged submersion in water, flooding is effective. By limiting the amount of oxygen available for plant growth, flooding destroys plants. The success of flooding hinges on the weeds being completely submerged for longer periods of time.

CULTURAL WEED CONTROL

To create favourable conditions for the crop, a variety of cultural practices including tillage, planting, fertiliser application, irrigation, etc., are used. If carried out appropriately, these methods aid in weed control. While cultural approaches cannot completely eradicate weeds, they can help to reduce their population. As a result, they ought to be employed in addition to other strategies. Tillage, fertiliser application, and irrigation are crucial in cultural practices. In addition, factors including variety choice, sowing method, cropping strategy, farm hygiene, etc., can all help reduce weed growth.

Field preparation

Weeds must be kept out of the field. Weeds shouldn't be permitted to flower. This aids in reducing the growth of the weed seed population.

Seasonal tillage

One of the most successful cultural practices to slow the spread of perennial weeds in crop cultivation is the use of summer or off-season tillage.

Optimal plant population maintenance

Lack of sufficient plant population makes weed infestations more likely and later more challenging to eradicate. To achieve a proper and uniform crop stand that can compete with weeds, practices including proper seed selection, appropriate sowing technique, adequate seed rate, protection of seed from soil transmitted pests and diseases, etc., are crucial.

Crop Rotation

If the same crop is planted year after year, the likelihood of a certain weed species or set of species emerging is higher. Crop rotation often eliminates or at least significantly reduces problematic weed issues. By integrating low land rice in crop rotation, noxious weeds like *Cyperus rotundus* can be efficiently controlled.

Intercropping

The ability to use crops as weed control techniques is made possible by the fact that intercropping suppresses weeds more effectively than solitary cropping. Numerous short-lived pulses, such as moong and soybean, effectively smother weeds without affecting main crop's yield.

Mulching

Mulch is a substance that is kept on top of the soil surface as a protective layer. Mulching inhibits top growth by blocking light from a plant's photosynthetic areas, which has a suffocating impact on weed control. It is extremely powerful against some perennial weeds, such as *Cynodon dactylon*, as well as annual weeds.

Stale seedbed

When the first one or two flushes of weeds are eliminated before planting a crop, the seedbed is said to be "stale." This is accomplished by soaking a field that has been properly prepared with irrigation or rain and letting the weed seeds develop. A non-residual pesticide like paraquat or shallow tillage can be employed at this point to eradicate the profusion of early weed plants.

Blind tillage

Blind tillage is the term for soil preparation done after a crop is sown but before the crop plants actually start to grow. When emergence of crop seedlings is hampered by soil crust created on receipt of rain or irrigation soon after sowing, it is frequently used to reduce weed intensity in drill sowing crops.

Weeds are major threat for crop production and challenge for successful natural farming. Adopting of effective weed management practices will enhance the crop productivity and income of the farmers involved in natural farming. In addition to the

growing concern for protection of environment, maintain biodiversity and protection of human and animal health, integrated weed management approaches are needed and more of research efforts are required to develop low cost and environment friendly weed management practices without altering the core concept of natural farming.

Plant Protection Systems

15. INTRODUCTION TO PESTS AND THEIR OCCURRENCE

What is a Pest?

The major aim for the natural farmer is to create conditions, which keep a plant healthy as a healthy plant is less vulnerable to pest and disease (biotic and abiotic stress) infestation. The way to a healthy plant is a healthy soil. A diversified cropping system will not allow an insect to build up to the level where it causes economic damage.

In nature there is no such thing called a 'pest'. They are only consumers at primary, secondary and tertiary levels. As insects are competing with food for human beings they are termed as pests. This is an anthropocentric view and not from nature's point of view.

Transition in pest management practices:

In traditional agriculture apart from the few organic chemicals that were used, pests were managed by cultural, agronomical practices and ITKs. At times there were huge losses to crops due to locust infestation, etc.

The first major pesticide that came into agriculture is DDT. The insecticidal properties were identified during war time research and application for control of mosquitoes (malaria) in the war fronts. Then slowly came the plethora of chemical pesticides. In the initial stages of euphoria scientists thought that they would eradicate all the agricultural pests.

This was quickly proved wrong with the resistance development in insects, resurgence and secondary pest attack. Apart from this there were problems of pollution and health hazards. This led to the idea that insects cannot be eradicated and that one has to control their numbers at which they do not cause economic damage to the crops. This, over a period of time, led to the Integrated Pest Management (IPM) theory with cultural, biological, mechanical, agronomic methods with chemical methods being the last option. However, in farmer's practice chemical options continued as the first rather than the last option.

To avoid the poisoning due to chemical pesticides Non-Pesticide Pest Management (NPM) was propagated without the chemical option of the IPM methods. This NPM forms the broad basis for the Natural Farming Pest Management (NF-PM) with the core objective of building soil fertility and crop diversity.

One of the first important steps in managing the insects is to understand them. There are several ways of classifying and understanding insects.

A. Based on incidence:

1. Regular pest- Frequently- Rice stem borer, Pod borer.
2. Occasional – Case worm in rice, Mango stem borer.
3. Seasonal Pests- Red Hairy Caterpillar, Cotton pink bollworm, Mango Hopper.
4. Persistent pests- Round the year- Chilli Thrips, Mealy bug on guava, cotton.

B. Based on feeding mechanism:

1. Sucking pests. (These also transmit viral diseases.)
2. Borers/Chewing (leaf eaters).

C. Based on the number of crops they attack:

1. Polyphagous pests – attacks several crops – e.g. Helicoverpa/ cotton pod borer
2. Monophagous – attacks only one crop – e.g. Brinjal shoot and fruit borer (BSF)

Understanding the insects helps choosing the management strategy/ options.

In natural farming the pests (and weeds) are seen as a symptom rather than as the problem. Whenever the farmers observe an increase in the number of insect pests they should see it as an indication of something that is wrong with the farming system/ cultivation practices, which could be:

a) Crop/ variety not suitable to the region
b) Grown in an inappropriate season.
c) Cultivating susceptible cultivars.

d) High Density plant population
e) Mono-cropping.
f) Deficiency or excess of nutrients
g) Water logging or water stress.

A well-managed farming system is a successful way of reducing the level of pest or disease population. Certain crop varieties have more effective mechanisms than others due to the adaptive nature to the environment and therefore have a lower infection risk. Mono-cropping increases the risk of pest infestation.

The health condition of a plant depends to a large extent on the fertility of the soil. When nutrition and pH is well balanced, the plant becomes stronger and is therefore less vulnerable to infection. Climatic conditions, such as suitable temperatures and sufficient water supply, are further factors which are crucial for a healthy plant. If one of these conditions is not suitable, the plant can become stressed. Stress weakens the defence mechanisms of plants and makes them easy targets for pests and diseases. One of the most important points for a natural farmer is therefore to grow diverse and healthy plants. This avoids many pest and disease problems.

Farmers have observed that the insect population is also affected by the waning and waxing phases of the moon. The aspects of improving soil health and crop diversity are long term measures. Some of these measures are:

Preventive Measures:

1) Selection of varieties which are well adapted to the local environmental conditions (temperature, nutrient supply, pests and disease pressure), as it allows them to grow healthy and makes them stronger against infections of pests and diseases.

2) Selection of good seeds/ planting material which has been inspected for pathogens and weeds at all stages of production.

3) Mixed cropping systems can limit pest and disease pressure as the pest has less host plants to feed on and more beneficial insect life in a diverse system. Crop rotation reduces the chances of soil borne diseases and breaks the life cycle of monophagous pests and increases soil fertility.

4) Green manuring and cover crops increases the biological activity in the soil and can enhance the presence of beneficial organisms (but also of pests; therefore, a careful selection of the proper species is needed).

5) No chemical fertilisers: steady growth makes a plant less vulnerable to infection. Synthetic fertilizers lead to lush growth resulting in susceptibility to insect pests and also reduces soil fertility, opening the way for secondary infections.

6) Input of organic matter increases micro-organism density and activity in the soil, thus decreasing population densities of pathogenic and soil borne fungi. It stabilises soil structure and thus improves aeration and infiltration of water.

7) Application of suitable soil cultivation methods facilitates the decomposition of infected plant parts, regulates weeds, which serve as hosts for pests and diseases, and protects the microorganisms which regulate soil borne diseases.

8) Conservation and promotion of natural enemies: Natural farming practices such as pest management and crop diversification help to build the natural enemies of pests.

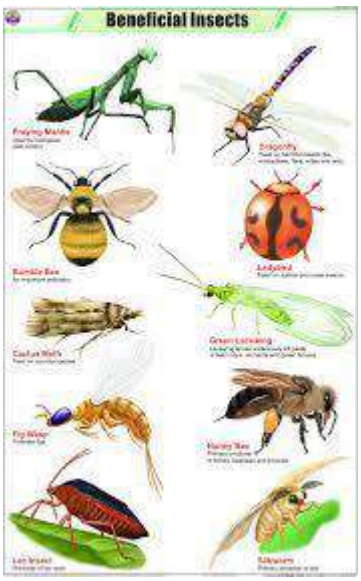
9) Pest avoidance: Most pests attack the plant only in a certain life stage; therefore, it's crucial that this vulnerable life stage doesn't correspond with the period of high pest density and thus that the optimal planting time is chosen.

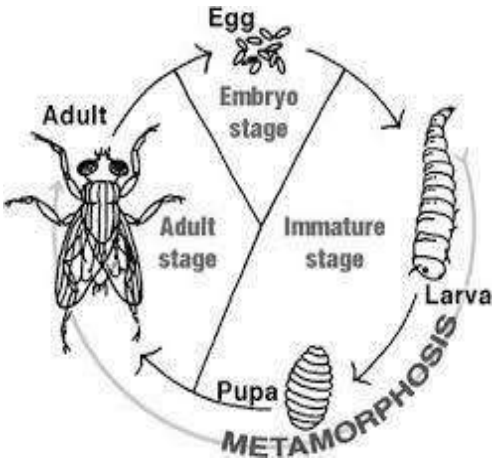
10) Remove infected plant parts (leaves, fruits, crop residues) from the ground to prevent the disease from spreading and eliminate residues of infected plants after harvesting.

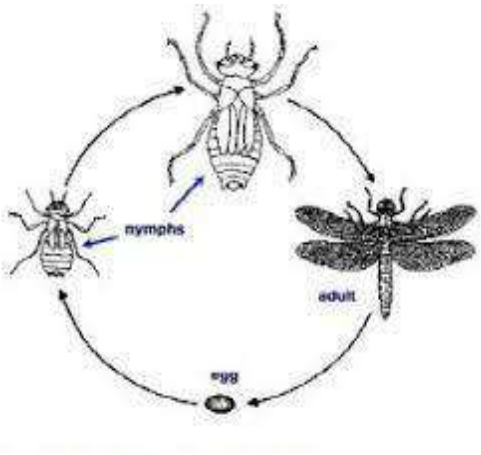
Identifying and understanding insects:

The predominance of chemical agriculture has created a belief that ‘a good insect is a dead insect’. However, this is not true.

The first step is to differentiate the beneficial insects from harmful insects.







It is also important to understand and identify the insects in all the stages of their life cycle. Normally there are two types of life cycles:

i) Egg – larva – pupa – Adult

ii) Egg – nymph – Adult

Understanding the life cycle will help the farmers to know the stage in which the insect causes damage and the stage in which it can be easily managed.

The second step is Pest Monitoring and Surveillance. A Natural Farmer should be regularly visiting the fields and observing the crops. Appropriate methods should be followed for monitoring the insects:

- Weather based monitoring
- Pheromone traps: Pest specific (borers)
- Sticky traps for sucking pests such as whitefly, jassids and thrips.
- Light traps/ Solar light traps- Moths all sucking pests.
- Insect nets and field observations.

The third step is to know the Economic Threshold Levels (ETL); i.e., the number at which an insect can cause potential damage. This concept is more suitable for single host pests (monophagous pests). Farmers should be aware of the right time to take up pest management practices.

16. PEST MANAGEMENT IN NATURAL FARMING

The ecological and economical problems of pests and pesticides in agriculture gave rise to several eco-friendly innovative approaches which do not rely on the use of chemical pesticides. These initiatives involved rediscovering traditional practices and contemporary grass root innovations supplemented by strong scientific analysis mainly supported by non-formal institutions like NGOs. Such innovations have begun to play an important role in development sector. This trend has important implications both for policy and practice.

The "Non Pesticidal Management" which emanates from collaborative work of public institutions, civil society organizations and Farmers in Andhra Pradesh shows how diverse players join hands to work in generating new knowledge and practice, can evolve more sustainable models of development.

Several voluntary agencies, farmers from different regions and few scientists from the subject area established that:

- Red Hairy Caterpillar
- This pest infests crops only on light red soils
- There is only one generation of moths that lay eggs producing the cater- pillars which later hibernate in the soils. Adult moths appear in waves at the onset of the monsoon. Controlling the pest necessitated the destruction of the early emergence moths.
- The caterpillars are also attracted to some wild non-economical plants such as calatropis, wild castor, yellow cucumber.
- The later instars of larvae had dense red hairs all over the body, which prevents pesticides from reaching the body of the insects as a result any pesticide sprayed will not cause the mortality of the insect.

Package of practices were evolved based on the insect behavior, which can manage the RHC before it reaches damaging stages and proportions. Deep summer ploughing exposes the resting pupae, adults of RHC. These insects are attracted to light-community bonfires. Bonfires were used to attract the insects and kill them. Alternatively light traps (electric bulbs or solar light) were also used. Trenches around the field to trap migrating

larvae by use of calatropis and jatropha cuttings were found to be effective. Neem sprays on the early instar larvae was found to be effective.

Pest is not a problem but a symptom. Disturbance in the ecological balance among different components of crop ecosystem makes certain insects reach pest status. From this perspective evolved the Non Pesticidal Management which is an "ecological approach to pest management using knowledge and skill-based practices to prevent insects from reaching damaging stages and damaging pro- portions by making best use of local resources, natural processes and community action."

Non Pesticidal Management is mainly based on:

- Understanding crop ecosystem and suitably modifying it by adopting suitable cropping systems and crop production practices. The type of pests and their behavior differs with crop ecosystems. Similarly, the natural enemies' composition also varies with the cropping systems.

- Understanding insect biology and behavior and adopting suitable preventive measures to reduce the pest numbers.

- Building farmers knowledge and skills in making the best use of local resources and natural processes and community action. Natural ecological balance which ensures that pests do not reach a critical number in the field that endangers the yield. Nature can restore such a balance if it is not too much meddled with. Hence no chemical pesticides/pesticide are applied to the crops. For an effective communication to farmers about the concept effectively, and to differentiate from Integrated Pest Management which believes that chemical pesticides can be safely used and are essential as lost resort it is termed as "Non Pesticidal Management".

Growing Healthy Plants from Good Quality Seed

In NPM –main emphasis is to prevent insect from reaching damaging stage and proportions. If the pest reaches damaging stage, reactive inputs locally made with local resources are used. In IPM chemical pesticides are integral part.

Selection and use of good quality seed which is locally adopted either from traditional farmers' varieties or improved varieties released by the public sector institutions is important. Farmers are suggested to make their decision based on a seed

matrix with information on value for cultivation and use is important which includes information regarding suitability of the different varieties into their cropping patterns, based on the soil types, reaction to insect pests and diseases and their consumption preference. They maintain the seed in their seed banks. This ensures farmers to go for timely sowing with the seeds of their choice. In rainfed areas timely sowing is one critical factor which affects the health and productivity of the crop. The seed is treated with concoctions depending on the problem for example cow urine, ash and asafetida concoction provides protection against several seed borne diseases like rice blast, or *beejamrut* to induce microbial activity in the soil and kill any seed borne pathogens. Similarly in crops like brinjal where there is a practice of dipping of seedlings in milk and dipping fingers in milk before transplanting each seedling was observed to prevent viral infections. Several such practices are documented and tested by the farmers. Non Pesticidal Management involves adoption of various practices which prevents insects from reaching to damaging stage and proportions (Fig. 1).

Reduce Stress

The pest and disease susceptibility increases with abiotic stress. Practices like mulching will improve the soil moisture availability.

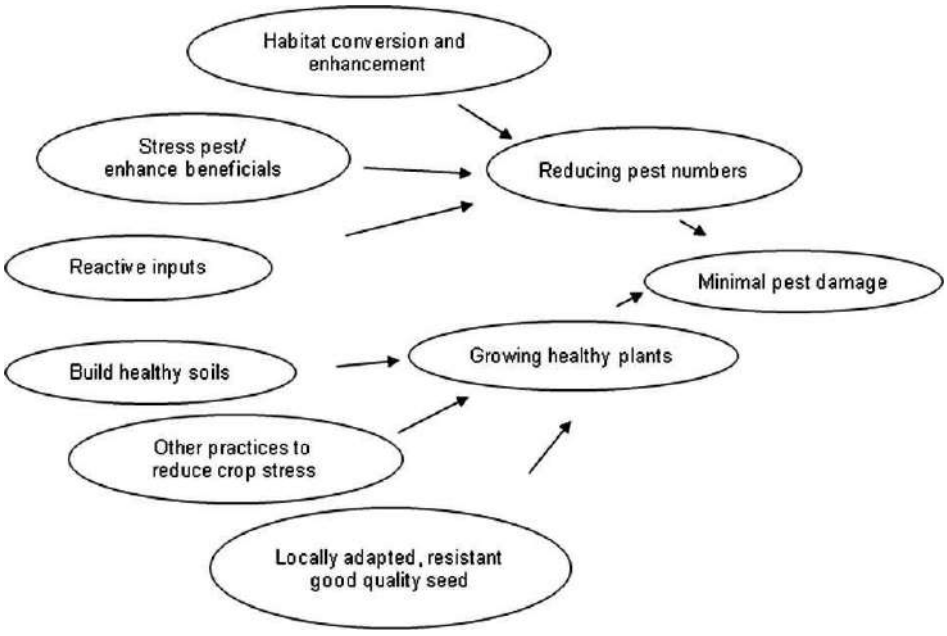


Fig. 1 Schematic representation of non-pesticidal management

Build Healthy Soils

Healthy soils give healthy crop. Chemical fertilizers especially nitrogenous fertilizer makes the plants succulent and increases the sucking pests like brown plant hopper in rice. Production practices, such as putting on crop residues or other biomass as surface mulch, using compost and green manures, intercropping of legumes in cropping systems, and biocontrol of insect pests and diseases, all help to enhance yields and sustain soil fertility and health.

Enhancing the Habitat

Crop Diversity

Crop diversity is another critical factor which reduces the pest problems. Tradition- ally farmers have evolved mixed cropping systems, intercropping and crop rotation systems. These systems will create a better environment for nutrient recycling and healthy ecosystems. On the contrary the monoculture of crops and varieties lead to nutrient mining and insect pest and disease buildup. Under NPM farmers adopt mixed and intercropping systems with proper crop rotations.

Trap and Border Crops: Many sucking pests fly from neighboring farmers' fields. In crops like chillies, groundnut, cotton, sunflower where thrips are a major problem, sowing thick border rows of tall growing plants like sorghum or maize will prevent insects from reaching the crop. Farmers adopt marigold as a trap crop for the gram pod borer and it reduces the pest load on pigeon pea. The flowers that have been oviposited by the female moths of *Helicoverpa* can be picked out and destroyed (Table 2).

Table 2 Trap crops used for pest management

Crops	Pests	Trap crops
Cotton, groundnut	Spodoptera	Castor, sunflower
Cotton, Chickpea, pigeonpea	Helicoverpa	Marigold
Cotton	Spotted bollworm	Okra

Source: KVK DDS, 2003

Other Agronomic Practices: Several crop specific agronomic practices like alley ways in rice to allow enough light to reach the bottom of the plant are documented by the farmers and suggested by the scientists.

