

ANUBHAV PRATISHTHAN TRUST

Present Understanding

of

Comprehensive Water &

Natural Resource Management



ANUBHAV PRATISHTHAN TRUST

S/No-6,183/2/D Jakhotia Arcade, Shilphata, khopoli, Tal. Khalapur, Dist. Raigad. Pin –410203.

Tel:02192-266875. Email ID – anubhavpt01@gmail.com

ANUBHAV PRATISHTHAN TRUST PRESENT UNDERSTANDING OF COMPREHENSIVE WATER & NATURAL RESOURCE MANAGEMENT

1. Watershed Development – An Understanding

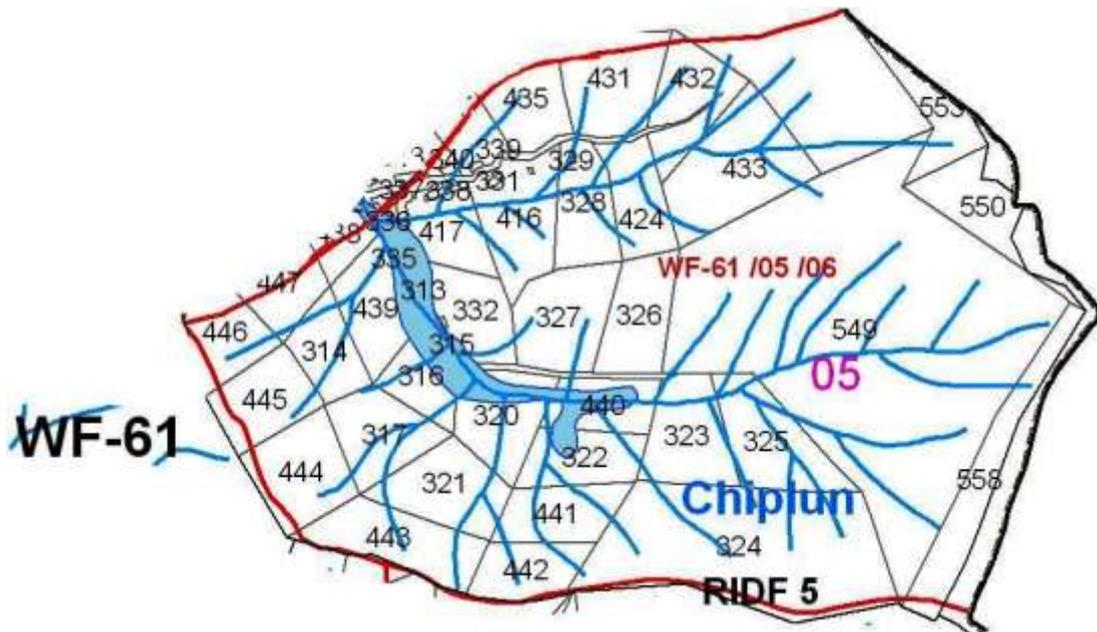
Introduction

Land, water and vegetation are the three basic resources of the life support system. These resources are under intense pressure due to natural and human induced factors. The ecosystem in this region tends to become fragile and precariously balanced due to rapid increase in human & population, over exploitation of natural resources to meet their food, fodder and fuel requirement and management of these resources. Traditional food production system prevailing in the region, undulating terrain and high and intense rainfall, has further accelerated the resource degradation and depletion processes leading to the deterioration of the overall ecosystem. Soil erosion not only affects the on-site by way of loss of fertile soil but also off-site in form of frequent incidences of flash floods in the lower valleys and plains with consequent damage to fertile farms, water resources.

The agricultural production system in the region is mostly rainfed, mono-cropped and at subsistence level. A long term developmental approach aimed not only at optimum utilization of natural resources but also at development of the natural resources such as land, water, vegetation and man power for restoration of ecological balance.

What is a Watershed?

A Watershed can be defined as an independent hydrological unit. It is a drainage basin or catchment area of a particular stream or river. In simple terms, it refers to the entire upstream topography around a defined drainage channel which feeds water to the lands below. A watershed may vary from a few hectares to several thousands of hectares.



Typical Micro Watershed Unit – showing survey numbers, streams, waterbodies and micro watershed numbers

Components of watershed development

Watershed development involves conservation, regeneration and judicious utilization of natural resources. It aims to bring about an optimum balance between the demand and use of natural resources so that they remain sustainable over time.

The components of watershed development are:

- Soil and land management
- Water management
- Crop management
- Afforestation
- Pasture/fodder development
- Livestock management

- Rural energy management
- Other farm and non-farm activities and
- Development of community skills and resources

People's Participation & Linkages

There is a close relationship between the environment and the human community living within for its livelihood. When the economic condition of a community deteriorates, it leads to over-exploitation and degradation of natural resources. It is necessary for people to understand the relationship between their poverty and the degraded environment they live in. Environmental regeneration is possible only when the concerned people realise a need for it and are empowered to have control over the process of resource utilisation, management and conservation. As human beings and their activities are the primary cause of environmental degradation, they can restore the health of the environment they have ruined by resetting their ways and activities towards the environment around. Hence, there can be no sustainable natural resource management unless it involves the participation of all inhabitants of the concerned environment/area in an active manner.