Understanding Crop Ecosystem

The pest complex and the natural enemy complex are based on the crop ecosystem. The pest complex of cotton is completely different from that of sorghum. The pest complex in wet rice ecosystem differs from the pest complex in dry rice. Decision about any pest management intervention should take into account the crop ecosystem which includes cropping pattern, pest-predator population, stage of the crop etc. Similarly, the management practices followed in one crop cannot be adopted in all other crops. For example: to manage *Helicoverpa* in pigeon pea, the farmers in Andhra Pradesh and Gulbarga shake the plants and falling insects are collected over a sheet and killed (see box). Similarly in paddy there is a practice of pulling rope over the standing crop to control leaf folder.

Fig. 3 Egg laying behavior of (a) *Spodoptera litura* (egg mass) (b) *Helicoverpa armigera* (single egg)

Reactive Sprays

Insect population may reach pest status if the preventive steps are not taken in time, changes in weather conditions and insects coming from neighboring farmers fields. In these situations based on the field observations farmers can take up spraying botanical extracts and natural preparations (Green sprays) instead of chemical pesticides. There are wide ranges of these preparations which are evolved by the farmers.

Based on the process of making, these sprays can be classified into four categories

Aqueous or Solvent Extracts

Extracts are made by dissolving the required material in water (aqueous) or other liquids (solvent). For example, neem seed kernel extract is prepared by dissolving crushed neem seed kernel in water. For extracting "Allenin" from garlic, kerosene is used as a solvent. After extraction this solution is mixed with chilli extract and used against sucking pests.

Fig. 4 Shaking method in pigeon pea for removing pests

Decoctions

For example, plants like tobacco, *Nux Vomica* contain volatile compounds which can be extracted by boiling them in water to get the decoction. Several decoctions are used in pest management.

Concoctions

Concoctions are mixtures. For example, five leaves mixture which is an aqueous extract of any five latex producing leaves is used to control pests in Tamil Nadu and other parts of south India.

Fermented Products

Products made by fermenting the different botanicals with animal dung and urine. These products have rich microbial cultures which help in providing plant nutrients in addition to acting as pest repellents and pest control sprays. For example, cow dung urine- asafetida solution is used to manage rice blast.

While the sustainable models in agriculture like NPM are established on smaller scale scaling up these experiences poses a real challenge in terms of:

- Relevance of small experiences for a wider application,
- Availability of resources locally,
- Farmers willingness to adopt these practices,
- Lack of institutional and support systems,
- Supplementing farmers' knowledge and enhancing the skills,
- Reducing the time of transformation,
- Reaching to larger areas with minimal expenditure, and
- Establishing extension system which give community a central stage.

eKrishi: Using IT tools

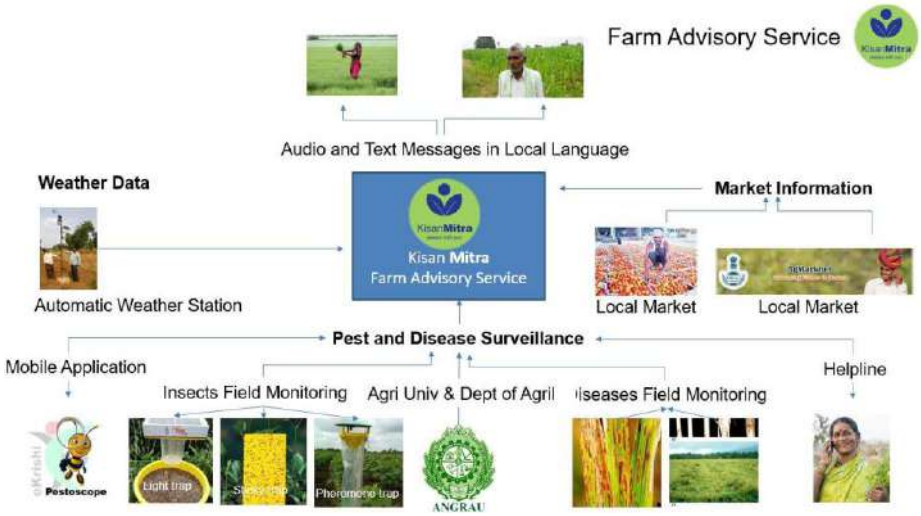
In the initial stages, the resource material was published to help farmers to identify the insect life cycles and natural enemies. With the advent of modern IT tools and social networks like WhatsApp were used to share the problems and solutions. In 2016 Centre for Sustainable Agriculture began working on a suit of IT tools which helps farmers to manage their crop production and marketing.

eKrishi Pestoscope is an android based problem diagnostic tool to help farmers and field extension staff to identify the pests and diseases in their field and find ecological solutions. Its currently under field testing. It can also be accessed online at http://www.pestoscope.com

Functionality

Farmer/extension personnel can

- Can find a solution from the existing library if he/she can identify the problem and suggested practices to manage, otherwise
- take a picture of the problem he/she observes marking the crop and plant part,
- Text, audio or video can be added to further describe the problem
- system automatically geotags the place
- Expert will respond with diagnostics and suggest a solution
- Farmer/extension personnel can also locate farmers with same crop/adopting similar practices who are nearby so that they can visit and mutually learn



17. DISEASE MANAGEMENT IN NATURAL FARMING (ITK)

When a plant cannot function normally, it is diseased. The primary causes of disease in crops and trees are pathogens and environmental factors. There are many disease pathogens: viruses, bacteria, fungi, nematodes, mycoplasma-like organisms, and parasitic higher plants. Fungal pathogens are the most prevalent. They cause seed rots, seedling damping-off, root rots, foliage diseases, cankers, vascular wilts, diebacks, galls and tumors, trunk rots, and decay of aging trees. Unfavourable weather and environmental factors such as temperature and moisture extremes, high winds, or ice can damage trees directly and predispose the trees to pest attack.

Biodiversity plays multifaceted roles in development and ecological sustainability. In agricultural ecosystems, using biodiversity to mitigate plant diseases has received renewed attention in recent years but the knowledge of using biodiversity to control plant diseases is still incomplete. In terms of crop diversification, it is not clear how genetic diversity per se in host populations interacts with identifiable resistance and other functional traits of component genotypes to mitigate disease epidemics and what is the best way of structuring mixed populations. Mixing crop varieties can significantly reduce disease epidemics in the field. To achieve the best disease mitigation, growers should include as many varieties as possible in mixtures or, if only two component mixtures are possible.

The many strategies, tactics and techniques used in disease management can be grouped under very broad principles of action. Differences between these principles often are not clear. The simplest system consists of two principles, prevention (prophylaxis in some early writings) and therapy (treatment or cure).

The first principle (prevention) includes disease management tactics applied before infection (i.e., the plant is protected from disease), the second principle (therapy or curative action) functions with any measure applied after the plant is infected (i.e., the plant is treated for the disease). An example of the first principle is enforcement of quarantines to prevent introduction of a disease agent (pathogen) into a region where it does not occur.

The second principle is illustrated by heat or chemical treatment of vegetative material such as bulbs, corms, and woody cuttings to eliminate fungi, bacteria, nematodes or viruses that are established within the plant material.

In an another method there are four general disease control principles, exclusion, eradication, protection and immunization (the latter principle is more appropriately called resistance since plants do not have an immune system in the same sense as animals). These principles are explained here.

EXCLUSION

This principle is defined as any measure that prevents the introduction of a disease-causing agent (pathogen) into a region, farm, or planting. The basic strategy assumes that most pathogens can travel only short distances without the aid of some other agent such as humans or other vector. In many cases pathogens travel with their host plants or even on nonhost material such as soil, packing material or containers. Unfortunately, exclusion measures usually only delay the entry of a pathogen, although exclusion may provide time to plan how to manage the pathogen when it ultimately arrives.

An important and practical strategy for excluding pathogens is to produce pathogen-free seed or planting stock through certification programs for seeds and vegetatively propagated plant materials such as potatoes, grapes, tree fruits, etc. These programs utilize technologies that include isolation of production areas, field inspections, and removal of suspect plants to produce and maintain pathogen-free stocks. Exclusion may be accomplished by something as simple as cleaning farming equipment to remove contaminated debris and soil that can harbor pathogens such as Verticillium, nematodes or other soilborne organisms and prevent their introduction into non-infested fields.

ERADICATION

This principle aims at eliminating a pathogen after it is introduced into an area but before it has become well established or widely spread. It can be applied to individual plants, seed lots, fields or regions but generally is not effective over large geographic areas.

Citrus canker eradication involved widespread removal and burning of diseased trees and, in some cases, destruction of entire citrus groves and nurseries. The disease appeared to be contained and the pathogen eradicated, but the disease has reappeared and new attempts at eradication are ongoing.

Eradication can also be on a more modest scale such as the removal of apple or pear branches infected by the fire blight bacterium (Erwinia amylovora) or pruning to remove

blister rust cankers (caused by Cronartium ribicola) on white pine branches. Or, it can be the sorting and removal of diseased flower bulbs, corms or rhizomes. Hot water seed-treatment of cereal seeds to kill smut mycelium in the seed and heat treatment to eliminate viruses from fruit tree budwood for grafting are other examples of pathogen eradication.

Eradication may also be accomplished by destroying weeds that are reservoirs of various pathogens or their insect vectors. Elimination of potato cull piles is an effective method of eradicating overwintering inoculum of the late blight pathogen.

Crop rotation is a frequently used strategy to reduce the quantity of a pathogen, usually soil-borne organisms, in a cropping area. Take-all of wheat (caused by Gaeumannomyces graminis) and soybean cyst nematode (Heterodera glycines) are two examples of soilborne diseases that are easily managed by short rotations of 1 and 2 years, respectively, out of susceptible crops, which may include susceptible weed hosts such as grasses in the case of take-all.

PROTECTION

This principle depends on establishing a barrier between the pathogen and the host plant or the susceptible part of the host plant. Other than chemical barriers there are physical, spatial, or temporal barriers also. The specific strategies employed assume that pathogens are present and that infection will occur without the intervention of protective measures. For example, bananas are covered with plastic sleeves as soon as the fruit are set to protect the fruit from various pests including fruit decay fungi.

Protection often involves some cultural practice that modifies the environment, such as tillage, drainage, irrigation, or altering soil pH. It may also involve changing date or depth of seeding, plant spacing, pruning and thinning, or other practices that allow plants to escape infection or reduce severity of disease. Raising planting beds to assure good soil water drainage is an example of cultural management of plant diseases such as root and stem rots.

RESISTANCE

Use of disease-resistant plants is the ideal method to manage plant diseases, if plants of satisfactory quality and adapted to the growing region with adequate levels of durable resistance are available. The use of disease-resistant plants eliminates the need for additional

efforts to reduce disease losses unless other diseases are additionally present. Resistant plants are usually derived by standard breeding procedures of selection and/ or hybridization.

INTEGRATED DISEASE MANAGEMENT

Integrated Disease Management (IDM) consists of scouting with timely application of a combination of strategies and tactics. These may include site selection and preparation, utilizing resistant cultivars, altering planting practices, modifying the environment by drainage, irrigation, pruning, thinning, shading, etc. However, in NF chemicals are not applied. But in addition to these traditional measures, monitoring environmental factors (temperature, moisture, soil pH, nutrients, etc.), disease forecasting, and establishing economic thresholds are important to the management scheme. These measures should be applied in a coordinated integrated and harmonized manner to maximize the benefits of each component. Cultivating healthy vigorous plants reduces the disease incidence. However, this is not always easy to accomplish, and "disease management" may be reduced to single measures exactly the same as the ones previously called "disease control." Whatever the measures used, they must be compatible with the cultural practices essential for the crop being managed.

Traditionally, there are several types of crop diseases: abiotic (also known as non-infectious) and biotic (infectious).

Unfavourable environmental conditions often generate non-communicable diseases. Examples are low or high temperature, excess, or lack of moisture. Also, diseases are usually caused by harmful impurities in the air. They can accumulate due to the presence of nearby chemical or metallurgical plants. Usually, the unhealthy physicochemical composition of the soil is the disease source. The latter factor is often the result of poor-quality treatment of fields with some herbicides. These examples prove the importance of sustainable agriculture not only for protecting the environment but also for a profitable business.

Even an unfavourable light regime can cause negative consequences. Toxins that some embryophytes (higher plants) and fungi release into the soil can also be causal agents of crop diseases.

Infections' causal agents include:

1. Bacteria

2. Viruses
3. Fungi
4. Nematodes
5. Parasitic plants.

Crop Diseases Caused By Bacteria

Among the most common infections in agriculture are crop diseases caused by bacteria. In this regard, the prevention and control of this kind of disease are pretty tricky.

To infect the causal agent needs to get into the culture's tissue. It occurs mainly through damaged areas, such as caused by agricultural tools, insects (fleas), or simply unfavourable weather conditions (dust, wind, heavy rain). But bacteria can also infect plants through natural holes or glands (for example, which secrete nectar).

Another feature of bacterial crop diseases is that causal agents, once in a plant or soil, can remain dormant for a long time until unfavourable conditions arise for them. First of all, significant temperature fluctuations and high levels of humidity act as catalysts for bacterial activity.

Symptoms of Bacterial Crop Diseases

The main bacterial disease indications include vascular wilting, necrosis, soft rot and tumour. Although this type of plant disease can be identified due to its pronounced symptoms, identifying a specific causal agent requires laboratory methods.

Common Bacterial Diseases

As noted earlier, due to a huge number of bacteria, there are many disease types. Here are some examples of the most common diseases of crop plants:

1. Black rot - *Xanthomonas campestris*
2. Bacterial canker - *Clavibacter michiganensis*
3. Bacterial soft rot - *Pseudomonas spp*
4. Bacterial leaf spot/Bacterial spot - *Pseudomonas syringae* - various strains
5. Bacterial wilt - *seudomonas syringae pv. pisi*
6. Bacterial leaf spot/Bacterial spot/Bacterial blight - *Pseudomonas syringae*
7. Bacterial brown spot - *Pseudomonas syringae*

Control Measures

Spraying of antibacterial solutions like Sour buttermilk etc.

Crop Diseases Caused By Fungi

Pathogenic fungi are the most typical agricultural problem. According to research, this plant disease type destroys about a third of all food crops every year. In this regard, this problem is severe both from a humanitarian and economic point of view. Like bacterial crop diseases, these infections affect plants mainly through wounds, stomata, and water pores. Also, fungal spores are often carried by gusts of wind.

Symptoms of Fungal Crop Diseases

Often, a fungal infection is expressed in local or general necrosis. Also, crop diseases caused by fungi can interfere with the average growth or contribute to its abnormal burst, called hypertrophy.

Other crop diseases symptoms include:

Spots on leaves, exfoliation, rot, anthracnose,ulcers, curls of leaves and warts.

***[Note**: Due to a vast number of pathogenic fungi types, the indications are very different. Therefore, timely disease detection is the most effective kind of protection.]*

Common Fungal Diseases

1. White blister/White rust (*Albugo candida*)
2. Downy mildews (individual species damage particular crop families)
3. Powdery mildews (some species are restricted to particular crops or crop families)
4. Clubroot (*Plasmodiophora brassicae*)
5. *Pythium* species
6. Sclerotinia rots (*S. sclerotiorum* and *S. minor*) – a range of common names are used
7. Sclerotium rots (*Sclerotium rolfsii* and *S. cepivorum*)

Control Measures

Seed selection and treatment

Spraying of plant based fungicides

Crop Diseases Caused By Nematodes

Nematodes are parasitizing roundworms, which usually cannot be seen without special equipment. They live in the soil, and therefore mainly affect roots, tubers, and bulbs. There are over 4100 dangerous nematode species.

Symptoms of Nematode Crop Diseases

Essentially, nematodes feed by sucking juices from plants. Because of this, plants affected by these parasites often appear dried out, as if they are suffering from drought.

Other symptoms are also similar:

Yellowing, growth retardation, lack of response to fertilizers and water, the gradual general decline of a plant, reduction or even destruction of root systems.

Although nematodes need a long period to cause significant damage to a plant, they spread exceptionally rapidly. Therefore, farmers should identify crop disease in the field to save the affected plants timely and prevent the disease from spreading.

Common Nematode Diseases

Diseases directly depend on the type of nematodes:

Fusiform thickening of the stems is provoked by stem worms. The disease is expressed in the deformation of leaves, swelling of petioles, and the appearance of dark spots on tubers.

Aphelenchoides, a disease of rice, is provoked by Aphelenchoides besseyi. Disease marks are blemishes on the tops of leaves, lack of grains, and culture depletion. The corresponding nematode

Tylenchulus semipenetrans cause serious citrus diseases. It is characterized by the gradual death of not only leaves but also branches.

Crop Diseases Caused By Virus

The most minor but most critical plant enemies are viruses and viroids (subviral contagious agents). After infection, it is almost impossible to save a plant. Therefore the effect of plant diseases on crop production is of critical importance throughout the world. In most cases, the infection spreads as a result of healthy plants with sick contact. Viruses can also spread through vegetative reproduction, through seeds, pollen, and insects. But viruses most often spread through the soil.

Symptoms of Viral Crop Diseases

The symptoms of crop diseases caused by virus are usually divided into four types: malformations, such as abnormal growth of shoots, distortion of leaves and flowers; necrosis, wilting and the appearance of annular stripes and spots; dwarfism, growth retardation of both individual parts and the whole plant; discoloration, e.g. yellowing, and vein clearing.

Root crop diseases, which are expressed in their rotting, are a characteristic indication of the presence of a virus. However, some plants may not show symptoms and are latent carriers of a disease. Therefore, extreme vigilance is required in the fight against this infection type.

Common Viral Diseases

Among the common examples of viral diseases in crop plants:

Tobacco mosaic manifests in dwarfism and mosaic-like patterns on leaves. The disease is widespread throughout the world and can have significant economic consequences.

Tomato spotted wilt is accompanied by the appearance and growth of necrotic yellow rings that gradually turn reddish-brown.

Potato spindle tuber inhibits plant growth, tubers become fusiform and shrink.

Do soil microorganisms protect against crop disease?

They do. Soil microorganisms increase immunity, protect plants from many pathogens. Moreover, if beneficial microbes are present in the roots of a plant, it can fight pests more effectively while maintaining natural growth.

Control of Crop Diseases Caused By Viruses

Control the vectors

Spraying of Cow urine based solutions to control

Crop Diseases Caused By Parasitic Plants

Parasitic plants are among the most dangerous plant pests in the world. With the help of particular organs, these plants settle in a host plant and satisfy at the expense of it (most often its vascular system). Although many parasites only weaken their “prey”, some can kill a

plant and pose a severe economic threat to agriculture. Depending on the species, parasites can attach from one to several dozen plant species.

Common Parasitic Plants

Today, there are about 400 parasitic plant species that have a substantial impact on the ecosystem in which they exist.

Few common examples:

Mistletoe (Viscaceae): This semi-parasitic plant is widely represented throughout the world and is evergreen. As a parasite, mistletoe can exist on a significant number of plant species. It spreads thanks to special seeds that stick to birds and are carried with them to other plants. These seeds germinate through the host plant bark and connect to its food system.

Cuscuta spp.: Cuscuta spp. is a parasitic bindweed plant, which is very dangerous for various plants. It actively spreads, disrupts the metabolism of host plants, reduces productivity, and often leads to the death of plants. Moreover, Cuscuta spp. can be a carrier of viral plant and animal diseases. Because of all these features, the weed is a quarantine object.

Orobanche spp.: It is a dangerous root parasite without green leaves that cannot photosynthesize, and is utterly dependent on a host. For seed germination of Orobanche spp., it is required that a suitable plant is planted in the soil. Then the weed will attach to its roots and begin to receive ready-made food. The parasite leaves up to 100,000 seeds. They remain viable in the ground for over ten years while waiting for a host. All it makes Orobanche spp. a dangerous pest.

Striga spp.: This group of parasitic plants is mainly found in tropical and subtropical regions and belongs to quarantine plants. In African countries, they are classified as a pandemic since Striga spp. can destroy up to 100 percent of a plant and cause irreparable economic damage. Primarily, this herb infects cereals but can also parasitize other plants, for example, when growing sugar cane. It’s spread through seeds, growing together when ripe with the root system of a host plant. These parasites are very tenacious, so re-planting of a previously infected area is possible after nine years. In regions dependent on agriculture, the Striga spp. can even lead to the migration of people.

Farm Machinery

18. FARM IMPLEMENTS, TOOLS AND SOURCE OF IMPLEMENTS RELATED TO NATURAL FARMING

The successful implementation of natural farming on an individual field hinges on the careful adjustment of crop geometry to accommodate intercropping alongside the main crop. Additionally, the utilization of mulch materials plays a vital role in preserving soil moisture, which is later made available to the crops through decomposition. This mulch layer also serves to suppress weed growth, which is particularly important during the kharif season when weed control can be challenging. Such challenges can lead to reduced yields for both the main crop and intercrop. Furthermore, a noteworthy aspect of natural farming is the prudent utilization of water through alternating furrows. This practice ensures adequate aeration in the root zone of the crops. However, these activities necessitate alterations in crop geometry. In flat-bed cultivation, it becomes challenging to execute all these practices effectively. Therefore, specific implements are required to minimize the overall disorderliness of the field and facilitate efficient bed preparation, allowing for optimal soil modification to support natural farming practices. Different components of Natural Farming with details and associated implements are given in Table number 1.

Table 1. Components of Natural Farming and associated implements

Components /Practice	Details	Suitable implements
Solid and liquid concoctions	Beejamrit, Jeevamrit, Ghanjeevamrit, etc	Plastic drums, muslin cloth and wooden stick for steering purpose
Multi-cropping / Intercropping	Ideally 365 days soil cover, live mulch, bund cropping	Trencher, bed planter, dibbler etc.
Mulching	Cover crops or crop residues, etc	Mulcher, rotary weeder/cono-weeder
Aeration	Humus development process, Soil aeration, alternate furrow irrigation, alternate wetting and drying in case of rice	Ridge and broad bed maker
Prophylactic pest control measures	Use of Bio formulations	Plastic drums, muslin cloth and wooden stick for steering purpose
Others	PMDS (Rainfed) /Multi-variate crop sowing (Irrigated) during fallow period etc	Seed drill, Zero-till seed drill, happy seeder and turbo seeder in case of PMDS

Fig:-1. Geometric arrangements to grow (wheat+chickpea) on bed and furrow for irrigation purpose

Essential Farm Implements and Tools:

- **Hand Tools:** Hand tools are the backbone of natural farming, allowing farmers to work closely with the land and crops. Tools like hoes, spades, and digging forks enable gentle soil manipulation, reducing compaction and disturbance. Weeding implements, such as scuffle hoes and hand weeders, facilitate precise weed removal without disrupting the soil structure. In case of natural farming in general weeds are controlled through mulching but in extreme conditions it can follow light weeding through hand tools as mention above. Some important tools used in Natural farming are given in Table 2. These are only illustrative examples and the tools/ names vary according to the region.

- **Mulching Equipment:** Mulching stands as a cornerstone within the framework of natural farming serving multiple essential functions such as moisture conservation, weed suppression, and soil enrichment. To facilitate the uniform application of organic matter throughout fields, various mulching implements such as straw spreaders, rotary mulchers,

hay rakes, and mulch layers are used. These tools contribute to the even distribution of mulch materials. This uniformity is crucial, as uneven distribution can pose challenges during the seeding and emergence of subsequent crops.

- Proper mulch distribution prevents complications like obstructing zero-till seed drills or happy seeders. These obstructions can lead to inadequate seed placement in the soil, subsequently impacting the desired crop population at the individual farm level. Challenges with crop residue management become particularly pronounced after harvesting non-basmati rice. This type of rice generates substantial residues, ranging from 7 to 10 tonnes per hectare. Such residues pose difficulties during the sowing of the next crop. In certain regions like the Indo-Gangetic plain, encompassing Punjab, Haryana, and Western Uttar Pradesh residue burning is being reduced with recycling the crop residue within the fields.

- **Seed Planters and Spreaders:** To enhance the precision of planting and sowing in the context of natural farming, specialized seed planters and spreaders are readily available. These implements are designed to ensure optimal seed spacing and appropriate planting depth, contributing to consistent germination and uniform growth of crops.

- In the case of intercropping within natural farming systems, precise adjustments in planting arrangements are crucial. Over time, various implements have been developed to cater to these needs. Examples include sugarcane trenchers, bed planters, and broad bed and furrow makers. These implements enable the simultaneous planting of the main crop and intercrop. They also create furrows for irrigation purposes and establish raised beds for crop planting. For the actual planting process, if a dedicated planter is not accessible, a dibbler can be utilized. A dibbler is particularly useful for small-scale vegetable growers who might not have the resources to invest in a planter. This tool aids in creating holes for seed placement, facilitating the planting process without the need for more advanced equipment.

- Lasers are primarily employed to create ridges and furrows at varying intervals of 60 cm, 75 cm, or 90 cm. This technique is applied in the cultivation of sugarcane, potatoes, and maize. For sugarcane, furrows are established for planting, while for potatoes and maize, ridges serve as the planting structure. In addition, single and double row trenchers are

utilized for intercropping within sugarcane fields. These trenchers create two furrows at 30 cm apart, forming a 120 cm bed where the top section, around 100 cm, is available for intercropping with the main crop. This trencher type also finds application in other crops, where the furrows function as irrigation channels and the beds serve as spaces for main and intercrops. Modern agricultural markets now offer bed planters capable of simultaneously preparing beds and planting diverse crops. If a farmer's budget does not allow for a bed planter, a dibbler can be employed. Dibblers facilitate easy intercropping of vegetables and cotton by creating planting holes.

Fig:- 2. Lazer mainly used sugarcane/potato and maize sowing to prepare ridge and furrow

Fig: - 3. (a) Single row trenchers

(b) Double row trenchers

Fig: - 4. Glimpse of intercrops with sugarcane in trench method

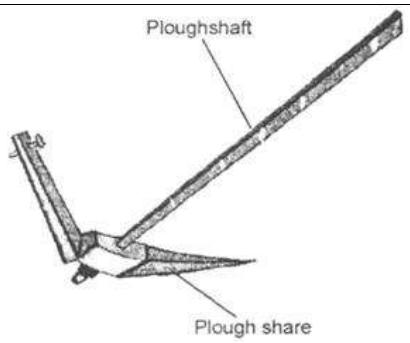
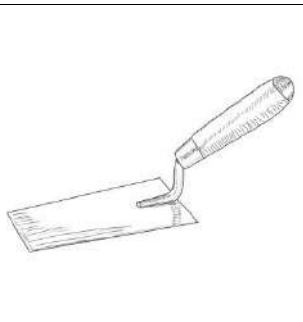
Fig:-5. Sugarcane dibbler used for vegetable sowing in between papaya and banana

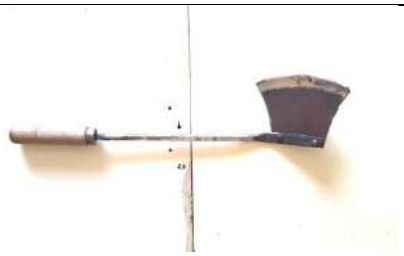
Fig:-6. Multi crop bed planter perform both bed preparation and bed planting

3. Animal-Drawn Implements: In accordance with the principles of natural farming, harnessing the capabilities of animals for plowing and cultivating fields aligns seamlessly with the philosophy. The utilization of animal-drawn plows and cultivators serves multiple purposes: it reduces dependence on fossil fuels, minimizes soil compaction, and fosters a more harmonious relationship between humans, animals, and the environment. Furthermore, the implementation of animal-drawn implements contributes to the responsible utilization of male cows, which might otherwise be left wandering on roads and streets. This not only poses risks to public safety but also harms crops when these animals venture into fields. The issue of stray cattle is particularly pronounced in the cow belt of India. Farmers often voice concerns about this matter on various platforms. The presence of stray cattle hampers the cultivation of diversified crops, including legumes, as they can cause damage. By effectively channeling these bulls for farm work, akin to practices from earlier periods, a win-win situation can be created. This approach not only addresses the issue of stray cattle but also harnesses their potential to contribute positively to agricultural endeavors.

Tools and their use:- Different tools and implements and their uses are given below.

Table 2. Different small tools/ implements used for different purposes in Natural Farming

Tool/implement	Description	Image
Tillage implements		
1. Plough (*Hal)*	Drawn either by oxe, it is used for ploughing.	
Intercultural operation tools		
2. Khurphi	Used to intercultural operation in small plots in mainly vegetables	
3. Spade (*Fawda*)	Used for digging and weeding operations. It used to irrigation to manage water channel and earthling up in sugarcane	
4. *Panjja*	Used to collect the garbage and plant waste material in the field	

Harvesting tools		
5.Sickle (*Daranti*)	It used to cut the fodder crops and weeds	
6. *Balkati*	It is specially used to harvest the sugarcane	
7.Chopper (*Gandasa*)	Chopper is used to chop the green forage for animals and feed them	
8. Knife	Use to remove leaves and cut the sugarcane	
10. *Jelli*	Used to manage the chopped wheat, rice, mustard etc straw	

Animal drawn cultivator: This type of cultivator is designed to be pulled by an animal, such as a buffalo or bullock, and is used for intercultural operations in fields, particularly in sugarcane cultivation. The cultivator has specific features such as 3-5 tynes (tines) for cultivating the soil, wheels to reduce the effort required by the operator and to improve manoeuvrability, and a plastic-covered handle for comfortable handling. Intercultural operations involve activities like weeding and soil loosening, which are crucial for maintaining the health and growth of crops like sugarcane. The cultivator helps remove weeds, aerate the root zone, and reduce soil compaction, which can contribute to better crop yields. In the sugarcane belt of Uttar Pradesh, India, this type of animal draw cultivator is commonly used. It's attached behind a male buffalo, which pulls the implement through the field.

Fig 7. Animal drawn cultivator used in sugarcane for weeding and intercultural operation

Rotatory conoweeder: Intercropping with rice poses a consistent challenge due to the constraint of finding compatible crops that can thrive in the standing water conditions unique to rice fields. To address this, it is recommended that farmers consider cultivating either azolla or Sesbania aculeata as intercrops. These options can be effectively incorporated into the soil using a rotary conoweeder. This process serves to not only integrate the green intercrop material into the soil but also to suppress competing weeds and enhance the root

zone's aeration. In instances where Sesbania aculeata is chosen for intercropping with rice, providing light irrigation during the initial growth stages is advisable.

Fig 8. Rotatory conoweeder in rice field

Sources of Implements for Natural Farming:

Local Artisans: Many local artisans possess the skills to create custom-made farm implements tailored to the needs of natural farming. These artisans can craft tools from locally sourced materials, reducing the environmental footprint associated with long-distance transportation. Gadia lohar a nomadic community in India is expert in preparing small agriculture tools.

Fig 9. Gadiya Lohars at the outskirts of the Meerut city with agriculture tool

Farm Co-operatives and Workshops: Farmers engaged in natural farming often collaborate to establish co-operatives or workshops focused on creating and sharing sustainable implements. These collective efforts help disseminate knowledge and provide access to specialized tools that might not be readily available elsewhere. Small, marginal and landless farmers should be aggregated which can double-up as custom hiring centres to provide the implements for Natural Farming.

Sustainable Agriculture Organizations: Numerous organizations are dedicated to promoting sustainable agriculture practices, including natural farming. These organizations may offer guidance on selecting appropriate implements, connect farmers with reputable suppliers, and even host workshops or training sessions on implement usage.

Online Market places: In the digital age, online market places have emerged as valuable platforms for sourcing natural farming implements. These platforms connect farmers with manufacturers and suppliers who prioritize sustainable and eco-friendly solutions.

Implement Maintenance and Care:

Maintaining and caring for farm implements is vital to their longevity and effectiveness. Regular cleaning, proper storage, and timely repairs ensure that implements remain functional and serve their purpose over a long term.

Farm implements and tools are integral to the success of natural farming, enabling farmers to work in harmony with the land while minimizing ecological impact. By adhering to the principles of natural farming and selecting appropriate implements, farmers can enhance soil health, promote biodiversity, and contribute to a more sustainable and resilient agricultural system. By utilizing local resources, collaborating with fellow farmers, and seeking guidance from sustainable agriculture organizations, practitioners of natural farming can access the tools they need to cultivate a healthier and more vibrant future for agriculture. The key to successful natural farming lies not only in the tools that are used but also in the understanding and application of the underlying principles that guide the actions on the land.

Certification & Marketing

19. CERTIFICATION

What is Certification?

Certification is a formal attestation of whether a good is produced as per the standards of the category. Upon definition of standards and regulations, the accreditation body may allow a third party to provide certification. It ensures and assesses compliance with the defined standards and provides an official certification mark or a declaration of conformity. This enables the product to have a competitive advantage in various markets, add to the brand value and gain premium prices.

Why is Certification Needed?

The growing demand for naturally grown products has stimulated the growth of natural produce.

The Covid situation in the country has also impacted on consumers in India to go for organic and safe, healthy and immunity booster products. The organic market in the couple of years has rapidly grown 25 to 30 % a year. There are several states practicing Natural Farming. Prominent among them are Andhra Pradesh, Chhattisgarh, Kerala, Gujarat, Himachal Pradesh, Jharkhand, Odisha, Madhya Pradesh, Rajasthan, Uttar Pradesh and Tamil Nadu.

To address this demand the quality of produce has to be checked and fraud has to be prevented. Therefore, certifying a product assures it of its quality.

Scope: The NFC (Natural Farming Certification) may be voluntary in nature and non-binding. It is based on continuity and recognizes the farmers adopting natural farming systems as unique to the area and crops. NFCS may be based on producer's declaration of the practices adopted against the standards followed by the physical appraisal by group peers and finally declared themselves to be ‘certified’.

NFC standards may be applicable to crop production, livestock production and processed products made thereof. NFC certification standards may provide traceability to ensure that Certified Products are grown/ produced, handled, processed and packed throughout the value chain through documented and verifiable chain-of-custody.

National Standards for Natural Farming (NSNF): National Standards for Natural Farming (NSNF) for certified Natural Farming Products (NFP) include all agricultural, horticultural, medicinal & herbal and agroforestry crops, wild harvest (non-timber minor forest produce), livestock / fisheries/ Bee keeping systems and their products. Processing under NSNF is limited to on-farm processing at individual or at group of producers. Multi-ingredients processing, where raw material from different sources and from different certification systems are derived is not part of natural farming standards.

General Requirements

Certification can be taken up as a stand-alone certification for either crop production, wild harvest, livestock or processing or an integrated certification for crop-livestock-processing.

Use of synthetic/ chemical inputs (chemical fertilizers, pesticides, hormones or synthetic growth hormones/ growth stimulants, synthetic feed additives) and genetically modified seeds/ planting material or their derivatives or products either directly or indirectly are prohibited.

Natural farming system avoids use of purchased inputs (organic, chemical or otherwise), therefore all inputs shall be prepared on-farm. Preferably the entire landholding with livestock should be converted to natural farming as per the standards.

If the whole farm cannot be converted, it should be ensured that the natural and conventional parts of the farm are separate and distinct. For this purpose a buffer zone or a natural barrier should be maintained.

Simultaneous production of same crop (parallel production) in natural and conventional method should be avoided.

Natural Farming Certification

A quality assurance system ensures consumers that the natural farming has been adopted and production met as per NFCS standards by producers which shall be verified by quality assurance authorities which may have the following major features:

- Provides traceability across the entire value chain.

- Enable producers, processors and brands to demonstrate their compliance with standards for claim verification.
- Educate producers about the Naturally Grown trait of their products.
- Provide recognition to producers that their systems and products are truly Naturally Grown
- Increase confidence of consumers in their choice for naturally grown food

Why Natural Farming Certification is Required

To build Trust: In India, both conventional, organic and natural farm products are being produced and sold. A strong certification mechanism and institutional structure is to be developed to identify natural products. In case of identity and trust in the product by consumer, the products should have label consisting of logo or certificate no.

Identity and differentiate products from non-certified products: Every product should have its own identity to be able to differentiate itself among many products when placed together.

Quality: Quality is the most important aspect of any product. In India, several quality control mechanisms have been developed in the food sector namely BIS, ISI, FSSAI, HALMARK, AGMARK etc. In the same way, the natural/ organic products should have specific standards to assure their quality.

Guarantee: Any product which follows certification under proper institutional mechanism with rules and regulations will guarantee the consumer regarding the quality.

Uniqueness: Uniqueness of a product enables specific differentiation among the certified products.

Ownership: Any product which comes under certification mechanism with proper labelling, i.e., by logo or UID no. enables any producer/ salesperson to build their brand with ownership of the specific logo.

Brand: In the market, many products are sold by retailers/ producers and most popular products become brands. By way of issuing certification for the natural farming products, it may facilitate making the product a brand.

Consumer acceptance: The certified products will likely have more acceptance among the consumers which may enable the farmer to get premium prices for their natural produce.

Documentation Aspects for Certification

To make sure that farmers or groups adopted Natural Farming Standards, package and practices in the farm, livestock rearing, etc documentation is necessary.

Farmer's Identification: Farmer's document related to their identity like ID card, Aadhaar card, driving license, passport etc. are to be recorded so that the farmers practising Natural Farming can be easily identified.

Farm Field – Gps, Coordinates Photos

Every farm field should be recorded by a unique survey number or land record and also GPS co-ordinates. This documentation also enables to integrate in future with GI system.

Purchase Of Seeds

In the market, several type of seeds like chemically treated, botanical treated seeds, GM seeds, traditional seeds are available. In the Natural Farming, farmers are encouraged to use traditional seeds/ locally available seeds. To track farmers whether they are using seeds as per requirement of Natural Farming standards, the bill's copy may be documented.

Natural Farming Inputs

In Natural Farming, locally available inputs / on-farm inputs are supposed to be used. To track inputs used by farmers, throughout the cultivation period, they need to be recorded. The unit's/ field preparations/ utensils pictures (Panchgavya, jeevamrit, Beejamrit, botanicals, compost etc.,) can be taken from time to time and recorded for verification.

Cultivation/ Production Practices

The Natural farmers are to adopt diversified crops, intercropping, multiple cropping, crop rotation etc. Its integration with horticulture and agro-forestry is a common feature. These practices need to be documented throughout the year at different intervals. This can be documented digitally by taking photographs and making videos for verification and certification.

Natural Ways of Pest Management

In Natural Farming, pests and diseases are to be managed by use of locally available botanicals/ ITKS/ soil fertility management / cropping pattern etc.

Usually, the pest and diseases will be managed by using various bio inputs. These practices need to be documented including their preparation, application and time/ quantity of applications in the farm field for certification.

Buffer Zone

The neighbouring farmers may not be practising Natural Farming. The chances of movement of chemical and pesticide residues to Natural Farming fields is possible. In order to avoid this, a clear buffer zone may be created between Natural Farming and conventional farming. The buffer zone may include bunding/ planting trees around the boundary of farm fields and making proper water channels to prevent entry of water from neighbouring fields. This should be documented during the certification.

Before and After Harvest

Inspection/ verification done needs to be documented during the crop standing in the field. The field pictures/ videos during the crop duration and also after harvest may be documented for certification process. The product pictures in the field should be documented for double verification and validation for quantity of crop produced.

Storage

The Natural Farming products should be stored separately to avoid mingling with other products. A separate storage unit/ utensils/ material should be used for Natural products. The pictures of storage units, materials used for handling Natural Farming products may be recorded for certification.

Transportation

When Natural Farming produce is harvested, care should be taken to transport it without mingling with conventional product. Preferably, a separate transport facility may be used. The transport unit can be recorded/ documented.

Labelling and Branding

The label is most important to identify/ to bring uniqueness. The label should have proper size and design as per standards. Labelling with proper UID/ certificate no. should be recorded. The pictures/ online traceability system may be developed/ used in labelling.

Processing and Handling Unit with Machineries and Infrastructure

In Natural Farming, products may be manufactured, collected or purchased by the dedicated production unit/ processor which have been certified or authorised by accredited agency/ organisation. They are to be properly inspected from time to time. Verification and evaluation are necessary to keep the processor operating as per Natural Farming standards. The processing units their machinery, storage, transportation, production, packaging, labelling, sale all need to be documented in a proper way to maintain quality of the products. Therefore, it is essential to keep records by way of pictures/ videos from time to time.