Linkages in Watershed Development

- A peoples' organisation called "Village Watershed Committee" (VWC) with adequate representation of women is formed for planning, implementing and eventual maintenance of the treatment measures / structures. VWC is responsible to Gram Sabha or entire village community.
- The treatment measures follow a "Ridge to Valley Approach". The "Net-Planning" approach adopted demands survey of each of the plots in the watershed and suggests appropriate technical measures for conservation and improvement in consultation with the farmer and his family.
- Efforts are made to encourage VWC to think of ways and means to involve the landless in project activities and design appropriate systems of benefits arising from common property resources.
- The women in the community, besides being represented in the VWC, are encouraged to form SHGs and undertake project related activities like raising a nursery, kitchen gardens, in addition to inculcating the habit of thrift and funds management / rotation of funds amongst themselves. Besides, women promotion/development activities are undertaken from a "Women's development Fund" set up by earmarking 5% of project measures.

Partners and their roles

- The Gram Sabha, the body representing the entire village, accepts and ratifies the project.
- The VWC plans, implements and supervises the project.
- The Implementing Agency / NGO motivate and mobilises the watershed communities and plays the role of facilitator and guide to the VWC during the project period.
- Concerned Government Departments, Technical Support Organisations and Agricultural Universities provide extension support during the implementation process as and when sought for.

Importance of Participatory Approach

1) The Watershed Development Program to be successful must involve the participation of the concerned people and must be related to the environment in which they live, and on which they depend for their needs. This involves the following:

- It has to be focused on the regeneration and equitable use of the resources in the particular environment on which the village depends for its needs. A watershed provides a naturally occurring hydrological unit and is also the area on which the inhabitants depend for survival. It thus becomes a common issue drawing the people together, giving rise to a common interest and fostering a common purpose.
- The people voluntarily must come together and accept full responsibility for regenerating their environment from concept to planning, implementation, supervision, maintenance of project measures and associated practices. This would imply consensus in arriving at a common understanding regarding rules and regulations and the setting up of mechanisms for organisation of works, sharing of benefits and resolution of conflicts.
- To make the project sustainable, it is necessary for all the key actors, like the Watershed Community, NGOs, Banks, Government Institutions and Technical Service Organisations, to participate actively and in close coordination with each other.

- 2) Participatory watershed development must be implemented on a “large enough scale” at different places to create many success stories, each of which can act as nuclei, becoming a source of inspiration and demonstration for neighbouring villages. This would provide a major impetus for the unfolding of a “people’s movement” for regeneration of environment.

Watershed Approach for Resource Conservation

The scope of soil conservation is very wide and encompasses much more than physical work for erosion control. The concept of soil conservation has been expanded to mean protection of the soil against physical loss by erosion or against chemical deterioration. Thus, the effective conservation and management of land, water and vegetation resources aimed at obtaining optimum and sustained return from these resources without degrading them can be achieved by adopting watershed as basic unit of development. Watershed being a natural hydrological entity, it responds most effectively to various engineering, biological and cultural treatments.

Monitoring of runoff and silt at the outlet of the watershed can help assess the impact of various treatments aimed at conserving soil and water, and protecting vegetation. Watershed management involves protection of land against all forms of degradation, restoration of degraded land, sediment control, pollutants control, and prevention of floods, etc. Demarcation of watershed and subsequently sub watersheds can be done either by using topo sheet of the area.

Prioritization of sub watershed should be done on the basis of sediment yield and pollutants concentration in the runoff from the sub watershed. Numerous treatment technologies in form of engineering measures and agronomic practices are available. But identification of most suitable technologies as per the site condition and their application in correct way is most important to achieve the desired results. These technologies when adopted within the boundary of watershed, facilitates favourable interaction among various watershed factors such as physiography, land slope, soil characteristics, land use, hydrological behaviour etc, land, and water resources to produce food, fodder, fuel and fibre on sustainable basis.

Conservation Objective

The main objective of Soil and Water Conservation is to prevent soil erosion, increase soil moisture, raise groundwater level, conserve and increase the biomass cover of the area. This would result in better production of land, would ensure availability of water for protective irrigation and drinking, increase availability of fodder, fuel and fibre. It would also help in adopting new cropping patterns; in such a situation multiple crops are possible.

Soil

Soil is one of the most important natural resources that covers much of the earth’s land surface. Most life on earth depends upon soil as a direct or indirect source of food. Plants are rooted in the soil and obtain nutrients (nourishing substances) from it. Animals also get nutrients from eating the plants in the soil. Soil is home to many organisms such as seeds, spores, insects, and worms. Soil is made up of four parts: air, water, mineral, and organic material. Air and water provide nutrients to plants so that they can make food for themselves. Organic matter, also known as *humus*, is made of plant and animal remains in various stages of decay. Minerals are the clay, sand, and silt particles. The mineral content determines the soil type. Sandy soil has mostly sand and no organic matter. Sand is the largest of the soil particles and allows water and air to move easily through it. Clayey soil has mostly clay, a little organic matter and sand. Clay particles are very fine and are the smallest of the three soil particles. Clay is sticky when wet and hard and brick-like when dry. Silt is the soil particle that falls between sand and clay. It is considered a medium-sized soil particle. Silt particles keep the soil rich and loose.