Training Records

To encourage and mobilise the farmers to adopt natural farming, farmer has to be exposed to regular training to update their knowledge on the latest package and practices and certification requirements on Natural Farming. The regular participation of the farmers in trainings will directly influence overall quality of Natural Farming production.

Meeting Records

The farmers practising Natural Farming either individually or in groups need regular interactions among the members to identify and resolve various issues. The regular participation in the meeting will enhance their shared vision and focused approach to make Natural Farming certification successful. Such kind of meetings regularly conducted by Natural Farmer groups is essential in the certification, which needs to be documented

Field Inspection

The most important feature of any certification system is physical inspection of field by individuals/ inspectors when the crop is in the field. The farmers are evaluated for their knowledge, their practices of natural farming. The entire process has to be evaluated, recorded and compliance and noncompliance statement prepared based on which certification status may be decided. The name of the person conducting inspection, how many times in the

year physical inspection was done are important aspects for certification purpose and need to be properly documented.

Exposure Visits

For any new individuals willing to adopt Natural Farming exposure visits are required. It can be to a model KVK based Natural Farming demonstration field or a Champion farmer field. Such visits also need to be documented.

Scope of Certification Issued by Agencies/ Organisations

The Certification granted has to be documented and preserved to track down the status of conversion and any non-compliances found against standard practise, to identify the quantity produced and continuity in adopting Natural Farming practices. In marketing, the traceability can be done by seeing certification number. Therefore, certificates issued may be preserved and documented at farmer's level.

Transactions of all Sale/ Invoice Bills

Transaction certificate/ DID is very important document for verification of sale of products with specific quantity and to trace aggregators/ retailers. The TC number is an important aspect of labelling which makes sure that farmer has sold only certified product and quantity in the market. It needs to be documented at various levels for making certification valuable.

Online Registration and Documentation Mechanisms

Entire certification system may be made in such way that all the information of farmers adopting and practising natural farming are captured online. Information regarding meetings, trainings, peer inspection, actual yield, TCs, Processors etc. should be online to make sure all certification and marketing occur in transparent way. The entire information should be available in public domain to build trust and acceptability toward Natural Farming products.

Annexure – 1: Certification System of Department of Agriculture, Government of Himachal Pradesh

The Sustainable Food Systems Platform for Natural Farming (SuSPNF) programme is initiated by the Department of Agriculture, Government of Himachal Pradesh. It is based on intensive engagement with smallholder farmers since 2018 and has a network of 150000+ farmers with the goal to become a 100 per cent Natural Farming state soon. This project plans to cover all farming families of the state and aims to extend its coverage to 20000 ha. Department of Agriculture, GoHP is inclined to consolidate and support natural farmers in segregated markets for natural farming-based products for two primary reasons.

- To incentivize the practice of natural farming among producers and provide recognition for the same.
- To promote awareness among consumers by providing a more natural and chemical-free alternative graded option.

About the Certified Evaluation System

The Certification process under SuSPNF programme is best called as a Self-Assessment Certified Evaluation Methodology.

Key Principles: The founding principles of the proposed certified evaluation methodology are:

- Simple for farmers and implementation agency
- Based on the principles of No use of Agro-chemicals and GMOs
- Based on the principles of Natural Farming as propounded under PK3Y Scheme
- Scalable with other schemes/regulations at the national and international level
- Based on transparency and traceability between Farmer and Consumer

Highlights of the Certified Evaluation system: The features that make it distinct from the existing certification system are:

- Self-certification is an easy process at the end of the farmer
- Convenient for new joining farmers as there is a defined rating from the start
- Fast in response as the certification is generated within a set time frame
- Possibility for individual farmers to also apply and certify their produce
- Review process based on peer farmers as well as nodal officers at the block

Grading and Rating System in the Certified Evaluation System: Through the SuSPNF platform, the Department of Agriculture, Government of Himachal Pradesh has laid down the standards of the NF practices and has provided an appropriate score for each under the PK3Y scheme. The ratings are received based on the final score obtained with the goal of promoting natural farming practices and conventional farming practices are discouraged by lowering the score to an entry level rating. This ensures fairness as well as the distribution of ratings across the number of farmers. State Domestic Production Certification Protocol (SDPECP) has defined three levels and ratings of NF:

- Antral-PK3 ★ Entry level rating which signifies a farmer's initial conversion from chemical to NF
- Sadharan-PK3 ★★ NF practices adopted by farmers with some use of external non-chemical inputs. This is provided after one year of Antral-PK3
- Vishisht-PK3 ★★★This rating specifies a farmer practicing NF strictly. This is provided after a year of Sadharan-PK3.

Process of Certified Evaluation: In the digital certification system, any farmer who practices natural farming can use this methodology for self-evaluation and evaluate their peers based on the parameters defined under this methodology. In addition, the peer farmer group will also certify that individual farmers are in this process for the same criteria. Upon verification by Block Technology Manager (BTM), of ATMA a final score and rating will be generated. The designated authorities in the Government of Himachal Pradesh will act as monitoring heads and thereby approve the certification rating and methodology. The certification process is decentralized in the manner that self-evaluation and peer-review of farmers are practiced in a defined methodology and approved by the respective Block Level Officer (BTM). Any anomalies in the procedure or any errors trigger a notification to the higher institutions for further action/review. This ensures the system to be reactive in nature instead of proactive wherein the superior authority for licensing certificates rests at the top level of the institution.

Organizational Structure: The branding of the methodology will remain at the Higher-order institutional level i.e. at the State Department of Agriculture while the farmers, FPOs, and other institutions will have the right to use it based on various accessibility nodes.

These standards are complying with and complement the existing regulatory systems and market identities, and do not aim to compete with any certification system.

Certification Process

A typical example of the process of obtaining certification for a farmer under SDPCEP is as follows:

- Application for registration made by the farmer on the certification portal/ mobile application in the prescribed format with KYC details
- Application for certified evaluation is made by the farmer to the certification agency in the prescribed format with necessary farm and NF practices details.
- In addition, the applicant/farmer provides details of farmers for its peer-review who will approve/disapprove the inputs given by the applicant/farmer
- Screening of application by local ATM/BTM ATMA office and if necessary further details/clarification sought
- Signing of agreement between farmer and ATMA officials for onboarding NF platform
- Certification agency seeks NF production/cultivation/processing plans and crop details
- Inspection schedule is worked out and is carried out on one or more than one occasion
- If required, an unannounced inspection can also be done. In case of doubt, the inspection team can also draw plant/soil/raw material/input/product samples for laboratory analysis.
- Upon verification by physical Inspection, the ATM/BTM official approves the application for certification
- Certification is granted
- On grant of certificate, the farmer is deemed as an NF farmer and is applicable for the license for use of the 'Natural HP' Logo
- Real-time monitoring of the aforementioned process and discrepancies in this SOP are alerted to higher district ATMA officials and ED, SPIU(PK3Y) for review.

Auditing Process

To ensure that the protocols and standards are followed, a randomized audit process will be carried out during the period of validation of the certificate. The following process will be carried out for randomized testing:

- The digital system identifies 5% of farmers by randomization for all districts of the state. These farmers are labelled as 'Farmers Under Review'(FUR)
- An Auditing Committee is formed comprising district officials (PD ATMA), the BTM, and one champion NF farmer of the panchayat. In the case of the non-availability of a champion NF farmer in the panchayat, the geographically nearest champion NF farmer is appointed for the committee.
- The Auditing Committee (AC) will conduct independent physical verification of the farmer
- Sufficient information is made available to the AC about the FUR to allow proper audit which includes earlier reports, if any, a description of activities/processes, specifications, inputs used, earlier irregularities, infringements, conditions, and disciplinary measures.
- The checklists used during the audit and the reports emanating from the inspection shall be comprehensive covering all relevant aspects of the production standards (SDPCEP) and shall adequately validate the information provided.
- Audit checklist and reports shall follow specified methods to facilitate a non-discriminatory and objective inspection procedure. The reports shall be designed to allow elaborate analysis by the AU on areas where compliance might be partial. The standards might not be clear.
- Audit reports shall give adequate information on what was checked including but not restricted to:
    - Date and time of inspection
    - Peer group of FUR interviewed
    - Crops/products requested for certification
    - Fields and facilities visited
    - Documents reviewed
    - Calculation of input/output norms, production estimates etc.
    - Assessment of the production system of the operator

    - Assessment of the use of logos/ approvals (India Organic logo, product logo as well as the Certification Body's logo)
    - Evaluation of compliance with standards and Certification requirements
- The final decision for adjusting the star rating of the FAU will be done by AU based on the detailed finding in the report.
- Of the total sampled FAU, 2-5% of them will be audited by SPIU independently.

Features of the digital certified evaluation system

Certified evaluation system scores the farmer based on the farming-based inputs for manure and pest control that it uses. There is positive scoring for using natural products and negative in case any fertilizer and external pesticide is used. The number of years since natural farming is practiced also provides an incremental score to the farmer. The details of natural farming practices and their parameters, weights, and scores are listed in the table.

The digital application platform is designed to have the following aspects:

- OTP-enabled login portal for farmers, block-level officers, and administrators
- Voluntary information on NF practices provided by the registered farmers
- Peer review by a group of five farmers to certify the authenticity of the information provided by the individual farmer
- Notifications sent to higher authorities for anomalies in the certification process
- QR code generation which can be scanned promptly to receive the updated rating of the farmer. This will ensure transparency to the market and the consumer.
- The certification format issued by the department provides suitable weight and score to each input that is to be entered
- The individual farmer enters the data online voluntarily and will declare a crop-wise area for the year immediately after the sowing of the crop. This information will be used for monitoring as well as forecasting production levels.
- The individual farmers' inputs are then endorsed by their peer farmers and block-level officers.
- System evaluates an appropriate star rating based on the total score received from the data acquired

- A digital mapping is produced for each farmer's rating with a QR code. This will further enable uploading the PGS data (SDPCP levels) on the national certification system of PGS-India.
- A GIS-based dashboard will present the status of certification of farmers and necessary analytics to monitor administration.

Natural Farmer's Self-declared Certified Evaluation

Particulars	**Data**	**Weight/Penalties**	**Score**
Gender (M/F)	Male /Female	0/2	
SPNF inputs use and practices			
Beejamrit	Yes/No	4/0	
Jeevamrit	Yes/No	4/0	
Ghanjeevamrit	Yes/No	4/0	
Whapasa	Yes/No	4/0	
Mulching	Yes/No	4/0	
Year of starting SPNF			
2018	Yes/No	4	
2019	Yes/No	3	
2020	Yes/No	2	
2021	Yes/No	1	
Crop rotation followed			
Kharif Season			
Rabi Season			
Fruit crops with mixed cropping			
Mixed Cropping with leguminous crop	Yes/No	4/0	
Indigenous /Crossbred/Exotic Cow	Yes/No	4/2/0	
Total land of farmer (ha):			
Land details (Khasra No. /GPS coordinates)			
Land under SPNF			
> 75% of total cultivated land	Yes/No	4	
50-75% of total cultivated land	Yes/No	2	

<50% of total cultivated land	Yes/No	1	
Training attended:	Yes/No	4	
Date			
Venue			
Duration			
Trainer			
Using self-prepared SPNF inputs	Yes/No	4/2	
Concoctions Applied			
Khatti Lassi	Yes/No	2/0	
Sapt Dhan Ankur Ark	Yes/No	2/0	
Neemastra	Yes/No	2/0	
Other Concoctions			
Agniastra/ Brahmastra/ Dashparni Ark etc.	Yes/No	2/0	
Above Astra's application Not Needed	Yes/No	4/0	
Separate storage facility for SPNF produce	Yes/No	2/0	
Externally sourced Organic inputs use			
Use of biofertilizers	Yes/No	-2/0	
Use of botanical extracts/biopesticides	Yes/No	-2/0	
Use of organic manure	Yes/No	-2/0	
Use of vermicompost	Yes/No	-2/0	
Chemical inputs used			
Fertilizers (Urea etc)	Yes/No	-5/0	
Fungicides	Yes/No	-5/0	
Insecticide	Yes/No	-5/0	
Herbicide	Yes/No	-5/0	
Final score			

CETARA Rating Criteria

Sr No	Marks Obtained	Ranking
1.	**< 30**	**One Star (★)**
2.	**30- 50**	**Two Star (★★)**
3.	**> 50**	**Three Star (★★★)**

20. MARKETING OF NATURAL FRESH PRODUCE AND PRODUCTS

Marketing enables the farmers to achieve economies of scale, streamline distribution from various sources into a single, centralized location, collection of fresh produce and products from multiple farmers or farmer groups into a common pool to access larger markets, and streamline distribution.

Important Steps for Successful Marketing

A) Aggregation of fresh produce and products.

Aggregation is the process of collecting and combining data or items from various sources into a single, centralized location. In the context of agriculture and farming, aggregation refers to the collection of fresh produce and products from multiple farmers or farmer groups into a common pool. This pooling of resources enables farmers to achieve economies of scale, access larger markets, and streamline distribution. Farmers should be made aware of the contamination and commingling. There could be contamination while storing, processing and value addition. Cold storage should be avoided where chemical fumigation is done. Persistent or carcinogenic pesticides and disinfectants are not permitted for storing. Produce can be protected from destruction by rodents by physical barriers, traps (including static bait traps), sound, ultrasound, light and UV light, and diatomaceous earth.

The steps involved in the aggregation process:

1. **Identifying Farmer Interest Group (FIGs) & Collection Centre units**: FIGs are community-based farmer organizations that are formed to promote collective farming, marketing, and support. Identify and collaborate with these groups to understand their produce and products.

2. **Cataloging Fresh Produce and Products:** Create a comprehensive catalogue of the various types of fresh produce and products being cultivated and produced by the FIGs & FPOs. This catalogue should include details like product name, description, quantity available, packaging, and any other relevant information.

3. **Quality Assessment:** Establish quality standards for the produce and products to ensure consistency and customer satisfaction. Implement a quality assessment process to monitor the products before aggregation.

4. **Logistics and Transportation:** Arrange for efficient logistics and transportation to collect the produce from different farmer groups and transport it to the aggregation centre. This could involve setting up collection centres at various locations or coordinating with farmers for delivery.

5. **Storage and Warehousing:** Have proper storage facilities in place to preserve the freshness and quality of the collected produce and products. Proper warehousing is essential to prevent spoilage and wastage.

6. **Market Access:** Develop a distribution network to sell the aggregated produce and products to retailers, wholesalers, or directly to consumers. Establish partnerships with supermarkets, restaurants, and other potential buyers.

7. **Financial Management:** Set up a transparent financial management system to ensure fair revenue distribution among the farmer groups involved. This is crucial for building trust and fostering long-term partnerships.

8. **Data Management & Analysis:** Maintain detailed records of the aggregation process, including the quantity of produce collected, sales data, customer feedback, and any challenges faced. Analyze this data to make informed decisions and improvements.

B) The steps to manage the supply chain of fresh produce under FIGs & collection centres.

1. **Demand Forecasting:** Understand market demands and consumer preferences for various fresh produce. Analyze historical data, market trends, and customer feedback to forecast the demand accurately. This will help farmers plan their production accordingly.

2. **Communication and Coordination:** Establish clear communication channels between FIGs, collection centres, and other stakeholders in the supply chain. Regularly update each party on product availability, quality, and transportation schedules.

3. **Quality Control and Standardization:** Implement strict quality control measures at both the farmer level and the collection centres. Standardize grading, packaging, and labelling to maintain consistency and meet market requirements.

4. **Inventory Management:** Use technology to track inventory levels and manage stock efficiently. This minimizes wastage and ensures a steady supply of fresh produce.

5. **Compliance and Regulation:** Stay informed about relevant agricultural regulations, certifications, and food safety standards. Ensure that all produce meets the necessary compliance requirements.

6. **Training and Capacity Building:** Provide training to farmers and collection centre staff on best practices for handling, storage, and transportation of fresh produce. Continuous education enhances the overall efficiency of the supply chain.

By following these steps and continuously refining the process, FIGs and collection centres can streamline the supply chain, minimize losses, and deliver high-quality fresh produce to the market consistently. Effective supply chain management ultimately benefits both farmers and consumers by ensuring a reliable and sustainable flow of fresh agricultural products.

C) Value addition aspect of naturally cultivated fresh produce

Value addition refers to the process of enhancing the value of a product through various methods and techniques. For small farmer collectives involved in naturally cultivated fresh produce, value addition can play a significant role in increasing their profitability, expanding market opportunities, and creating a competitive advantage. Here are some value addition aspects that small farmer collectives can consider:

1. **Processing & Preservation:** Small farmer collectives can process their naturally cultivated fresh produce into value-added products such as jams, sauces, pickles, dried fruits, frozen items, or canned goods. This not only extends the shelf life of the produce but also opens up new market segments.

2. **Packaging and Branding:** This is detailed out separately.
3. **Certification & Labels:** Obtain certifications for organic, sustainable, or fair-trade practices. These certifications add credibility to the products and appeal to consumers looking for environmentally friendly and socially responsible options.

4. **Market Diversification:** Explore different market channels, such as farmers' markets, speciality stores, online platforms, and restaurants. Diversifying the distribution channels can lead to increased sales and a broader customer base.

5. **Product Differentiation:** Highlight the unique qualities and flavours of the naturally cultivated produce to differentiate it from conventionally grown products. Educate consumers about the benefits of consuming naturally grown food.

6. **Adding Convenience:** Offer pre-cut, pre-washed, or ready-to-eat fresh produce to cater to the convenience-seeking consumer segment. This can be especially appealing to busy urban dwellers.

7. **Value-Added Services:** Provide value-added services like recipe cards, cooking tips, or educational workshops to create a deeper connection with customers and showcase the versatility of the produce.

8. **Collaborations and Partnerships:** Partner with local chefs, restaurants, or food companies to create unique dishes or products using naturally cultivated fresh produce. Such collaborations can enhance brand visibility and credibility.

9. **Export Opportunities:** Explore export opportunities for value-added products in regions where there is a demand for organic and naturally cultivated produce.

Value addition can significantly improve the economic viability of small farmer collectives engaged in naturally cultivated fresh produce. It empowers farmers to capture a larger share of the value chain, create a niche market, and foster long-term customer loyalty. By leveraging these value addition aspects, small farmer collectives can build sustainable businesses while promoting environmentally friendly and socially responsible practices.

D) Packaging

Packaging of value-added products from naturally cultivated produce is a critical aspect of the overall branding and marketing strategy. The packaging should not only protect the product but also reflect the premium nature of value-added offerings and communicate their unique selling points. Here are some key considerations for packaging value-added products:

Premium and Eco-Friendly Materials: Use high-quality and eco-friendly packaging materials to convey the premium nature of the product and align with the values of naturally cultivated produce. Recyclable, biodegradable, or compostable materials can be excellent choices.

Packaging as per Natural farming certification standards using approved Products for Packaging of Organic Foodstuffs can also be recommended for natural foodstuffs.
Paper, wax paper, cold boxes with coating film or inside bag, textile packaging (tested for harmful substances), glass and other methods (clip seals).

1. **Differentiation:** Create packaging that stands out from conventional products on the market. Consider unique shapes, colours, and designs that catch the consumer's eye and convey the product's speciality.
2. **Product Information:** Provide clear and comprehensive information about the value-added product on the packaging. Include the product name, key ingredients, nutritional facts, usage instructions, and any certifications or sustainability credentials.
3. **Story Telling:** Use the packaging as a canvas to tell the story of the small farmer collective and the unique journey of the naturally cultivated produce. Storytelling enhances the emotional connection with consumers.
4. **Brand Identity:** Ensure that the packaging design reinforces the brand identity of the small farmer collective. Use consistent brand colours, fonts, and logos to create a recognizable and cohesive visual presence.
5. **Functional Packaging:** Consider packaging that enhances the convenience and usability of the value-added product. For example, resalable pouches or containers can prolong the shelf life of the product and offer easy storage for consumers
6. **Window Packaging:** For products with appealing visual qualities, consider window packaging that allows consumers to see the product inside. This can enhance the product's appeal and help build trust with customers.

7. **Regulatory Compliances:** Ensure that the packaging complies with all relevant food safety and labelling regulations. Adhere to packaging size requirements, allergen labelling, and other industry-specific regulations.
8. **Batch or Lot information:** Add batch or lot numbers on the packaging to facilitate traceability and quality control. This is especially important for products with limited shelf life or seasonal variations.
9. **Consumer Engagement:** Use packaging as a tool to engage consumers. This could include adding QR codes that lead to the product's webpage, recipes, or information about the farmer collective's practices.
10. **Sustainable Packaging Practices:** Consider implementing sustainable packaging practices throughout the value chain, such as using minimal materials, optimizing packaging sizes to reduce waste, and encouraging consumers to recycle or reuse the packaging.
11. **Packaging Durability:** Ensure that the packaging protects the value-added product during transportation and handling. Fragile products may require additional protective measures.

By paying attention to these packaging considerations, small farmer collectives can elevate the presentation of their value-added products, effectively communicate their brand message, and appeal to consumers seeking premium, sustainable, and naturally cultivated offerings. A thoughtful and attractive packaging design can significantly impact the success of value-added products in the market.

Branding

1. **Brand Name:** Choose a compelling and memorable brand name that reflects the essence of the value-added products and resonates with the target audience.
2. **Logo Design:** Design a visually appealing logo that embodies the natural and organic values of the produce and establishes brand recognition.
3. **Brand Colors and Fonts:** Establish a consistent colour palette and font selection that reinforces the brand identity across all marketing materials, including packaging and promotional materials.

4. **Brand Story:** Craft a captivating brand story that narrates the origin, mission, and values of the small farmer collective. Share this story through packaging, websites, and marketing materials to create an emotional connection with consumers.

By integrating thoughtful packaging design and a compelling branding strategy, small farmer collectives can create a strong market presence for their value-added products of naturally cultivated produce. A well-executed packaging and branding approach can attract loyal customers, drive sales, and ultimately contribute to the success and growth of the brand.

Preservation of naturally cultivated products

Instead of using chemical preservatives, small farmer collectives that focus on naturally cultivated produce may employ various other techniques to extend the shelf life of their products:

1. **Refrigeration and Cold Storage:** Keeping produce at low temperatures helps slow down spoilage and maintain freshness. Many naturally cultivated products are sold in refrigerated sections or stored in cold storage facilities.
2. **Drying and Dehydration:** Drying fruits, vegetables, and herbs removes moisture and inhibits the growth of microorganisms, making the produce less susceptible to spoilage.
3. **Canning and Fermentation:** Freezing fresh produce immediately after harvesting helps retain its nutrients and quality until it reaches the consumers.
4. **Freezing:** Freezing fresh produce immediately after harvesting helps retain its nutrients and quality until it reaches the consumers.
5. **High-Acid and Low pH Foods:** Certain fruits and vegetables have natural acidity that acts as a preservative. Pickling and preserving in vinegar are examples of this preservation technique.
6. **Salt and Sugar:** Salt and sugar are natural preservatives used in certain products, like salted vegetables or fruit preserves.
7. **Harvest Timing:** Harvesting produce at the optimal stage of ripeness ensures that it reaches the market at its peak freshness, reducing the need for preservation.

Proper packaging, such as vacuum-sealing or using airtight containers, can slow down the deterioration of produce by limiting exposure to air and moisture.

Preservation of naturally cultivated produce as per ITKs

Indigenous Traditional Knowledge (ITK) includes a wealth of practices and techniques developed by local communities over generations to preserve and utilize natural resources, including the preservation of agricultural produce. These practices are often rooted in the local ecosystem and take advantage of natural methods to extend the shelf life and nutritional value of produce.

Some common preservation methods from ITKs for naturally cultivated produce:

1. **Sun Drying:** Sun drying is a traditional method of preserving various fruits, vegetables, and herbs. Produce is spread out in the sun until it loses most of its moisture, making it less susceptible to spoilage.
2. **Smoking:** Smoking is used for preserving meat, fish, and certain fruits and vegetables. The smoke acts as a natural preservative and helps protect the produce from insects and bacteria.
3. **Fermentation:** Fermentation is a technique used to preserve foods by promoting the growth of beneficial micro-organisms**:** It is commonly used for preserving some vegetables.
4. **Salt Curing:** Salting is a traditional method for preserving fish, meat, and certain vegetables. Salt draws out moisture from the produce, preventing bacterial growth and spoilage.
5. **Pickling:** Pickling involves preserving produce in a solution of vinegar, salt, and spices. The acidic environment inhibits the growth of spoilage-causing microorganisms.
6. **Root Cellars:** Root cellars are cool and dark storage areas used to preserve root vegetables, tubers, and fruits. The stable temperature and humidity slow down spoilage and maintain freshness.
7. **Herbal Preservatives:** Some ITKs involve using specific herbs with natural preservative properties to extend the shelf life of produce.
8. **Covering with Ash or Sand:** In some cultures, produce like root vegetables or fruits are stored by burying them in ash or sand, providing protection and insulation against spoilage.
9. **Honey and Syrup preservatives:** Coating certain fruits in honey or syrup can preserve them while also adding sweetness.

10. **Oil Preservatives:** Storing produce submerged in oil can prevent spoilage and infuse flavours.
11. **Use of Natural Antimicrobial Agents:** Some ITKs use natural antimicrobial agents, such as garlic, ginger, or neem leaves, to protect produce from spoilage.

It's important to note that while ITKs can offer valuable insights into traditional preservation methods, it's also essential to ensure food safety and hygiene standards are met. Combining these traditional preservation practices with modern food safety guidelines can help small farmer collectives preserve naturally cultivated produce in a sustainable and safe manner for market sale.

Different types of Marketing Strategies

a) **Offline Marketing**

1. **Canopies:**
    - Set up canopies or pop-up stalls in high-traffic areas, such as local fairs, festivals, community events, and public gatherings.
    - Create an inviting display showcasing the naturally cultivated fresh produce. Use banners, posters, and product samples to attract attention
    - Engage with potential customers by offering product tastings, sharing information about farming practices, and answering their questions.
    - Provide promotional materials like brochures or flyers with details about the FPO, their produce, and contact information.

2. **Captive Outlets:**
    - Establish captive outlets at strategic locations like transportation hubs, tourist spots, or recreational areas where there is a steady flow of people.
    - Ensure that the outlets are well-branded and visually appealing to capture the interest of passersby.
    - Offer a diverse range of naturally cultivated produce, including seasonal offerings, to cater to the varying demands of customers.
    - Implement regular quality checks and ensure a consistent supply of fresh produce.

3. **Shops at Vantage Points and Reputed Market Locations:**
    - Partner with existing shops or retail outlets at vantage points and renowned market locations to display and sell naturally cultivated produce.
    - Ensure that the packaging and labelling of the products are attractive and convey the FPO's branding and story effectively.
    - Train the shopkeepers or staff to educate customers about the benefits of naturally cultivated produce and the practices of the FPO.
    - Exclusive deals or promotions to incentivize customers to purchase the products.

4. **Visual Merchandising:**
    - Utilize effective visual merchandising techniques to make the produce display visually appealing and draw the attention of customers.
    - Use natural elements like wooden crates or baskets to enhance the natural and organic appeal of the fresh produce

5. **Sampling and Product Demos:**
    - Conduct product sampling and demos regularly to allow customers to taste the freshness and quality of the produce.
    - Engage customers by demonstrating how naturally cultivated produce can be used in different recipes and dishes.

6. **Seasonal Marketing**
    - Tailor the marketing strategies to highlight the seasonal produce and create a sense of urgency and excitement around the limited-time offerings

7. **Customer Loyalty Programs:**
    - Implement customer loyalty programs to encourage repeat purchases and reward regular customers.

8. **Collaborations and Partnerships.**
    - Collaborate with local chefs, restaurants, or hotels to feature the naturally cultivated produce in their menus and dishes.

The offline platform for marketing naturally cultivated fresh produce of Farmer Producer Organizations (FPOs) through offline platforms, such as canopies, captive outlets, and shops at vantage points and reputed market locations can be an effective way to directly connect with consumers and promote the unique qualities of the produce.

1. **Farmers' Markets and Local Events:** Participate in farmers' markets and local community events to directly engage with consumers, offer samples, and share information about your naturally cultivated produce and products.
2. **In-Store Promotions:** Work with retailers to conduct in-store promotions, such as product tastings or demos, to attract customers and showcase the unique qualities of your produce.
3. **Flyers and Brochures:** Distribute flyers and brochures at local grocery stores, community centres, and events to inform consumers about your naturally cultivated produce and products.
4. **Word-of-Mouth Marketing:** Encourage satisfied customers to spread the word about your products through word-of-mouth marketing. Positive reviews and recommendations from happy customers can significantly impact brand reputation.
5. **Collaborations with Restaurants and Chefs:** Partner with local restaurants and chefs to feature your produce in their dishes, creating a buzz around your brand and enticing more consumers to try your products.
6. **Community Outreach:** Engage with the local community by organizing workshops, seminars, or farm visits to educate people about the benefits of naturally cultivated produce.
7. **Local Media Coverage:** Reach out to local newspapers, radio stations, and community publications to share your brand's story and promote your products.

b) **Online Marketing**

Establishing Online e-commerce platforms for marketing naturally cultivated fresh produce of farmers or Farmer Producer Organizations (FPOs) can be a powerful way to reach wider consumers and facilitate direct sales. The steps to set up such an e-commerce platform are described later. The following are the onine marketing strategies:

1. **Market Research:** Conduct market research to understand the target audience, demand for naturally cultivated produce, and potential competitors in the online marketplace.

2. **Choose the e-commerce Platforms:** Select a suitable e-commerce platform that aligns with your needs and budget. Popular options include Shopify, Woo-Commerce, Big Commerce, Magento, & Market Mirchi etc.
3. **Professional Website:** Create a user-friendly and visually appealing website that showcases your naturally cultivated produce and products. Include information about the farming practices, product range, and purchasing options.
4. **Domain and Hosting:** Purchase a domain name that reflects your brand and the type of products offered. Secure reliable hosting to ensure the website's performance and security.
5. **Website Design and Development:** Design an attractive and user-friendly website that showcases the naturally cultivated produce, highlights the FPOs' unique selling points, and provides essential product information.
6. **Product Catalogue:** Create a comprehensive product catalogue with high-quality images, detailed descriptions, and pricing information for each type of naturally cultivated produce available.
7. **Seasonal Offers and Discounts:** Offer seasonal promotions and discounts to attract customers and encourage repeat purchases.
8. **Sustainable Packaging:** Highlight your commitment to sustainability by using eco-friendly packaging materials for shipping the products.
9. **Online Payment and Security:** Set up secure online payment gateways to allow customers to make purchases easily and safely. Consider SSL certificates for enhanced security.
10. **Shipping and Delivery Options:** Implement a shipping system that calculates shipping costs based on location and provides multiple delivery options for customers to choose from.
11. **Order Management:** Set up an efficient order management system to track orders, manage inventory, and process shipments promptly.
12. **Customer Support:** Offer multiple channels for customer support, such as live chat, email, or phone, to address any inquiries or concerns.
13. **Legal and Regulatory Compliance:** Ensure compliance with all relevant laws and regulations related to e-commerce, food safety, and data protection.

14. **Continuous Improvement:** Regularly gather feedback from customers and monitor website performance to identify areas for improvement and make necessary adjustments.
15. **Social Media Marketing:** Leverage social media platforms like Facebook, Instagram, Twitter, and LinkedIn to share product updates, farm stories, and engage with your audience.
16. **Content Marketing:** Write blog posts and create informative content related to organic farming, sustainable agriculture, and the health benefits of naturally cultivated produce.
17. **Email Marketing:** Build an email subscriber list and regularly send out newsletters with product updates, seasonal offers, and valuable content to keep customers informed and engaged.
18. **Digital Advertising:** Invest in online advertising through platforms like Google Ads or social media ads to promote your products to a targeted audience.
19. **Video Content:** Create engaging videos showcasing your farm, production process, and product usage to connect with consumers on a deeper level.
20. **Customer Reviews and Testimonials:** Encourage customers to leave reviews and testimonials on your website or social media pages to build trust and credibility.
21. **Search Engine Optimization (SEO):** Optimize your website and content for relevant keywords to improve visibility on search engines and drive organic traffic.
22. **Partnerships with Influencers:** Collaborate with influencers or bloggers in the food and health niche to feature your products in their content.

By setting up a well-designed and user-friendly e-commerce platform, FPOs can expand their market reach, connect directly with consumers, and promote the benefits of naturally cultivated fresh produce.

Addendum (From NCONF Training Manual)

The following are the approaches for marketing strategies for Natural Farming Produces.

Some have been around for decades others have been developed more recently.

1. Marketing strategies at Farmers' level
2. Community Supported Agriculture (CSA)

3. Subscription base marketing.
4. Farmers Markets
5. U-Pick farms
6. Farm Stands, Restaurants
7. Farm to School and Institutions
8. Agritourism
9. Natural Seed Bank.
10. Online Marketing

1. Marketing Strategies at Farmers' Level

Farmers should record their presence in society by using social media platforms like Facebook, WhatsApp, Telegram and YouTube etc.

In this social media platform farmer should post their daily farming, activities in particular sowing, input preparation, harvest and post-harvest. This will help to popularize their farm produce. It also increases credibility and authenticity amongst their group members and supposed customers. When the group member sees the farm work on social media it will be converted in to customer base.

2. Community Supported Agriculture

Community Supported Agriculture (CSA) is a relatively recent and innovative concept that is intended to create a relationship between farmers and consumers, wherein risks and bounties are shared. CSA customers buy shares for a season by paying a fee in advance. In return, they receive regular (in most cases weekly) supplies. Having cash in advance of the growing season and a regular customer following provides financial security for farmers. The regular supply of food directly from the farm provides nutritional security and a sense of community for customers. On some farms, get-togethers with customers or workdays are part of the agreement. In its purest form, customers share in the risk of low production and crop failures, as well as any abundance, by receiving less or more food. This aspect has seen a variety of adaptations on CSA farms. Operating a CSA requires excellent crop management skills to provide attractive and diverse weekly food baskets, as well as good customer service. CSA can be integrated with farmers' market sales and other techniques. It has been an excellent start-up strategy for many small organic farms, providing

crucial cash flow at the beginning of the growing season and allowing farmers to "boot strap" their way into farming.

CSA can be implemented in the following way.

- Traditional single farm models,
- Cooperatives/ multi-farm CSAs,
- Low-income consumer-targeted CSAs,
- Multi-farm innovations targeting unique consumer segments with a health and wellness marketing partner,
- CSAs associated with urban market innovations, and

  Food hub concept with CSA aggregation and distribution model. Farmers who have adapted and innovated to reach growing local market demand have found numerous ways to adapt the CSA subscription model in a way that fits their goals and unique market conditions. The model is highly flexible to accommodate a variety of products produce, meat, dairy, eggs, as well as value-added and processed products coming from the farm.

3. Subscription Base Model for Natural Farming

The subscription based model is similar to CSA, but the only difference is farmers need to take care of the continuous supply of fruits and vegetables without break. This model provides financial security to farmers in advance, and the subscribed customers get regular produce from natural farms.

4. Farmer's Markets

A farmers' market is a place where a number of growers assemble on a particular day to sell farm products directly to consumers. The sites are often parking lots, streets closed during the market, parks, etc. Farmers at these markets sell their products from "stands" that may consist of the back of a farm truck or a simple tabletop to elaborate and attractive covered displays, 'canopies', etc. Farmers generally receive retail prices or higher for their products. Start-up costs for becoming involved in a farmers' market can be very inexpensive-like stall fee in some instances. Because of the low start up investment, farmers' markets can provide a low risk setting for new farmers or an opportunity to try out new products. Many farmers participate in more than one market to increase their sales. Farmers' markets also

provide the opportunity to build a customer base. Some farms advertise other outlets for buying their products.

Farmers can create a natural farming farmers market where they all gather and sell their produce and also process food. For example, Juhu Organic Market, Mumbai.

Ima Keithel (Mother's Market), also known as Women's Market is a market run exclusively by women in Imphal, India. It is a commercial center and a popular tourist attraction in the state of Manipur and is currently located in Khawairaband Bazaar. Developing markets like this all over India, will help in women empowerment and strengthen the women farmer condition.

5. U-PICK Farms

U-Pick or Pick-Your-Own farms grow crops specifically to be harvested by customers. In this manner, the task of picking the crop, one of the major costs of growing fruits and vegetables, is passed on to customers. There continues to be an interest by families in picking produce for fresh use and, in some instances, having their children experience where their food comes from. U-Pick operations can be blended with other marketing techniques such as roadside markets, farmers' markets, etc. U-pick operations serve as an alternative selling method that supplements other marketing strategies. Such strategies defiantly help natural farming farmers to grow their income and to find new consumers. The Farm, Bannerghatta Road. Bangalore, Karnataka, is one example of such marketing.

6. Farm Stands, Restaurants

Farm stands or markets are structures of some type from which the farm products are sold. They tend to be located on the farm, often on a well-travelled road with good access and parking. They can operate seasonally or all year and focus on one product or a full line of products. Roadside markets usually charge near retail prices. Given that farm stands or markets are structures, they are subject to local building codes and highway setback regulations.

Many farms are now marketing directly to restaurants providing the specific products and the high quality that chefs are demanding. Many restaurants cultivate relationships with farms even noting the farm name and its product on their menu. These restaurants serve a

niche of customers who find high quality food produced locally appealing. Supporting local farms is a philosophical goal for these restaurants. Similar opportunities for farm direct sales are to institutions that serve food to large or "captive" groups such as: Hospitals Retirement and nursing facilities. **Om Made Cafe** is an example where farmers sell their natural farm products.

6. Farm to School and Institutions

This provides farmers, school administrators, and institutional food-service planners with contact information and descriptions of existing programs that have made connections between local farmers and local school lunchrooms, college dining halls, or cafeterias in other institutions. To help communities initiate similar programs, this publication includes resource lists of publications on how to initiate and manage local food programs, funding and technical assistance sources, and provisions of the 2002 Farm Bill that support farm-to-school and other community food programs.

Farm to School programs is popping up all over the world and same can be implemented in India. These programs connect schools with local farms with the objectives of serving healthy meals in school cafeterias, improving student nutrition, providing health and nutrition education opportunities that will last a lifetime, and supporting local small farmers. Unlike other guides, this one focuses on agricultural practices, because these practices are inseparable from nutrition and sustainability. This guide establishes the best and worst practices in the field. It provides a list of questions you need to ask to get the very best product for your institution. It also offers helpful hints, so that you can learn from work that has been done.

7. Agri-tourism

Agri-tourism appeals to customers who have a desire to visit a farm and experience its activities. As urban families are loosing ties with agriculture, many are interested in maintaining some sort of contact with farming, especially for their children. This is a theme with most types of direct marketing and is also a key feature of agri-tourism. The concept of Agri tourism is very simple, whereby the urban tourists go the farmers home; stay like farmer, engage in farming activities, experience the bullock cart, tractor ride, eat authentic food, wear traditional clothes, understand the local culture, enjoy the folk songs and dance, buy fresh farm produce. The sells his farm produce at a better price and earns a livelihood all

year round. Agri-tourism and entertainment techniques can work in both urbanized areas and very rural areas. As with many direct marketing techniques, people skills are crucial. Maharashtra and Karnataka are the pioneers in agri-tourism. Green path, Bangalore is an example in this aspect.

8. Move from *1-To-Many* to *1-To-1 Marketing*

The old approach to advertising (general ads placed in newspapers, directories, radio, TV etc.) spreads one message to many consumers. Combining traditional methods for quick buys don't require any real investment or thought. One-to-one relationship building digital marketing methods for bigger purchases can be a winning formula. Natural farmers must do more to position themselves as competitive alternatives to traditional food providers.

Health & Nutrition

21. HEALTH AND NUTRITION

The holistic concept of health is contained in the expression of wholeness. Health is a relative state in which one is able to function well physically, mentally, socially, and spiritually to express the full range of one's unique potentialities within the environment in which one lives.

As per WHO health is "a state of complete physical, mental and social well-being and not merely the absence of disease and infirmity". Good health helps people live a full life. Health is a state that allows the individual to adequately cope with all demands of daily life. Health is a state of balance, an equilibrium that an individual has established within oneself and between oneself and the social and physical environment.