Soil consists of small particles of rock that have been made fine by the process of weathering. But no crop can grow on a soil composed entirely of rock particles. Agricultural soil also needs soil water, soil air, decaying organic matter, and living organisms in order to be productive. Soil forms the upper-most layer of the earth’s crust and is made up of inorganic and organic matter. The inorganic components are weathered rock, air, water and minerals. The organic components are the decomposing (rotting or decaying) fragments of plants and animals. The spaces between the small particles that make up the soil are filled with air or water.

Engineering Measures

Engineering measures are also called mechanical measures. These measures are aimed at arresting the movement of eroded soil by reducing the slope length and / or slope steepness or gradient. Some of these measures suitable for agricultural lands and their design and potential land use models are discussed.

a) Contour bund

Contour bunds are mechanical (earth made) barriers created across the slope following the line of contour. Contour bund may follow exactly the line of contour in the low rainfall areas where the objective is to conserve entire amount of rainfall in-situ. But in high rainfall areas where in addition to the in-situ conservation of rainfall, safe disposal of runoff is also one of the objectives, the contour bunds may deviate from the line of contour in order to attain longitudinal gradient. This gradient will help guide the runoff to grassed waterways safely. Such bunds are called graded bunds. The graded bunds divert the excess runoff during rains to the grassed waterways and retain eroded soil.

- 1 **Side bunds:** These are constructed along the slope at extreme ends of the contour bunds.
- 2 **Lateral bunds:** The safety of contour or graded bunds from excess accumulation of runoff is very essential. This bund is constructed along the slope in between two side bunds to prevent concentration of runoff.
- 3 **Supplemental bunds:** If the horizontal spacing between two contour bunds is large, supplemental bunds are constructed at those places across the slope to limit the horizontal spacing.
- 4 **Marginal bunds:** These bunds are constructed along the margin of watersheds, streams, roads and gullies.

Crop cultivation practice is continued in the area within the two bunds; with the slow process of silt deposition within the bunds, the area between the two bunds gets leveled up and takes shape of terrace in due course of about 4-8 years time. It has been found that developing bench terraces through slow process with the help of contour bunds is very effective, as this method avoids sudden disturbance of the soil profile exposing the subsoil as happens in case of bench terracing by cut-fill method. These bunds require care and maintenance during first two years.

b) Bench terracing

Bench terraces are flat beds constructed across the hillslopes along the contours with half cutting and half filling. They serve as barriers to break the slope length and also reduce the degree of slope thereby eliminating the all erosion hazards. On sloppy and undulating lands, agricultural practices can effectively be performed on these bench terraces. All the external nutrients supplied to the crops in form of manures and fertilizers remain in the cropped field. In micro-watersheds involving steep slopes (up to 33%) few bench terraces only at foothills may easily be constructed to produce food crops. Bench terraces can also be developed with vertical stone walling and are in use by the farmers. Side bunds on the outer edge of the terrace should be provided to prevent slipping down of soil and overtopping of excess runoff from the terraces. To maintain top soils in terraces, the construction should start from the foot hills.

There are three types of bench terrace they are as under:

- 1 **Level bench terraces:** Benches are almost leveled to ensure uniform depth of impounding water. This type of bench terrace is used for paddy cultivation. Therefore, they are also called table top or paddy terraces.
- 2 **Inwardly slopping bench terraces:** These types of bench terraces are preferred for cultivation of tuber crops such as potato, ginger, turmeric, and sweet potato, which are susceptible to water logging. Benches are made inward slopping to drain runoff as quickly as possible.
- 3 **Puertorican or California type of terraces:** These terraces are formed by gradual conversion of land between two barriers into terrace by natural leveling process. Mechanical barriers (bunds) or vegetative barriers (grasses or shrubs) or combination of both, are laid along the contours. Due to ploughing and interculture operations soil is eroded and gets deposited at the barriers. Thus, in due course terraces are formed.

c) Half-moon terraces

The half-moon terraces are constructed for planting and maintaining saplings of fruit and fodder trees in horticulture and agroforestry land use system. The construction of this type of terrace is made by earth cutting in half-moon shape to create circular level bed having 1 to 1.5 m diameter. The bed may also have inward slope. This type of terraces is made at an interval of planting spacing of the fruit and fodder trees. Half-moon terrace helps retain soil fertility, moisture and added fertilizers and manures for healthy growth of the plant.

d) Contour trenching

Trenches are any form of depression or micro pit or trench constructed over the land surface. In order to prevent soil erosion and to absorb rainwater in non arable lands, trenches are constructed along the contours (called contour trenches) on hillslopes above 15% with vegetative supports for forestry and horticulture land uses. For proper drainage of excessive runoff, they may be connected with longitudinal drains and drop pits. It will improve moisture status in soil, water yield in the springs, increase in fruit and wood production.

e) Grassed waterways

In high rainfall area, safe disposal of runoff is very important for safety of any trace system. The main function of grassed waterways is to drain out excess runoff from the field at non-erosive velocity. It helps protect land against rill and gully erosion. A waterway is constructed according to a proper design. Turfs or sod of perennial grasses which are drought resistant, erosion resistant and submergence resistant should be developed to protect the channel section against any kind of erosion because of the concentrated flow.

f) Diversion drains

Diversion drains are sometimes called simply diversions. They are the channels constructed across the slope for the purpose of intercepting runoff and conveying the same to a safe outlet. Diversion drains are located above the agricultural lands at lower reaches of hill slope. Diversion drains are also constructed at the gully heads or at the upstream of bunded or terraced areas to intercept the surface runoff to avoid any damage from concentrated flow.