The concept of health as a balance between a person and the environment, the unity of soul and body, and the natural origin of disease, was the backbone of the perception of health in ancient civilisations. All modern concepts of health recognize health as more than the absence of disease, implying a maximum capacity of the individual for self-realization and self-fulfilment.

Environmental health examines the interaction between the environment and our health.Environment can be defined as a sum total of all the living and non-living elements and their effects that influence human life. We rely on forests, rivers, oceans and soils for numerous goods and services for our health, happiness and prosperity. A healthy environment means a healthy human.

Clean air, stable climate, adequate water, sanitation and hygiene, safe use of chemicals, protection from radiation, healthy and safe workplaces, sound agricultural practices, health-supportive cities and built environments, and a preserved nature are all prerequisites for good health.

Global Health includes chemical pollution, air pollution, climate change, disease-causing microbes, lack of access to health care, poor infrastructure, and poor water quality. Climate change is impacting human lives and health in a variety of ways**.** It threatens the essential ingredients of good health.

Why Environmental health is Important

All Living organisms draw all energy from environment for their survival and growth. FOOD, WATER and the AIR we breathe comes from the environment. This Body depends on the environment for its survival hence the environmental health is of utmost importance.

Land, water, air, space are contaminated due to the food production systems, our life style – heavy use of chemicals, burning fossil fuels, free flow of affluents from our industries in to the rivers, oil spills in our oceans, mindless dumping of garbage in to landfills, indiscipline in disposing of plastic. This is choking life on earth, air and water.

Agriculture is one of the main activities in our country, it contributes to 14% of GDP and 70% of our population is engaged in agriculture. Agriculture is also a major water guzzler making a large drain on the natural resources.

The current **food production** system with usage of heavy dose of chemicals is causing a direct loss of bio diversity in and above the soil.

Cocktail of chemicals used to store, process, add value, preserve and extend the shelf life of the products are taking a toll on the health and impacting the environment too.

What we eat is what we are – Jaisa Ann vaisa Mann…

Energy comes from food. Plants manufacture their food by harnessing the solar energy. Grains, fruits seeds form food for multitude of creatures on this planet earth. Balanced, nutritive food begets a healthy and energetic body, a happy mind and a happy society in general. Our dependence on the environment for our existence is enormous and our environment depends on the inhabitants.

Our seas and oceans are defiled and contaminated, our skies are contaminated. ANNAM – food which is regarded as sacred is contaminated. Farmer the Annadata produces contaminated food, the trader sells contaminated food and the lady at home cooks and serves this poisonous food. We are unaware of the food that we are eating, whether it is chemically laden food, genetically modified food, organic or naturally produced. This cluelessness is responsible for a host of physical and mental diseases that we are experiencing today.

Food miles and ultra-processed food

Food miles is the distance the food travels to reach our plates - the distance food travels from where it is grown to where it is ultimately purchased or consumed by the end user. Fewer food miles help to create a more sustainable chain, protecting the future of our economy, energy efficiency and planet. These “food miles” are responsible for about 6% of the world's greenhouse gas emissions. Instead of heading to a big supermarket for your next food shopping, try getting your food from a local independent store, a farm shop, or a farmers market. These outlets tend to supply food from local farms, which means they won't have to travel very far.

Transporting food is a fuel-guzzling process. The use of fossil fuels generates large quantities of carbon dioxide, a heat-trapping greenhouse gas, that warms our atmosphere. Simply put, the more food we transport, the more greenhouse gases we emit.

Eight ways to reduce food miles

1) Buy local
2) Shop at farmers markets
3) Grow your own vegetables
4) Eat seasonally
5) Pick your own
6) Learn to cook from scratch
7) Walk or cycle to the shop
8) Shop less frequently

For those of us concerned about our carbon 'footprint', trying to eat foods with fewer food miles on the clock can be a useful thing to do.

Buying food items like grains and flour, which have a longer shelf life in large quantities not only reduces the food miles but also reduces the time and energy spent on frequent shopping.

“Food-miles emissions are driven by the affluent world,” a study says. It finds that while “high income nations” represent only about 12.5% of the world’s population, they are responsible for 52% of international food miles and 46% of the associated emissions. Food

miles also includes emissions from transporting fertilisers, machinery and animal feed as well as the more obvious shipping and vehicle emissions from sending food products around the world.

The current global food system requires food and related equipment to be transported a total of 22 trillion "tonne-kilometres" per year, This drives 3 billion tonnes of CO2 equivalent (CO2e), accounting for almost one-fifth of total food system emissions. Studies also indicates that the "cold chain" of keeping food in a temperature-controlled environment throughout transit and sales accounts for 5% of global food system emissions. Recent studies have shown that this distance has been steadily increasing over the last 50 years. Studies estimate that processed food in the United States travels over 1,300 miles, and fresh produce travels over 1,500 miles, before being consumed. Reducing the energy intensiveness of our food has several economic, social and environmental benefits.

- Enjoy fresher, healthier food
- Support local farmers
- Keep their money in the community
- Know where their food comes from
- Reduce their carbon footprint

Ultra-Processed food

Some foods are highly or ultra-processed. They most likely have many added ingredients such as sugar, salt, fat, and artificial colors or preservatives. Ultra-processed foods are made mostly from substances such as fats, starches, added sugars, and hydrogenated fats. They may also contain additives like artificial colors and flavors or stabilizers. Examples of these foods are frozen meals, soft drinks, hot dogs and cold cuts, fast food, packaged cookies, cakes, and salty snacks.

Ultra-processed foods include ice cream, ham, sausages, crisps, mass-produced bread, breakfast cereals, biscuits, carbonated drinks, fruit-flavoured yogurts, instant soups, and some alcoholic drinks.

Ultra-processed foods are packaged foods that have been made by food companies using many manufactured ingredients. But in Natural Farming they maintain the integrity or nutritional content of the original foods.

Unprocessed or minimally processed foods are whole foods in which the vitamins and nutrients are still intact. The food is in its natural (or nearly natural) state. These foods may be minimally altered by removal of inedible parts, drying, crushing, roasting, boiling, freezing, or pasteurization, to make them suitable to store and make them safe for consumption. Unprocessed or minimally processed foods would include carrots, apples, raw chicken, melon, and raw, unsalted nuts.

Whenever possible, try to avoid or limit ultra-processed foods. Consider the examples in this table to help you quickly determine if a food is minimally processed, processed, or ultra-processed

Minimally Processed	Processed	Ultra- processed
Corn	Canned corn	Corn chips
Apple	Apple juice	Apple pie
Potato	Baked potato	French fries
Carrot	Carrot juice	Carrot cake
Wheat	Flour	Cookies

Ultra-processed foods are linked to more greenhouse gases than other food groups, creates greenhouse gases that trap the sun's heat and contribute to climate change. About a third of all human-caused greenhouse gas emissions is linked to food.

Packaging waste is responsible for polluting our climate, blocking our drains and potentially harming wildlife when it ends up in our oceans and rivers. When plastics are left to degrade in the environment, they emit several greenhouse gases, such as methane and ethylene. Once released, these gas emissions can be toxic and have adverse effects on the environment and human health.

Often referred to as convenience or pre-prepared foods, processed foods are suggested to be a contributor to the obesity epidemic and rising prevalence of chronic diseases like heart disease and diabetes.

Advantages and disadvantages of processed food:

Advantages	Disadvantages
Improved microbial food safety and increased shelf life	Excess fat, sugar, and salt
Removal of pesticides and toxins (e.g., aflatoxin)	Inclusion of additives with unclear health implications
Decrease of toxin formation (e.g., acrylamide)	Leaching of chemical contaminants

In comparison to processed food, unprocessed and freshly cooked food contains all the essential nutrients and vitamins, and are free of additives and preservatives that can cause things like Insulin resistance, diabetes, obesity.

Carbon neutral food

For carbon neutral food, we calculate the carbon emissions throughout the life cycle of the product. This includes emissions caused by raw materials, production, distribution, processing and packaging of the product plus end-of-life.

A diet rich in peas, pulses and nuts can be incredibly low-carbon. Producing 100g of protein from peas emits almost 90 times less than getting the same amount of protein from beef.

Carbon neutral refers to offsetting carbon emissions by implementing practices that remove carbon from the atmosphere. The result is net-neutral carbon emissions. This makes it clear that food plays a big role in climate change.

Creating a sustainable lifestyle means rethinking our way of living, what we consume, how we buy and being aware of the personal energy we use for transportation and in the home,

and taking steps to reduce that energy use. It's thinking about the products we purchase and their impact on our health as well as the environment. It's giving consideration to waste produce and considering how it may be reduced, recycled or reused.

Nutrition

It is the process of providing or obtaining the food necessary for health and growth. There are more than 40 different kinds of nutrients in food and they can be classified into the following 7 major groups:

- Carbohydrates
- Proteins
- Fats
- Vitamins
- Minerals
- Dietary fibre
- Water

Why Nutrition is required?

Proper nutrition helps keep energy levels up and protects against many age-related illnesses and diseases like heart disease, cancer, and diabetes. Malnutrition is a global problem

Do we have nutrition in our food?

Millions of people are suffering from different forms of malnutrition. In fact, 1.9 billion adults are overweight or obese while 462 million are underweight. Among children, 52 million under-fives are suffering from wasting, where they have a low weight for height.

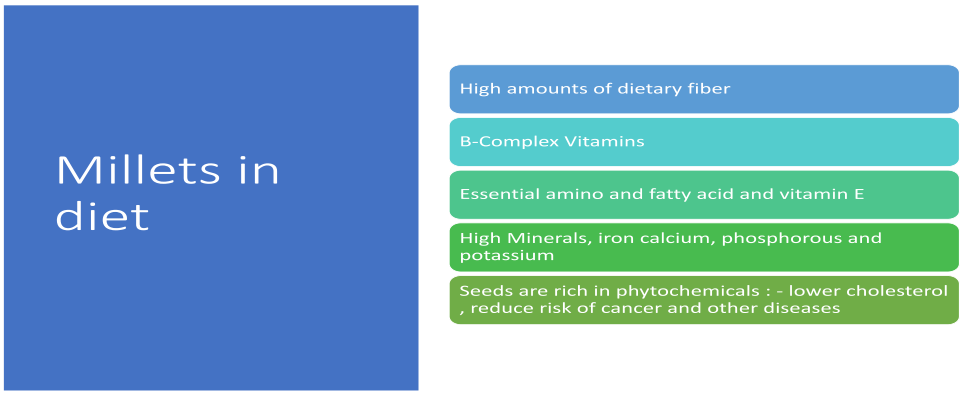
Rising carbondioxide levels in the atmosphere are also undercutting the nutritiousness of our foods. An average Indian is having 15% more chemicals in their food than an average American. Our daily food that we eat is a cocktail of chemicals.

Farmer's ignorance leads to enormous health hazards. Out of their ignorance farmers spray a lot of pesticides more than the prescribed dosage. Consumer eats chemically laden food which is highly carcinogenic in nature. Milk supplied is also laden with hormonew like bST Bovine Somatotropin.

The one and only solution to all the problems is Natural farming, sustainable, eco-friendly, integrating farm with farm animals and following the principals of agroecological practices.

Chemical free Natural farming helps reduce public health risks. Mounting evidence shows that food grown organically are rich in nutrients, such as Vitamin C, iron, magnesium, and phosphorus, and with no exposure to nitrates and pesticide residues.

Millets are easily grown in natural farming systems and provide essential nutrients for healthy living.



Nutrients for optimal immune functions

Vitamins A, E and D - the three fat soluble vitamins; C & B vitamins, and minerals such as zinc, selenium, iron, copper etc. and phytonutrients, amino acids, fatty acids are necessary for optimal immune function (to prevent establishment of viral infection) and immune regulation (to check uncontrolled proliferation of immune cells that may cause more harm than good to the body).

These nutrients are critical for the function of T cells, B cells, killer cells, macrophages, neutrophils/ granulocytes that are involved in the killing and elimination of infectious microbes.

In addition, there are many other immune related functions that are carried out by these nutrients and phytonutrients. For instance, vitamin A maintains structure and function of the mucosal epithelial cells of the respiratory tract and enhances mucosal immunity (critical for prevention of respiratory infection). Vitamin E, beta-carotene, vitamins C & B, Zinc, Selenium act as potent antioxidants and reduce oxidative stress in the body.

It is prudent to obtain these nutrients through a good balanced diet. In addition to the nutrition an individual should also follow a regular daily routine – eating, exercise, balancing work and life skilfully to have a balance physical, mental and emotional health that should enable one to live up to his/her potential.

Ecosystem services

22. ECOSYSTEM SERVICES

An ecosystem is a group or community composed of living and non-living things and their interactions with each other. It is a dynamic complex of biotic components and abiotic components. These biotic and abiotic interactions maintain equilibrium in the ecosystem. We as humans are an integral part of it. The numerous benefits we obtain from the ecosystem are known by the term ecosystem services.

The earth is home to millions of species. Every organism depends on one or another organism for energy, survival, and other life processes. This dependence of organisms on one another and their surroundings forge an interacting system called ecosystems. The interactions among different components of ecosystems are fundamental to a well-defined environment.

As a part of an ecosystem, humans derive lots of benefits from the biotic and abiotic components. These benefits are collectively termed as ecosystem services. Life and biodiversity on earth depend on these services. For example, Wetlands provide fresh, clean water, regulate pollution, and reduce climate risk and uncertainty for people, agriculture and aquaculture (fisheries). They are also hotbeds of biodiversity and are home to a vast range of animals, especially bird species.

Some examples of ecosystems are:

1. **Deciduous forest ecosystem**- A deciduous forest is characterised by trees that shed their leaves annually and renew them at the beginning of the next growing season. They shed leaves as an adaptation to the cold season in temperate climates or the dry seasons in subtropical and tropical climates.

2. **Savannah ecosystem**- Savannah ecosystems combine woodland and grassland elements. Light can penetrate and reach the ground thanks to the widely spaced, scattered canopy trees. As a result, grass-dominated shrubs and herbaceous strata are able to develop abundantly as well.

3. **Coral reef ecosystem**- The coral reef is an ecosystem formed by corals that build reefs. Coral reefs are groups of coral polyps, such as stony corals, that live together in

colonies. They are one of the world's most diversified ecosystems. As a result, they're known as the sea's rainforests.

4. **Hot spring ecosystem**- A hot spring is one with water temperatures that are higher than the ambient temperature. The water from the spring is geothermally heated, meaning it is heated by the earth's mantle.

5. **Micro-ecosystems**- Micro-ecosystems are ecosystems that are confined to small or microscopic spaces yet are determined by unique environmental conditions. Consider the environment of a tree. A tree produces a miniature ecosystem that is home to a variety of species. Lichens and other epiphytes, for example, may be found on a tree (arboreal plant)

Ecosystem services are classified into four types:

Provisioning Services

This includes the products/raw materials or energy outputs like food, water, medicines and other resources from ecosystems. Ecosystems are a source of food, water, medicines, wood, biofuels, etc. Also, they provide conditions for these resources to grow.

Regulating Services

This includes the services which regulate the ecological balance. For example, terrestrial environments like forests purify and regulate air quality, prevent soil erosion, and control greenhouse gasses. Biotic components such as birds, rats, frogs, act as natural controllers and thus help in pest and disease control. Hence, ecosystems act as regulators.

Supporting services

Supporting services form the basis for other services. They provide habitat for different life forms, retain biodiversity, nutrient cycling, and other services for supporting life on the earth.

Cultural services

It includes tourism; provides recreational, aesthetic, cultural and spiritual services, etc. Most natural elements such as landscapes, mountains, caves, are used as a place for cultural and artistic purposes. Even a few of them are considered sacred. Moreover, ecosystems provide enormous economic benefits in the name of tourism.

Agricultural ecosystems

Provide humans with food, forage, bioenergy and pharmaceuticals and are essential to human wellbeing. These systems rely on ecosystem services provided by natural ecosystems, including pollination, biological pest control, maintenance of soil structure and fertility, nutrient cycling and hydrological services. Preliminary assessments indicate that the value of these ecosystem services to agriculture is enormous and often underappreciated.

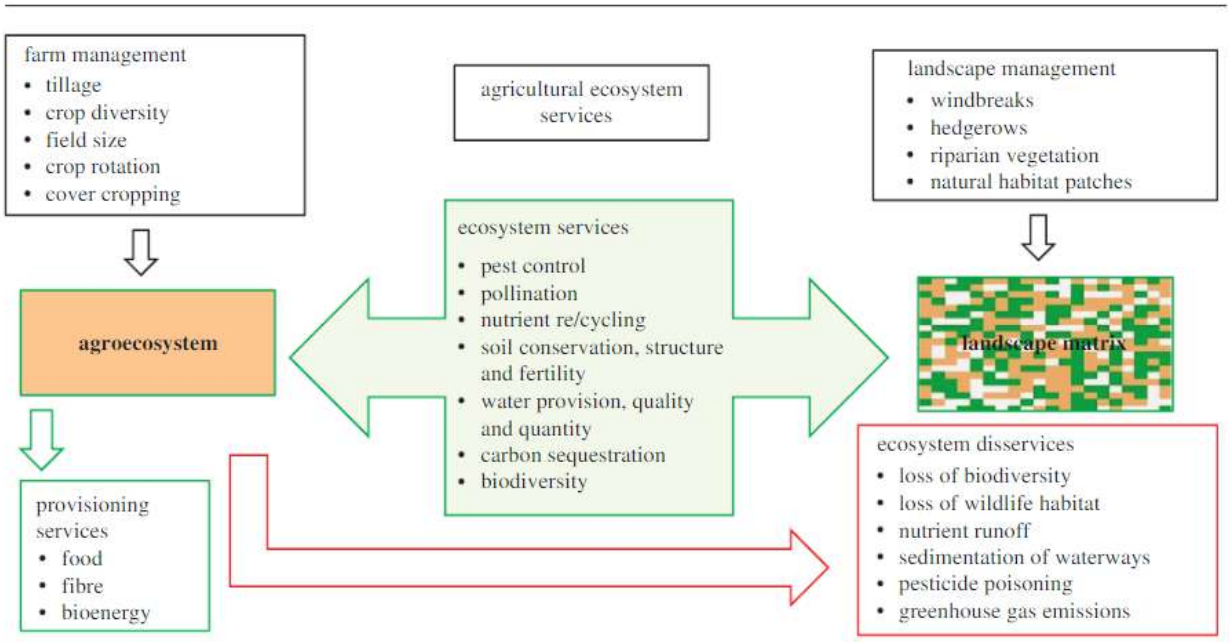
Agroecosystems also produce a variety of ecosystem services, such as regulation of soil and water quality, carbon sequestration, support for biodiversity and cultural services. Depending on management practices, agriculture can also be the source of numerous disservices, including loss of wildlife habitat, nutrient runoff, sedimentation of waterways, greenhouse gas emissions, and pesticide poisoning of humans and non-target species. The tradeoffs that may occur between provisioning services and other ecosystem services and disservices should be evaluated in terms of spatial scale, temporal scale and reversibility. As more effective methods for valuing ecosystem services become available, the potential for 'win-win' scenarios increases. Under all scenarios, appropriate agricultural management practices are critical to realizing the benefits of ecosystem services and reducing disservices from agricultural activities.

Supporting services include genetic biodiversity for use in breeding crops and livestock, Soil formation and structure, soil fertility, nutrient cycling and the provision of water. Regulating services may be provided to agriculture by pollinators and natural enemies that move into agroecosystems from natural vegetation. Natural ecosystems may also purify water and regulate its flow into agricultural systems, providing sufficient quantities at the appropriate time for plant growth.

Traditionally, agroecosystems have been considered primarily as sources of provisioning services, but more recently their contributions to other types of ecosystem services have been recognized. Influenced by human management, ecosystem processes within agricultural systems can provide services that support the provisioning services, including pollination, pest control, genetic diversity for future agricultural use, soil retention, regulation of soil fertility and nutrient cycling. Whether any particular agricultural system provides such services in support provisioning depends on management, and management is influenced by the balance between short-term and long-term benefits.