Economically Viable and Sustainable Farming System on Micro Watershed Basis

The above mentioned conservation measures were employed to reduce the soil and water loss from the field. Some of the promising and most suitable systems are discussed below.

i) Agro-pastoral farming system

The conservation measures adopted were contour bunds at higher reaches, bench terrace at lower reaches and grassed waterways in drainage channel. Top of the hillock (0.06 ha area) was kept under forest. Two cropping systems: rice based (Rice-mustard /potato/radish, maize based cropping system (maize-groundnut/soybean/mustard) may be practiced. The perennial grasses and legumes suitable for plantation on terrace risers for stability of the risers and fodder production. The fodder crops should be pruned before attaining height of 50 to 60 cm to avoid any shade effects on agriculture crops in the terrace.

ii) Agri-horti-silvipastoral farming system

Contour bunds, bench terrace, grassed waterways and half moon terraces were the conservation measures adopted in the micro-watershed. Timber, fuel, fodder, and fruit trees were grown along with fodder grasses, and legume crops. The produce can meet the food, fodder and fuel requirement of a tribal family consisting of 5 members. The system can sustain 10 goats from the fodder obtained from risers, horticulture and silvipasture area.

iii) Livestock based farming system

This system was found suitable for steep slope and shallow soil depth. Minimum soil manipulation is required. Contour trenches and grassed waterways can provide effective conservation of soil and water in the system. Selection of leguminous and non-leguminous annuals and perennials, shrubs and trees will depend on the type of enterprises (such as milk, beef, mutton, wool, pork and poultry production). The fodder production system has to ensure stability in fertility status of soil, availing the moisture supply towards maximum fodder production for longer period during the year and conservation of fodder for lean season. Annual legumes develop 100% canopy within 45 days of the onset of rains. Combination of cultivated varieties of perennial legumes, grasses, shrubs and

trees can extend availability of green fodder up to February shortening the requirement of conserved fodder for lean season. Livestock-based farming system has potential for substantial income from the farmyard manure and self-sufficiency in the matter of fuel through biogas plants.

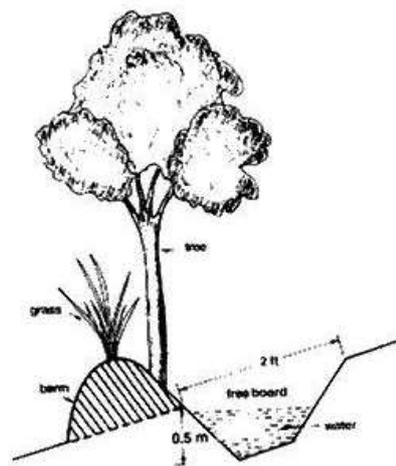
iv) Horticultural based land use system

The land use can be adopted in a slope not more than 100% having maximum soil depth of 1.0 meter. Contour bunds, half-moon terrace at the fruit plant location, grassed waterways and few bench terraces at the lower terraces for growing vegetables crop are essential conservation measures. Such lands are expected to retain over 90% rainfall in the slope and reduce the soil loss below 1.0 tonne hayr . Land development cost will be about 108 man days ha. Variety of horticultural crops can be grown under the system depending on the market potential. Terrace riser in the vegetable blocks should be planted with fodder legumes. Hilltop should be used for forest species to meet the fuel and fodder requirement.

v) Hydrological evaluation of land use systems

Watershed based farming systems have shown the scope of using steep slopes for crop production. Some of the potential farming systems such as agriculture on bench terraces, horticulture, agri-horti-silvipastoral systems, etc., have been evaluated at the watersheds for their long term runoff, soil losses and so on. Land use practices in micro-watersheds with soil and water-conservation measures were found very effective in retention of rainfall; rainfall retained in situ varied between 80-100%. The surface runoff from shifting cultivation watershed remained higher in the range of 19.89 mm 54.99 mm in a year compared to other watersheds. Provision of trenches in fodder based agriculture most effectively conserved moisture and produced peak runoff 7.81 mm/hr.

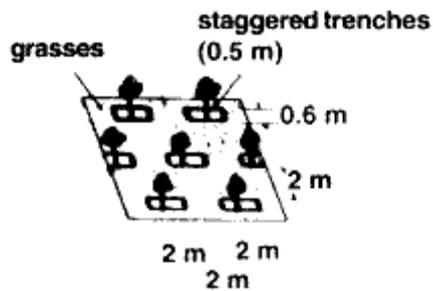
Food production system on hill slope without proper conservation measures is highly resource depleting and unsustainable. Proper land use in conjunction with mechanical soil conservation measures when adopted within the boundary of watershed can enhance sustainability of the production system in the region. The technologies, as mentioned above, help conserve rainfall in situ, thereby arresting soil loss and preserve soil fertility. The farming system models - agropastoral, agri-horti-silvipastoral, livestock based system and horticulture based systems developed for upland ecosystem through adoption of engineering measures on micro watershed basis restricted the soil loss



Techniques for Steeply Sloping Land

These techniques are useful to slow runoff and erosion from sloping land, and also to revegetate degraded areas. Areas with high rainfall, steep slopes, and thin soils should use slightly graded bunds / terraces / trenches to allow some drainage.