Management practices also influence the potential for 'disservices' from agriculture, including loss of habitat for conserving biodiversity, nutrient runoff, sedimentation of waterways, and pesticide poisoning of humans and non-target species. Since agricultural practices can harm bio- diversity through multiple pathways, agriculture is often considered anathema to conservation. However, appropriate management can ameliorate many of the negative impacts of agriculture, while largely maintaining provisioning services.

Impacts of farm management and landscape management on the flow of ecosystem services and disservices to and from agroecosystems



Source - https://www.researchgate.net/publication/45659710_Ecosystem_services_and_agriculture_tradeoffs_and_synergies_Philos_Trans_R_Soc_B_Biol_Sci

ECOSYSTEM SERVICES FLOWING TO AGRICULTURE

The production of agricultural goods is highly dependent on the services provided by neighbouring natural ecosystems, but only recently have there been attempts to estimate the value of many of those services to agricultural enterprises. Some services are more easily quantified than others, to the extent that they are essential to crop production or they substitute directly for purchased inputs.

(a)Biological pest control

Biological control of pest insects in agroecosystems is an important ecosystem service that is often supported by natural ecosystems. Non-crop habitats provide the habitat and diverse food resources required for arthropod predators and parasitoids, insectivorous birds and bats, and microbial pathogens that act as natural enemies to agricultural pests and provide biological control services in agro ecosystems. These biological control services can reduce populations of pest insects and weeds in agriculture, thereby reducing the need for pesticides. Because the ecosystem services provided by natural enemies can substitute directly for insecticides and crop losses to pests can often be measured, the economic value of these services is more easily estimated than many other services.

(b)Pollination

Pollination is another important ecosystem service to agriculture that is provided by natural habitats in agricultural landscapes. Approximately 65 per cent of plant species require pollination by animals, and an analysis of data from 200 countries indicated that 75 per cent of crop species of global significance for food production rely on animal pollination, primarily by insects. Of the most important animal-pollinated crops, over 40 per cent depend on wild pollinators, often in addition to domesticated honeybees. Only 35–40% of the total volume of food crop production comes from animal-pollinated crops, however, since cereal crops typically do not depend on animal pollination. Based on data from the United Nations Food and Agriculture Organization (FAO) on the production of 87 globally important crops during 1961–2006 it is estimated that the consequences of a complete loss of pollinators for total global agricultural production would be a reduction of 3–8%. The percentage increase in total cultivated area that would be required to compensate for the decrease in production was much higher, particularly in the developing world where agriculture is more pollinator-dependent.

Like biological control, pollination services are more readily quantified than many other services. Early estimates of the value of pollination services were based on the total value of animal-pollinated crops, but recent estimates have been more nuanced. Since most crops are only partly dependent on animal pollination, a dependence ratio or a measure of the proportion reduction in production in the absence of pollinators can provide a better approximation of production losses in the absence of pollinators. Clearly, these estimates are

also fairly crude and intended to provide a broad brush assessment of potential economic benefits.

(c)Water quantity and quality

The provision of sufficient quantities of clean water is an essential ecological service provided to agroecosystems, and agriculture accounts for about 70 per cent of global water use. Perennial vegetation in natural ecosystems such as forests can regulate the capture, infiltration, retention and flow of water across the landscape.

Water availability in agroecosystems depends not only on infiltration and flow, but also on soil moisture retention, another type of ecosystem service. While the supply of surface water and groundwater ('blue water') inputs to agriculture through irrigation are indispensable in some parts of the world, 80 percent of agricultural water use comes from rainfall stored in soil moisture ('green water'). Water storage in soil is regulated by plant cover, soil organic matter and the soil biotic community (bacteria, fungi, earthworms, etc.). Trapping of sediments and erosion are controlled by the architecture of plants at or below the soil surface, the amount of surface litter and litter decomposition rate. Invertebrates that move between the soil and litter layer influence water movement within soil, as well as the relative amounts of infiltration and runoff. These soil processes provide essential ecosystem services to agriculture.

(d)Soil structure and fertility

Soil structure and fertility provide essential ecosystem services to agroecosystems. Well-aerated soils with abundant organic matter are fundamental to nutrient acquisition by crops, as well as water retention. Soil pore structure, soil aggregation and decomposition of organic matter are influenced by the activities of bacteria, fungi and macrofauna, such as earthworms, termites and other invertebrates.

Micro-organisms mediate nutrient availability through decomposition of detritus and plant residues and through nitrogen fixation. Agricultural management practices that degrade soil structure and soil microbial communities include mechanical ploughing, cultivating and harvesting, but management practices can also protect the soil and reduce erosion and runoff. Conservation tillage and other soil conservation measures can maintain soil fertility by minimizing the loss of nutrients and keeping them available to crops. Cover crops facilitate

on-farm retention of soil and nutrients between crop cycles, while intercrops and border vegetation reduce erosion and runoff among fields. Incorporation of crop residues can maintain soil organic matter, which assists in water retention and nutrient provision to crops. Together these practices conserve a suite of ecosystem services to agriculture from the soil.

One of the aspects of ecological services viz pollination through bees and other benefits flowing from them are discussed in detail here:

Bee Keeping in Natural Farming for better increase in yield

For thousands of years honey hunters have plundered the hives of wild bees for their precious honeyand beeswax – a practice still common today. The most widely used honeybees are the European Apis mellifera, which have now been introduced worldwide. Tropical Africa has a native Apis mellifera, which is slightly smaller than the European Apis mellifera, and is more likely to fly off the comb and tosting. They are also more likely to abandon their hives if disturbed, and in some areas the colonies migrate seasonally. In Asia there are three main native tropical species, Apis cerana, Apis dorsata, andApis florea; cerana is the only species that can be managed in hives, but the single combs of the other two are collected by honey hunters. There are three different kinds of bees in every colony: a queen, the drones, and the workers. The queen's job is to lay eggs, as many as several hundred in a day. These larva develop into drones, workers, or new queens, depending on how the workers treat them. Drones are the only male bees in the hive, and their main function is to mate with a virgin queen outside the hive. They die after mating. They have no sting, do not carry pollen, are unable to produce wax, and when resources are scarce they can be driven out of the hive to die. The all-female worker bees, make up about 98 per cent of the colony, and they do almost all the work. They bring water, pollen, nectar, and propolis (bee glue) back to the hive, while some remain to guard the hive, and some clean it, build the wax comb, nurse the young, and control the temperature of the hive. Workers eat honey to produce heat in cold weather and fan their wings to keep the hive cool in hot weather. Their legs are specially equipped with pollen baskets, and they have glands that produce wax on their abdomens. The worker has a sting, but usually dies after stinging anything. A honey bee nest consists of a series of parallel beeswax combs. Each comb contains rows of wax with hexagonal compartments containing honey stores, pollen, or developing bee larvae (brood). To thrive and produce honey the bees need adequate supplies of nectar, pollen, and water. The combs are evenly spaced and are attached to the ceiling of the nest. The space between the faces of the combs is known as the

'bee space'; it is usually between 6 and 9mm and is critical in maintaining optimal conditions within the nest, with just enough space for bees to walk and work on the surface of the combs while maintaining the optimum nest temperature. Bee-space, dimensions of combs, and nest volume all vary with the race and species of honey bee. The bee space is a crucial factor in the use of bee equipment, and honey bees cannot be managed efficiently using equipment of inappropriate size. Be careful! Most equipment is manufactured to the specifications of European bees.

Equipment

Most of the equipment needed for small scale beekeeping can be made at village level. It can be helpful to import basic equipment to serve as prototypes for local manufacturers. For practicing on a large scale, some specialised equipment will probably need to be bought, such as honey gates, special filtering gauze, and gauges to determine honey quality.

Smoker

A beekeeper uses a smoker to produce cool smoke to calm the bees. The smoker consists of a fuel box containing smouldering fuel (for example dried cow dung, hessian, or cardboard) with a bellows attached. The beekeeper puffs a little smoke near the entrance of the hive before it is opened, and gently smokes the bees to move them from one part of the hive to another.

Protective clothing

Adequate protective clothing gives beginner beekeepers confidence, but more experienced beekeepers find that too much protective clothing makes it difficult to work sufficiently gently with the bees, and it is very hot. Always wear white or light-coloured clothing when working with bees - they are much more likely to sting dark-coloured clothing. It is most important to protect the face, especially the eyes and mouth; a broad-rimmed hat with some veiling will suffice. Individual items of clothing must be impermeable to bee stings, and every joint between them must be bee-tight; rubber bands can prevent bees from crawling up trouser legs or shirtsleeves. Some people find that a good way to protect their hands is to put a plastic bag over each hand, secured at the wrist with a rubber band.

Hive tools

The hive tool is a handy piece of metal which is used to prise boxes apart, scrape off odd bits of beeswax, separate frame ends from their supports, and so on. They can be made from pieces of flat steel, and screwdrivers are often used. It is possible to use an old knife for this job, but knife blades tend to be too flexible and give insufficient leverage.

Harvesting honey and bee wax

Honey is harvested at the end of a flowering season. The beekeeper selects those combs which contain ripe honey, covered with a fine layer of white beeswax. These combs are usually the outside-most ones. Combs containing any pollen or developing bees should be left undisturbed. Honey will keep a long time if it is clean and sealed in an airtight container, but will deteriorate rapidly and ferment if it has absorbed water. Preventing this from happening is crucial in honey harvesting.

Honey extraction

The honeycomb can be simply cut into pieces and sold as fresh, cut comb honey. Alternatively, the honey and comb can be separated and sold as fresh honey and beeswax. It is important when processing honey to remember that it is hygroscopic and will absorb moisture, so all honey processing equipment must be perfectly dry. The most common traditional methods of honey extraction are squeezing or burning the combs. Burning the honeycomb is wasteful and makes the quality of both the wax and the honey inferior; it should be avoided at all costs. If your quantity of honey or financial resources are small, then squeezing the honey out by hand is probably the most viable option. The honey extracted by this method will have to be strained through several increasingly finer meshes to remove any bits of wax or debris, ending with something like muslin cloth. It is very important that this procedure be carried out hygienically, and that the honey is not left exposed to the air, where it will pick up moisture and deteriorate. Another good way of extracting honey from top-bar or movable frame hives is a radial or tangential extractor. This is a cylindrical container with a centrally-mounted fitting to support combs or frames of uncapped honey, and a mechanism to rotate the fitting (and the combs) at speed. The honey is thrown out against the side of the container and runs down to the bottom, where it is collected and then drained off with a tap. Most manufactured extractors are made to hold frames and have to be adapted to take comb from top bar hives. This is usually done by making wire baskets to hold the comb. The baskets

can either lie flat horizontally, or be attached to the vertical frames and sit tangentially within the container. Top-bar combs in tangential extractors have to be spun twice, once on each side, to extract all the honey. The honey must be stored in airtight, non- tainting containers to prevent water absorption and consequent fermentation. If you want to sell your honey it would be helpful to add a label describing the source of the honey (for example sunflower, mixed blossom, tree honey), the country and district it was produced in, the weight or amount of honey in the container, and your name and address.

Bee wax extraction

The comb from which bees build their nest is made of beeswax. After as much honey as possible is separated from the combs, the beeswax can be melted gently over moderately warm water (boiling water will ruin the wax) and moulded into a block. Another option for processing the wax is a solar wax melter. This appliance is easy to make and consists of a wooden box with a galvanised metal shelf with a spout, a bowl or container that sits under the spout, and a glass or plastic cover. When placed in the sun the temperature inside the box will melt down a comb and the wax will flow into a container inside the box. Any honey that was left in the combs will sink to the bottom; it is usually used for cooking or beer making as its taste is spoiled somewhat by this process. Beeswax does not deteriorate with age and therefore beekeepers often save their scraps of beeswax until they have a sufficiently large amount to sell. Many beekeepers still discard beeswax, unaware of its value. Beeswax is a valuable commodity with many uses in traditional societies: it is used in the lost-wax method of brass casting, as a waterproofing agent for strengthening leather and cotton strings, in batik, in the manufacture of candles, and in various hair and skin ointments. Beeswax is also in demand on the world market. Beeswax for export should be clean and have been re-heated as little as possible.

Bee stings

Bee stings can be avoided by wearing protective clothing, but if you are stung, you should remove the sting as soon as possible by scraping it off with a fingernail or knife. Do not try to pick it off as you may squeeze poison into your flesh. Some steps to help avoid bee stings are:

- Wash yourself to make sure you are free of odours.
- Do not use any cosmetics, perfume, etc.

- Approach the hive from the side or behind the entrance.
- Do not wear dark clothing.
- Provide bees with water during the dry season.

Be careful not to crush a bee, as it gives off an alarm scent. If you are stung, you should move awayand remove the sting, as other bees will be attracted by the powerful smell that the bee leaves on thespot where you have been stung. As soon as the sting is out, the site should be smoked to disguise thealarm pheromone. If you are allergic to bee stings, you should not take up beekeeping.

Disease and pests

During the last two decades there has been a tremendous increase in the spread of bee disease aroundthe world. This has been brought about by the movement of honey bee colonies and used beekeeping equipment by people. There are few remaining regions without introduced honey bee diseases, and as a rule used beekeeping equipment should not be imported.

Pollination

Effect of Bee Pollination on the Economy

There is an ever-increasing demand for food security in the face of challenges such as climate change, land-use changes, habitat transformation, and the expanding human population. Proper pollination can improve the quantity and quality of fruits, nuts, oils, and other crops produced. According to market prices, pollination by animals improves the global crop output by an additional USD 235–577 billion annually, with the greatest economic benefits having been seen in the Mediterranean, Southern and Eastern Asia, and Europe. However, greater production also leads to an increased demand for pollination services. Around the world, 5–8% of crop production would be lost without animal pollination, and pollination also provides many services to ecosystems, such as enhancing biodiversity and increasing food production without threatening the environment.

Bees are the main pollinators of plants. According to Gallai et al., insect pollination provided EUR 153 billion, representing 9.5% of the total economic value of agricultural production used directly for human food. Consequently, countries that grow cash crops such as coffee (Coffea spp.), cocoa, almond (Prunus dulcis ((Mill.)), and soybeans (Glycine max L.) have a much greater reliance on pollination in agriculture at a large scale. Scientists have

used several methods to estimate the annual benefit of certain ecological costs incurred by native insects in the USA, which have been shown to amount to more than USD 57 billion, USD 3.07 billion of which is a result of bee pollination. The pollination services of non-apis pollinators were valued at USD 3.44 billion, but honey bees contributed approximately USD 11.68 billion by 2009 in USA. Honey bees are responsible for pollinating over 100 commercial crops in North America. Both honey bees and wild bees are also economically important for sunflower seed production, which is an uprising industry estimated at approximately USD 10.4 million annually. Bee pollination also increases the yield of crops cultivated in farmland. For instance, in sub-Saharan Africa, which is considered the main producer of cotton, bee pollination increases the cotton yield to 62% compared with an estimated 37% without bee pollination. In addition, economic returns from bee pollination have been recorded in smallholder farming systems in Kakamega (western Kenya), where several crops benefit from pollination, including green gram (Vigna radiata), beans, cowpea (Vigna unguiculata L. Walp), sunflower, tomato (Solanum lycopersicum linn), bambara groundnut (Voandzeia subterranean L.), passion fruit, and capsicum, with pollination dramatically improving the production rate and being responsible for almost 40% of the annual crop production .

The estimated annual value of pollination services rendered by bees in Brazil's protected areas in 2016 was approximately USD 564,000 in the north (Serra da Bocaina, Pará) and USD 246,000 in the southeastern region (Mata do Jambreiro) . Of the 36 crops produced in the state of Pará, 20 (55%) are dependent on animal pollinators, and the overall value of pollination services was USD 983.2 million in 2016, equating to 33% of the total value of crop production (USD 2.95 billion). Four groups represented for 96% of Pará's pollination service value including; cocoa (USD 187.6 million), Acaí palm (USD 635.6 million), watermelon (USD 26.1 million), and soybean (USD 98.4 million). In the USA, wild bees and honey bees have produced comparable quantities of pollination for most crops, including in agriculturally-intensive areas. The annual production value of wild pollinators for seven crops is over USD 1.5 billion. The value of wild pollinators is estimated to be the largest in apples, with a value of USD 1.06 billion while the approximate values of watermelon (USD 146 million), blueberry (USD 50 million), sweet cherry (USD 145 million), art cherry (USD 32 million), and pumpkin (USD 101 million) are evidentially

high. The economic value of honey bees on yield across these crops is about USD 6.4 billion.

Role of Bee Pollination in Crop Production (Quality and Quantity)

The number of visits and the aggregate effects of various bee species influence not only the quantity of crops produced but also their quality, which is important mainly from an economic perspective. Plant pollination by more than one bee species, including honey bees, carpenter bees, stingless bees, bumble bees, long-tongued bee, feral bees, social bees, and solitary bees, results in a better pollination/vegetation process.

Western honey bee have been widely used as pollinators since the application of pollination services began, and are the primary managed species worldwide for both honey production and crop pollination . Indeed, the Western honey bee ranks as the single most popular species of pollinator for crops globally and is the most effective crop visitor worldwide, contributing approximately 13% of floral visits to 5% of plant species across all plant networks . However, there are at least eight other honey bee species in the genus Apis, such as A. florea Fabr., A. cerana Fabr., A. andreniformis, and A. dorsata Fabr . In 2009, it was estimated that honey bees contributed USD 11.68 billion to agriculture in the USA. Honey bees are considered significant pollinators due to their effectiveness and wide availability. The mutualistic relationship between plants and honey bees results from the exchange of nectar and pollen. Bees play a vital role in the pollination of plants, and plants secrete a rich liquid sugar similar to nectar from their glands to attract pollinators to their flowers so that the pollen can adhere to bee-collected pollen grains. Researchers have found that honey bees (A. mellifera L.) appear to prefer crops rich with nectar and pollen in order to store large quantities of food, thus sustaining the colony growth and improving foraging performance. Many countries have used honey bees and achieved great results in terms of the quality and quantity of crops. In the USA, the pollination activity of honey bees is well recognized for three species of crops: cucumber (Cucumis sativus Linn), for which there has been a 10% increase in yield and the number of colonies has increased from 40,000 to 45,000; cranberry (Vaccinium oxycoccos Linn), which experienced an increase in yield from 3.7 million in 1989 to 5.4 million in 1998 , and pear (Pyrus communis Linn), which exhibited a 7% increase in fruit size and a net income increase of $400 per hectare . In India, the use of honey bees as pollinators improved the fruit quality of guava (Psidium guajava

Linn), as well as the fruit length and girth of coconut (Cocos nucifera Linn) and citrus (Citrus spp.) compared with the controls. In Egypt, honey bees have significantly improved the seed set percentage and seed yield in onion (Allium cepa Linn) crops compared with other insects. Furthermore, in Burkina Faso, the production of sesame (Sesamum indicum Linn) seeds tripled after using honey bees as pollinators. The pollination of oilseed rape (Brassica napus Linn), buckwheat (Fagopyrum esculentum Moench), and strawberry (Fragaria × ananassa (Duchesne ex Weston) Duchesne ex Rozier) have clearly been dominated by honey bees, which have improved their quality and yield. Similarly, black cumin flowers are attractive to a range of pollinators, such as Hemiptera (true bugs), Coleoptera (beetles), Diptera (flies), and Hymenoptera (bees). However, honey bees are the most abundant pollinators affecting its productivity and quality, with their pollination activity increasing the number of seeds and affecting the total yield, which has led to the recommendation that beekeepers place bee colonies near black cumin fields for better pollination.