Above an 8% slope, contour trenches are useful. These are trenches dug in a trapezoid shape with a top width of 0.6 meters, and a bottom width of 0.4 meters, and a depth of 0.4 meters. The soil removed is used to create a berm just downhill from the trench. Trees and grasses can be planted on the berm and inside the trenches. The trenches should be dug perpendicular to the slope (along the contours). They can either be continuous or staggered, such that they are 2 meters long, with 2 meter gaps between every section, and two meters between every row. Note: in hilly areas, this method has been shown to decrease runoff by 80%.

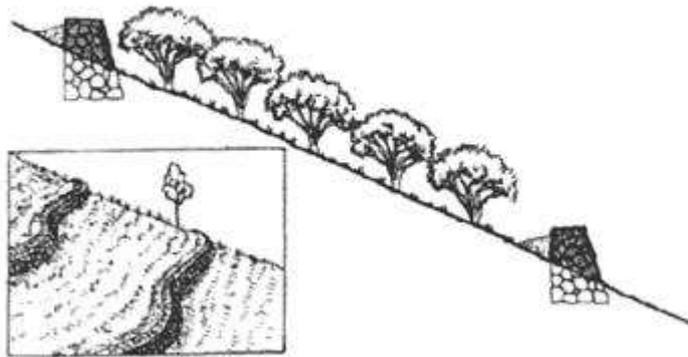


Staggered Trenches

Catch Pits or Crescent Pits

A similar concept can be applied by planting trees within full pits, or crescent shaped bunds across the slope.

Contour stone walls



Contour Stone Walls

Where stone is available, and if the soil is too shallow for creating bunds or terraces, stone walls can be built across the contours to slow the movement of soil and water down the slope.

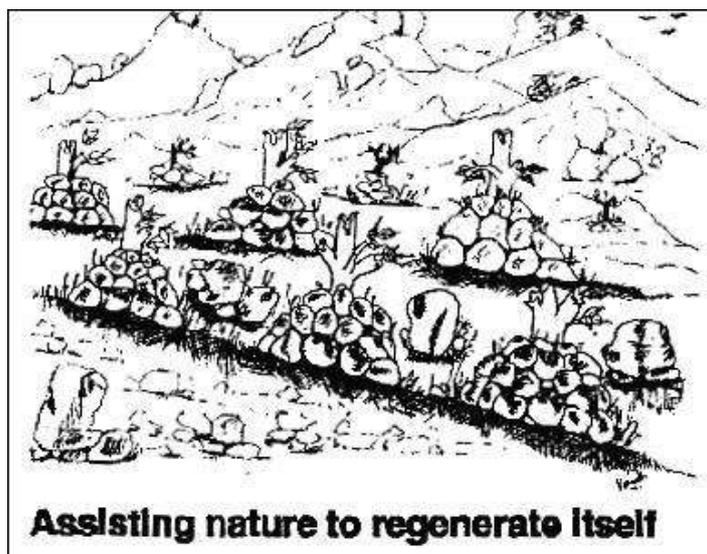
Using Bunds in Cultivated Land

Bunds have many benefits, including marking the boundaries of farm-holdings, slowing the movement of soil and water, and providing a place for integrating trees into agricultural systems. Here are some tips for using bunds within farmland:

- Cattle should be kept away from the area while establishing saplings, by using livehedge fencing. Cactus and Agave are useful for a livehedge fence.
- Larger trees can be planted on boundary bunds, and smaller trees which will be harvested more frequently can be planted on internal bunds, which divide one holding into separate sections.
- Internal bunds can be spaced every 20 to 30 meters apart to promote soil and water conservation. These bunds should follow the contours of the landscape.
- Trees on internal bunds can be pruned to a height of 5 feet to avoid shading crops, and the harvested biomass can be introduced to the soil to increase organic content.
- A ½ foot trench should be maintained ½ meter from the trees on the bunds to encourage the roots to grow downwards, rather than into the fields.
- Fodder grasses, such as Stylo hamata can also be planted on the bunds to increase stability, and provide fodder for harvesting.
- In sloping lands experiencing heavy rainfall, bunds should not follow the exact contour, but should be slightly sloping to allow for drainage along the bunds.
- Grass species for bunds include: vetiver grass, Sachcharum munja, and Stylo hammata

Restoring Highly Degraded Lands

In places where the land is too degraded for agriculture and the soil is too shallow for bunding, rocks can be used to protect existing stumps from browsing and allow regeneration. Rock fences can also be used to protect areas planted with fodder species. Hardy, drought tolerant trees such as neem, tamarind, custard apple and other local species can be planted. After a few years, the trees and fodder will yield income.



2. Watershed Drainage Basins – An Understanding

A Watershed Drainage Basin is an area of the earth's surface occupied by a surface stream or lentic water body together with all of the tributary streams, surface, and subsurface water flows. Drainage basins are important to understanding the characteristics of stream habitats. Basin features are a factor in predicting flood patterns, estimating sediment yield, and predicting water availability and quality. The downstream transfer of water, sediment, nutrients, and organic material all influence the characteristics of stream habitats. It is therefore important to understand the geologic, hydrologic, morphologic, and vegetational setting of a stream in its basin.

Large-scale features of a Watershed Drainage Basin include the size, shape, and relief of the basin. Small-scale features include measurements of channel length and slope, storage capacity, and drainage density of the stream network within the basins. Each of these geomorphic

understanding drainage basin attributes aids habitat investigators when interpreting field data. Basin scale attributes are regularly estimated from maps and digital terrain and land cover data.

Geomorphic Properties

Rationale: The most useful basin attributes for characterizing the setting of a stream and drainage basin are described here. The properties can be measured and estimated by one of two basin approaches. Basic area and length measurements can be done by hand on topographic maps.

Procedures: Delineate the drainage basin on a topographic map. The drainage basin divide (border) should approximate all locations at which surface run-off splits flow into and away from the basin. For all of the land enclosed in the drainage divide, precipitation drains by gravity into the stream or water body within the basin. Drainage divide should begin and end at the mouth of the stream or river being studied and should enclose only its tributaries.

Basin length. Basin length is estimated as the straight-line distance between the mouth of the basin and the drainage divide nearest to the source of the main stream. Basin length is used to calculate drainage shape.

Basin relief. Basin relief is the difference in elevation between the highest and lowest points in the basin. It controls the stream gradient and therefore influences flood patterns and the amount of sediment that can be transported.

Basin relief ratio. The basin relief ratio index is the basin relief divided by the basin length. It is useful when comparing basins of different sizes because it standardizes the change in elevation over scheme.

Basin surface storage. The percentage of the basin covered in lentic and impounded water bodies, including wetlands (optional), reflects the surface storage capacity of the basin. Determine the basin surface storage by measuring the area of each lake or impounded water body.

Drainage Density. An index of the length of stream per unit area of basin is calculated by dividing the drainage area by the total stream length. This ratio represents the amount of stream necessary to drain the basin. High drainage density may indicate high water yield and sediment transport, high flood peaks, steep hills, low suitability for agriculture, and high difficulty of access.

Drainage shape. An index of drainage shape is computed as a unitless dimension of drainage area divided by the square of basin length. It describes the elongation of the basin and is useful for comparing basins.

Main Channel Slope. Main channel slope is an estimate of the typical rate of elevation change along the main channel that drains the basin. This measurement is often related to peak flow magnitude and flood volume. Estimate the main channel slope by measuring the length of the main channel from the mouth of the stream or the study site to the mapped source of the main stream. At each stream channel bifurcation, follow the fork with either the higher stream order number (explained below) or the longer pathway to a stream source.

Total Stream Length. Total stream length is the sum of the lengths of all perennial streams within a basin.

Stream Order. Stream order, or classifying streams based on the number and type of tributary junctions, is an easily obtained, useful, but general indicator of stream size, discharge, and drainage area. These are techniques for determining stream order.

3. Sustainable Agriculture – An Understanding

Sustainable Development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The term sustainable is used in the strategy to mean improving the quality of human life while living within the carrying capacity of supporting ecosystems.

It is very difficult to define Sustainable Agriculture since there is no generally accepted definition of a sustainable agriculture system.

Agricultural Sustainability means different things to different group of people. The concept being 'organic farming', or other terms as 'natural farming', 'ecological farming', 'Biological farming', 'alternative farming', 'low input farming' and 'regenerative farming' in contrast to "high input, maximum production", SRI and intensive agriculture.

Sustainability is feeding people both today and tomorrow as well as preservation and maintenance of natural resources and productivity by developing land use systems that are both economically viable in short run, yet not environmentally degrading in long run. It thus conveys the idea of balance between human needs and environmental concerns.

The ultimate aim of sustainable agriculture is to develop farming systems that are productive and profitable, conserve the natural resource base, protect the environment and enhance health and safety over the long term. Effective soil and water conservation practices are essential for sustainable agriculture.

Sustainability has several dimensions - ecological, economic, social and cultural. The concepts of ecological and economic sustainability have implications for those engaged in packages of technology, services and public policies for farmers. Economic sustainability can be ensured through public policies based on remunerative marketing opportunities and equity for economically and ecologically disadvantaged sectors of farming community. Integrating the dimension of sustainability with productivity, profitability and stability in technology development and dissemination is however, no doubt a more difficult and challenging task. The traditional methods have been developed with the sole objective of maximising the available water for crop, and minimising soil erosion.

Living Soils

Directly or indirectly all food comes from soil. If it is not a living system, it can't continuously produce. Just as any other living thing, soil possesses physical, chemical and biological properties. It has physiological systems like digestion, respiration, circulation and excretion.