The yield of anise also significantly relies on pollinator activity. One study showed that honey bees exhibited a daily peak in anise pollination activity between 12 noon and 2 p.m., and increased the yield above levels seen with insect exclusion, though levels were below those obtained with open pollination. Honey bees and six species of Andrenidae are the main pollinators of coriander, with 63%of honey bee visits and 100% of the visits by three species of Andrenidae resulting in pollinating activity. For the apple (Malus domestica Borkh), increased flower visitation rates by high-quality honey bee colonies increased fruit set by 15%, as well as the fruit sugar content and seed set compared with visits by conventional colonies, resulting in the farmer's profits increasing by 70%. Pollination by high- quality colonies also increased fruit weight by approximately 20%. In the fruit of cape gooseberry (Physalis peruviana Linn), western honey bees' pollination improved the equatorial diameter by a mean of 13.3%, fruit mass by 30.3%, seed variety by 7%, and seed mass by 8.4% compared with self- pollination, while the use of honey bees for almond pollination increased fruit set by 60% compared with bee-remote trees, which translated into a 20% increase in yield. Observations of blueberry (Vaccinium corymbosum Linn) pollination in the presence of wild bees (Bombus spp., Halictids bees, Andrenids bees, and Xylocopa virginica) and controlled honey bees in small isolated and large fields inMichigan, USA, showed that wild bees were the primary pollinators in the small fields, accounting for

58% of flower visits, whereas honey bees were the main pollinators in the large fields, accounting for 97% of visits. Furthermore, it was found that flowers in the large fields were visited by four times as many bees as flowers in the small fields. The weight of the fruit was affected by the level of bee pollination and the abundance of bees, and the weight of berries was twice as high in the large fieldscompared with the small fields.

Bee Pollination vs. Non-Bee Pollination

Bees are considered the most effective pollinators; however, the contribution of other insect pollinators cannot be considered negligible, as they serve to increase and stabilize crop pollination and rely on these plants for the supply of pollen and nectar. The main groups of other insect pollinators arebutterflies, moths (Lepidoptera), some flies (Diptera), and beetles (Coleoptera).

Extension services

23. LINKAGES & EXTENSION APPROCHES FOR PROMOTION OF NATURAL FARMING

Stakeholder matrix as per location will be prepared by Master Trainers and their Roles and responsibilities (of working at various levels) will be prepared.

Importance of linkages: Linkages are important in the spread and diffusion of knowledge, which not only acts as building blocks for new knowledge which is further synergized through creative duplication and accumulation. Linkages with institutions and stakeholders are integral to the success of natural farming. These collaborations provide essential knowledge, resources, policy support, risk management strategies, and community engagement creating an enabling environment for farmers to effectively implement and benefit from natural farming practices.

1. **Conceptual linkage framework (Farmer and location specific)**

1) **Central Govt. Initiatives:**

MANAGE: MANAGE is the Centre of Excellence & Knowledge Repository on Natural Farming

List of Master Trainer supporting Institutions

ICAR Institutions: ICAR committee will draft syllabus and course curriculum for inclusion in UG and PG courses. ICAR has already notified a dedicated Masters course in Organic farming. Gujarat Organic Agricultural University (GOAU), Godhra, is running degree courses on natural farming.

EEIs: Organising different OF and NF trainings for farmers and stakeholders.

Externally aided and National projects: Institutions such as IFAD, World Bank, GIZ etc are supporting organic and natural farming projects of respective state governments.

KVKs: KVKs as Model Centres for Natural Farming. The farmers associated through KVKs will be identified and Trainer farmers and CRPs will be selected.

NCONF: NCONF for Certification and Training. The farmers associated through PGS will be listed and Trainer farmers and CRPs identified.

Namami Gange: "Natural Farming to be promoted throughout the country, with a focus on farmers' lands in 5- km wide corridors along river Ganga".

NRLM: Focusing on women SHGs and their federation-based NF and OF. Krishi Sakhis will be trained as NF trainers at village and cluster level.

Cooperatives: Focusing on PACS and higher-level coops-based development comprising of all types of agriculture. PACS which promote NF will be identified and Trainer farmers and CRPs identified for training and capacity building. Farmers Interest Groups (FIGs) and FPOs would be the key stakeholders.

It will be ensured that there is no duplication of beneficiaries from different schemes.

State Government initiatives: SAUs, Agricultural Departments, Watershed Department, Soil and Waters Conservation, Animal husbandry, Fisheries, ATMA, Projects etc., Identified Trainer farmers and CRPs will be trained for NF.

Communicate the guidelines for NF as per State at least before Kharif and Rabi crops as done under the NF project in Andhra Pradesh. Roles and responsibilities of stakeholders and administrative instructions communicated clearly. The PoP for various crops under NF that are already available are compiled. Region specific PoPs have to be developed as per the need.

HP Agriculture department has prepared the Kisan diary in which the month wise activities to be carried are communicated with photos.

NGOs: WASSAN, CSA, RySS, NCNF, etc

Sahaja Samruddha and other initiatives have been working on seed conservation. Best practices can be upscaled. In addition, individual farmers are actively involved in traditional and indigenous seeds collection and distribution.

Input Supplies of NF: Bio Resource Centres

Spiritual Agencies: Isha Foundation, Art of Living, Patanjali etc. have following of lakhs of persons who represent the urban and rural communities. Initiatives like Yoga and overall wellbeing of the individuals and communities is at the core of their initiatives which can be synergized with the NMNF.

Consumers: Family Farmer, Govt agencies, hostels, export etc.

Financing Agencies: NABARD, GIZ, CSR etc.

Private Sector: ITC, Mahendra, Swaraj etc.

Co-operatives: FPOs, AMUL, SAFAL, HOPCOMS, PACS, IFFCO

Branding & Marketing: Content making, documentation, processing, branding & certification, advertising

Engaging with Schools, Universities with Students and Teachers: learning through games, practical activities, short projects, debates, banner, poem writing activities etc.

Concept of voluntary knowledge sharing by farmers and stakeholders can be reviewed and upscaled eg. Yogahaar.

Extension Advisory Services

- Toll Free No.
- Chat Bot
- Websites
- Social Media
- Literature for Study material

Knowledge Sharing and Training:

Collaborating with agricultural research centers, universities, and extension services offers access to scientific knowledge and research-based information. These institutions can conduct workshops, training programs, and seminars to educate farmers about the principles and techniques of natural farming. Farmers gain a better understanding of the underlying science, helping them make informed decisions when implementing these practices.

Skill Enhancement:

Stakeholders, such as experienced farmers and local agricultural communities, hold valuable practical knowledge gained from years of working in the local environment. Their insights about local soil conditions, climate patterns, and indigenous crop varieties are invaluable. Linking with these stakeholders allows new natural farmers to benefit from their expertise, learn from their successes and failures, and gain hands-on experience in the field.

Adaptation to Local Context:

Natural farming practices need to be adapted to suit local conditions. Institutions and stakeholders provide context-specific advice and recommendations for optimizing natural farming techniques based on the specific agroecological characteristics of the region. This

tailoring enhances the effectiveness of natural farming and ensures that practices are aligned with local realities.

Access to Resources and Inputs:

Natural farming often requires specific resources, such as organic fertilizers, compost, and natural pest control methods. Collaborating with institutions can help farmers access these resources, either through research or direct connections. Stakeholder networks can provide practical insights on producing these resources locally, reducing costs and environmental impacts.

Policy Advocacy:

Institutions are often involved in policy research and advocacy. Collaborating with these entities allows farmers to voice their needs and concerns, influencing policies that promote and support natural farming practices. Building alliances with stakeholders also strengthens advocacy efforts, as collective voices have a greater impact on policymakers.

Market Access and Value Chains:

Establishing linkages with farmer cooperatives, local markets, and organic food networks facilitates the transition from production to market. These stakeholders can connect natural farmers with consumers who value organic and naturally grown products. Collaborating with such entities helps farmers access premium markets and receive fair prices for their produce.

Research and Innovation:

Research institutions are centers of innovation. Collaborating with them can lead to the development of new natural farming techniques, tools, and approaches. These innovations can improve productivity, reduce environmental impact, and address emerging challenges faced by natural farmers.

Risk Mitigation:

Institutions and stakeholders often have insights into managing risks associated with natural farming. They can provide information on pest and disease management strategies, climate-resilient practices, and methods to cope with adverse weather conditions. By sharing these strategies, they help farmers mitigate risks and ensure stable yields.

Community Support and Knowledge Exchange:

Collaborating with local communities and farmer groups creates a support network for natural farmers. Regular meetings, workshops, and knowledge exchange platforms allow farmers to share their experiences, troubleshoot challenges, and learn from one another's successes and failures. This sense of community support fosters a culture of continuous learning and improvement.

Scaling Up and Replication:

Once successful natural farming models are established, institutions and stakeholders can play a pivotal role in scaling up the practices. They can organize demonstration plots, field days and knowledge-sharing events to showcase the benefits of natural farming to a wider audience. This encourages more farmers to adopt these practices and expand the movement.

The linkages with institutions and stakeholders are integral to the success of natural farming. These collaborations provide essential knowledge, resources, policy support, risk management strategies, and community engagement creating an enabling environment for farmers to effectively implement and benefit from natural farming practices.

EXTENSION APPROACHES

i. **Farmer -to -farmer extension:** Extension Support at the village level to be provided to the farmers through a Farmer Friend (FF) in every village. This would be very useful in extending the reach of the agriculture extension system up to the farmer level.

ii. **Farmer field schools (FFS):** FFS is a season long training programme imparted to the farmer for one day in a week throughout the season. Intern these farmer train other farmers.

iii. **Farm school:** Farm Schools would provide season long technical backstopping/ training to target farmers by having an interactive session once at least during each of the 6 critical stages in a cropping season.

iv. **Farmer to consumer:** building awareness and creating demand for natural products

v. **Problem solving approach:** Identification and solving the problems through the farmers

Different Extension Methodologies in diffusion of NF techniques

Existing/Prescribed Knowledge and skills will be documented and kept in common online repository.

Farm Lab / Model Farm approach used by various states, agencies eg Himachal Pradesh, AP Project, Patanjali and other institutions in which the demonstration of NF practices at farmer's field and comparison of the various parameters with farmers own practice has been identified. The HP department of Agriculture is using grading methodology to rate the farmers practicing NF based on specific criteria on three star, two star and single star. This methodology can be revised for extending to the entire country after careful review of the approach and methodology.

Observation of the select parameters at critical crop stages taken along with farmer and experiences will be shared and recorded. Similarly, the record of the inputs used is to be carefully documented. Soil testing of farmer's field will be done using simple methodologies as part of baseline data collection.

Use of IT tools can be taken to record the data of the farmers, conduct specific surveys etc. Save Soil campaign is taking help of app sheet which is open source software and recording of the farmer's data can be carried out using the best possible actions.

Conduct documentation of ITKs, success stories through videos, short stories, TV shows, social media etc

NMNF will develop case studies of farmers practicing natural farming as per prescribed format. Various ITKs being used will be shared and feedback taken. The well performing farmers will be identified and their videos made to be disseminated through social and other media. Live shooting of few farmers will be done who can share their experiences and shared in TV shows, social media and other media.

Success stories will be shared at all levels and the learnings will be shared at appropriate levels for necessary course correction in strategy and approach. The NMNF will develop case studies of consumers who experienced the benefits of natural farming products. The concept and success stories of NF will be endorsed by celebrities and NF related songs, poem, skits etc to be collected and disseminated. In addition Folk Songs, Spiritual lectures, songs poems will be encouraged from the farmers also.

24. IMPORTANCE OF SUPERVISION, MONITORING, EVALUATION AND FOLLOW-UP OF THE NATURAL FARMING TRAINING PROGRAMME

Monitoring refers to close observation/watching of events/activities/programme may be in respect of individual/organization/materials

What is it?

- Monitoring is a process of keeping a watch/observation on the progress of a programme/ project in terms of its target and time schedule.
- Another way of defining monitor is that, it is a process of collecting, recording, measuring, processing and communicating information to assist project management in decision making.
- Monitoring reveals whether the components of the extension programme/ activity are operating as intended.
- To be precise and brief, "monitoring is an information system for management decision making''. Thus, monitoring is a management function, which begins with the start of the project and ends with the completion of the project, but it is a continuous process during the implementation of project.
- The key requirement for monitoring is an "Action plan" without which monitoring is not possible

Objectives of monitoring

1. To oversee proper allocation and utilization of resource such as money, Human Resources etc.
2. To supervise the activities of programme, i.e. concerned with supervision of schedule of activities
3. To identify areas of short coming and factors responsible to overcome/correct shortcomings.
4. Monitoring is need for accountability purpose, i.e. who is getting what and how.
5. To know operational performance of the programme so that desirable and needed change or alterations can be made in day-to-day activities.

Types of monitoring:

1. **Input monitoring**: It refers to monitoring of various resources which are needed to carryout activities. These, for e.g. include Human Resources, materials, money, machine, management, message, person hours etc.
2. **Activity monitoring**: It refers to monitoring of series of activities/ tasks carried out by the implementing staff and the target beneficiaries to achieve outputs. These include – conducting training, field days, demonstrations, field visits etc.
3. **Output monitoring**: Refers to tangible results of an activity or series of activities like number of field staff trained, number of leaflets distributed, no. of storage structure constructed etc.

Evaluation of Extension Programme

- Dictionary meanings of evaluation are the determination of the value, the strength or the worth of something, appraisal or making judgment of something.
- Evaluation as applied to the field of extension may be defined as a process of systematic appraisal by which we determine the value or worth of an activity or an enterprise or programme.
- Evaluation is a method for determining how far an activity has progressed & how much further it should be carried to accomplish objectives.

Evaluation is defined as:

- a process by which the values of an enterprise are analyzed by which one is able to understand and appreciate the relative merits or deficiencies of persons, group, programme, situations ,methods and process
- a comparison of the situation before and after a development programme has operated within it for a predetermined period
- the process of determining the value or amount of success in achieving a predetermined objectives
- a process of determining how well the desired behavioral changes have taken place or taking place as a result of extension educational effort.

Degrees of Evaluation

1. **Casual every day evaluation**: Simple observations are important for some things, but have their limitations.
2. **Self checking evaluation:** making conscious attempt to apply principles of evaluation. i.e. checking ordinary observation by talking with other, getting other people judgment etc.
3. **Do it yourself evaluation**: It involves careful planning, application of principles of evaluation and are more systematically done. Ex. Surveys and collection of observation with score or observation cards/ schedule.
4. **Extensive studies :** More complex and use more scientific approach
5. **Scientific research:** Experimental studies scientifically carried out to determine cause and effect relationship.

Steps in Evaluation: The following steps may be adopted in evaluation of a project.

1. **Objective:** Decide on the purpose of evaluation. What information is needed and why?
2. **Sampling:** Decide on the sampling method and the sample size which shall furnish the required Information.
3. **Collection of information**: Decide when and how the information will be collected and who will do it. Train personnel for the purpose, if required. Prepare appropriate data collection devices like interview schedule, questionnaire etc.
4. **Analysis of data:** Select appropriate statistical tools. Take the help of statistician or computer, if needed. Analyze and interpret the data.
5. **Report writing:** Prepare an appropriate report, highlighting the major finding. Avoid producing a faulty report. State clearly the implications and recommendations and mention what specific action is to be taken at different levels and by whom.

Advantages of Evaluation

1. It helps to establish a 'bench mark'.
2. It helps to know how far our plans have progressed
3. Evaluation helps to know whether we are proceeding in the right direction or not.
4. It indicates the effectiveness of a programme.
5. It helps to locate strong and weak points.
6. It improves our skill in working with people.

7. Evaluation helps to determine priorities for activities in the plan of work
8. Evaluation brings confidence and satisfaction to extension work.

Tools and Techniques of Evaluation:

1. Study of Historical records
2. Observations
3. Interview schedule
4. Questionnaire
5. Interview
6. Tests

Training need assessment & conducting the training in a systematic manner

The understanding and application of Training Need Assessment will help the Master trainers to design the training programs for Trainer Farmer and CRPs in an appropriate manner. Before start of the training and after completion of the training the knowledge and skills acquired will be assessed and the results analyzed carefully for the future.

For the purpose of gaining holistic understanding of NF various tools that help the participants become more aware icebreaking tools such as the Snake and Ladder developed by Patanjali and other institutions can be used to invoke discussions and reach common understanding amongst the participants on the various chapters/components /principles of natural farming. Examples of PRA tools which can help to assess the farming system for the Master trainer will be provided.

Checklist of tasks to be done before, during and after each training event will be prepared to streamline the training activity and ensure that the tasks are planned and implemented systematically.

At various levels of the training trainers and stakeholders will be monitored in terms of delivery and outputs.

Feedback mechanism: assessment of knowledge and skills acquired using questionnaire, verbal etc. and also on training venue, logistics etc,

PRA TOOLS

1. Brainstorming eg. snake and ladder
2. Focus Group on importance and need of NF vs CF and prepare the priority grid
3. Transects / Maps to be done at village level to study the various crop patterns, AH, existing tools etc. Specifically, transect walks help to achieve the following:

1. An appreciation of the biodiversity and the resource endowments of the specific farming community
2. An understanding of the challenges and opportunities for Natural Farming development in that area.
3. The establishment of rapport with farmers and other key actors in that area.
4. Resource Mapping and Crop Calendar
5. SWOT Analysis including Stakeholder Analysis using Venn Diagrams
6. Time Budget Analysis (Male and Female) and Gender Analysis : role of women vis a vis men
7. Analysis of the Relations of Production
8. Trend Analysis of food habits and farming system
9. Role Play (dealer, farmer, NF extension worker)
10. Case Studies of well performing NF, conventional farmer expenses vs NF to be identified
11. Resource Flow (exp flow of NF vs CF) for farming and other expenses
12. Comparison of availability of tools, equipment etc with NF as compared with CF
13. Crop Budgeting, role of market and credit

Report of the PRA findings to be prepared including action points

Checklist of tasks to be done before, during and after each training event:

- **<u>Before the training:-</u>**
  - **Training Coordinators:-**
    - Mobilization Pictures
    - Planning the monitoring & field visit time to time
    - Monitoring plan share with their field staff and HO team
    - Conversation with their field staff and Trainer Farmers for training scheduling status
    - Trainees documents collection for new trainings

- Training venue/location visit for the info about internet connectivity

- **Field Staff:-**
  - Called to all trainer farmers for start the training before 30 minutes training starting time.
  - Conversation with their Trainer Farmers for training scheduling status
  - Update to their respective state coordinators for all started training session
  - Trainees documents collection for new trainings
  - Training venue/location visit for the info about internet connectivity
  - Connect with the person who will take the virtual online training

- **Trainer Farmer:-**
  - Called to all trainees for the training session before the timing on the daily basis.
  - Prepare the training's topic
  - Seating arrangement
  - Proper Branding (Banner)
  - Farmers documents collection for new batches and provide to field staff
  - Connect with the person who will take the virtual online training

❖ **<u>During the training:-</u>**

- **Training Coordinators:-**
  - Conversation with field staff regarding the training and photographs status
  - Conversation with Trainer farmers (randomly) through the audio or video call
  - Timely field visit (as per schedule)
  - Pin the all training locations on google map

- **Field Staff:-**
  - Conversation with Trainer farmers (randomly) through the audio or video call
  - Timely field visit (as per schedule)
  - Collected the training photograph(starting timing pictures) and share with respective state coordinators
  - Pin the all training locations on the google map

- **Trainer farmers:-**
  - Take the training pictures of (starting and ending time) with notecam or time stamp on the daily basis
  - Make a training session video (Minimum 2 Min) on the daily basis and share with field staff.
  - Take feedback from trainees about the training session
  - Take a practical video or testimonials videos

❖ **<u>After the training:-</u>**

- **Training Coordinators:-**
  - Conversation with Field staff for the training session status, training photograph and videos
  - Collect and compile batch wise training photographs
  - Check the all training pictures (branding picture, session picture through notecam, practical picture, and videos) and upload on drive
  - Update to HO team for uploading the training pictures

- **Field Staff:-**
  - Conversation with trainer farmers regarding the training pictures and videos
  - Collect and check the training pictures and videos and share with respective state coordinator.
  - Collect the trainees feedback about the training session

- **Trainer Farmer:-**
  - Share all training pictures (starting & ending timing) and video to field staff on daily basis.

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NATIONAL INSTITUTE OF AGRICULTURAL EXTENSION MANAGEMENT (MANAGE)
(An Autonomous Organization of Ministry of Agriculture and Farmers Welfare, Government of India)
Rajendranagar, Hyderabad-500030, Telangana State, India.
www.manage.gov.in