Soil organic matter is an essential component of the soil and in association with the soil fauna, contributes to the soil fertility. Soil is said to have "life" only when it is holistically looked upon along with its inhabitants, in the form of flora and fauna. Soil faunal density and diversity is also partly due to the C: N availability in soils. Though the soil is rich in microflora, it remains inactive and inefficient when there is lack of organic carbon. Sources of carbon in the form of cellulose are mainly contributed by plants. Practices like mulching and incorporating crop residues into the soil helps build up the soil carbon. Integrating livestock with agriculture enables access to animal waste which can be converted to organic manure.

Most living things in soils, including plants, insects, bacteria and fungi, are dependent on organic matter for nutrients and energy. Soils often have varying degrees of organic compounds in different states of decomposition. Many soils, including desert and rocky-gravel soils, have no or little organic matter; while soils, that are all organic matter are infertile.

Organic matter that has decomposed to a point where it is resistant to further breakdown or alteration. Humic acids and fulvic acids are important constituents of humus and typically form from plant residues like foliage, stems and roots. After death, these plant residues begin to decay, starting the formation of humus. Humus formation involves changes within the soil and plant residue, there is a reduction of water soluble constituents including cellulose and hemicellulose; as the residues are deposited and break down, humin, lignin and lignin complexes accumulate within the soil; as microorganisms live and feed on the decaying plant matter, an increase in proteins occurs.

Humus formation is a processes dependent on the amount of plant material added each year and the type of base soil; both are affected by climate and the type of microorganisms present. Soils with humus can vary in nitrogen content but have 3 to 6 percent nitrogen typically; humus as a reserve of nitrogen and phosphorus, is a vital component effecting soil fertility. Humus also absorbs water, acting as a moisture reserve, that plants can utilize; it also expands and shrinks between dry and wet states, providing pore spaces. Humus is less stable than other soil constituents, because it is affected by microbial decomposition, and over time its concentration decreases without the addition of new organic matter.

4. An Understanding of Climate Change

(Dr. Suman Sahai – Gene Campaign Foundation)

Climate change is likely to have a long term impact on social, environmental, economic, technological and political process. Most destructive influence will be on agriculture and food production in the poor. Changes in rainfall patterns and temperature regimes will influence the local water balance and disturb the optimal cultivation period available for particular crops, thus throwing food and agricultural production out of gear.

The biggest blow to food production is expected to come from the loss of multiple cropping zones. The worst affected areas are predicted to be the double or triple cropping areas, where two to three crops are produced in a year. To offset this loss, an effort must be made to convert single cropping areas into two crop zones. This can be done by efficient rain water harvesting and developing micro watersheds and water bodies so that in rain fed areas where crop is being harvested today, water can be made available for a second crop.

Coping with the impact of climate change on agriculture will require careful management of resources like land, water and biodiversity. Food production can be stabilised and livelihoods secured if the impact of climate change is factored into the design and implementation of development programmes. Large scale awareness programmes are necessary to prepare farmers, who are today bewildered by the rapid fluctuations in weather conditions that are affecting their farming. Their traditional knowledge does not help them to manage the current anthropogenic changes.

It is necessary to develop and demonstrate successful, replicable models to enable agriculture and food production to both adjust to the changing climate as well as mitigate the emissions from crop production.

To introduce the fundamental changes that are necessary to make agriculture sustainable and high yielding.

Practices in agriculture will need to shift from intensive, mechanized, water demanding agriculture to more sustainable, conservationist methods that give higher crop yields using less water. 'More crop per drop of water' is the strategy recommended to tackle drought. The approach is applicable in a wider sense when addressing the challenges posed by climate change.

Sustainable practices like conservation agriculture can keep carbon fixed. Conservation agriculture is a system of farming that conserve, improves and make more efficient use of natural resources through integrated management of available soil water and biological resources. The reduced till agriculture advocated by conservative agriculture means more carbon can remain trapped in the soil instead of being released when the soil is ploughed extensively before each planting. Important interventions include proper land preparation to minimize soil erosion, making contours and water channel to maximize water use, keeping overall water use low. Micro irrigation and drip irrigation are effective but expensive. Other helpful actions are planting trees and fodder crops on contours and watersheds, agro forestry and reforestation, crop rotations, green manure crops and intercropping as well as mulching and keeping a cover of crop residues on the surface.

Replacing agrochemicals with bio-organic substitutes, leads to a significant reduction in the carbon footprint. Reducing the application of nitrogenous fertilisers like urea will have a great impact on nitrous oxide emissions. Indian agriculture which is largely manual, as against the highly mechanized agriculture of the west, has a low carbon footprint because it does not use fossil fuels.

System of Rice Intensification

Some (relatively) new agronomic intensification practices are showing promise as adaptive strategies and are yielding good results, particularly in rice, wheat, maize & sugarcane cultivations.

The System of Rice Intensification (SRI) is a water saving, methane emission reducing rice cultivation strategy. Instead of flooding paddy fields as in current rice cultivation, the SRI consists of watering and draining the fields in a manner that significantly reduces the amount of water required. Essentially, SRI changes agronomy practices in a manner that enables prolific root formation and tilling that leads to more panicles and hence more grains per plant. This has an obvious impact on raising crop yields. This strategy increases weeds in the fields which have to be dealt with but apart from reducing the use of water in crop production, SRI also reduces the build up of methane by doing away with standing water in rice paddies.

5. An Understanding of Crop & Tree Intensification

Improving Crop Productivity –

Crop productivity is a function of a range of factors. These may be classified as:

1. Land & water related factors (such as farm/watercourse location, quality of land, source of water, quality and quantity of water and timing of water application, etc.)
2. Climatic factors (rainfall, temperature, sunshine, etc.)
3. Agronomic factors such as quality, quantity and timing of input application (seed, fertilisers, labour, etc.)
4. Socio-economic factors (such as farmer education level and experience in farming, farm size, land fragmentation, availability of credit)
5. Farm management factors (adoption of modern production technologies, farm planning and management practices, etc.)

Increasing Agricultural Production

The principal technical programmes for increasing agricultural production, around which intensive work is to be organised, are : (1) irrigation, (2) soil conservation, (3) fertilisers and manures, (4) seed multiplication and distribution, (5) plant protection, (6) better ploughs and improved agricultural implements, and adoption of scientific agricultural practices.

Steps in Raising Improved Agricultural Produce

To increase our food production we can sow good quality seeds and improve the methods of sowing. We can make the soil more rich and even use better techniques for harvesting the crops. Some of the agricultural practices which scientists have developed and which our farmers have started are explained here.

1. Preparation of soil & farm land management

This is an important practice of land preparation with organic manuring, green manuring, system of retaining soil moisture, which helps to enrich the soil and make it more fertile and aerated. It involves addition of manure followed by turning, loosening and leveling of the soil, using agricultural implements like plough, weeders and other mechanical farm implements. Each farm land is advised to have a detail soil analysis conducted and enrichment of soil is done in order to meet the deficiency.

2. Seed selection & treatment

Good quality seeds are essential to grow a strong and healthy crop. Healthy seeds can be brought from trusted sources or farmers can produce their own seeds. In that case, seed selection can be used to improve the quality of seeds.

Seed treatments refers to the application of fungicide, insecticide, or a combination of both, to seeds so as to disinfect and disinfect them from seed-borne or soil-borne pathogenic organisms and storage insects. It also refers to the subjecting of seeds to solar energy exposure, immersion in conditioned water, etc.

3. Nutrient rich raised bed nurseries

In certain crop plants like cereals, minor millets, pulses and some of the vegetables, seeds are not sown directly in the main field. First these seeds are sown in a nursery bed. Once they grow to a certain age they are transferred and planted in the main field. These small plants are called seedlings or saplings.

The raised beds are made in high rainfall areas. Raised bed of 10-15cm above ground level are made of bricks, stones, bamboos or stands which prevent edges of beds from crumbling during rains or while giving irrigation the beds. These beds prevent waterlogging and drainage is also easy.

The raised bed nursery requirements are a layer of healthy soil mix arranged on a raised firm surface. It uses less land, requires fewer seeds and inputs, such as organic fertiliser and water, reducing nursery costs by up to 50%. After 8 to 12 days, the seedlings reach the two-leaf stage—which favors quick establishment in the field and rapid growth—and are ready for transplanting. This is much quicker than the 25–35 days required for traditional wet-bed nurseries.

Raised Bed Nurseries are basically nutrient-rich and un-flooded raised nurseries, which is one of the major requirements.

How to establish Nutrient-rich and un-flooded raised nursery:

- i. Use good-quality seeds. It is important to use good seeds because they result in higher & more uniform germination, less replanting, fewer weeds, healthy seedlings and 5–20% higher yields.**
- ii. Pre-germinate your seeds. Soak your seeds in salt water for 12 hours (some varieties may need a longer time to bud). Drain the water after 12 hours, and keep the seeds moist by covering them for another 24 hours. By this time, the seeds will have sprouted buds and the first seed root will be about 2 to 3 millimeters long.**
- iii. Prepare the soil mixture. You need 4 cubic meters of soil mix for every 100 square meters of nursery area. Mix 7 parts soil with 2 parts well-decomposed and dried cow & chicken manure, green manure, vermi compost and 1 part fresh or charred rice hull.**
- iv. Prepare the raised firm surface nursery area by increasing & raising the height of the soil by 4 to 6 inches (provide canals to facilitate drainage). Prepare a 100-square-meter nursery area for every 1 hectare that will be planted. Select a level area near or in the main field. Level your seedbed and spread banana leaves or plastic sheeting on top to prevent the roots of the seedlings from penetrating into the soil.**
- v. Lay the soil mixture. You can do this with or without using a wooden frame/bricks/bamboo or wooden sticks above the plastic sheets. For those using a wooden frame or frames (bricks, bamboo, wooden sticks, etc.) place the frame on top of the plastic sheets. The frame should be half a meter long, 0.3 meter wide, and 4 centimeters deep, divided into equal segments (or one small frame 12 x 12 inches). Smaller segments are required to facilitate transplanting the seedlings to the field without damaging the roots. Then, fill the frame almost to the top with the soil mixture you prepared.**
- vi. Sow the pre-germinated seeds uniformly. Sprinkle soil and pat gently to embed them at about 2–3 centimeters into the soil, mulch with paddy straw and then sprinkle water immediately. Cover the nursery area with plastic sheets.**
- vii. Remove the wooden frame or sticks and repeat laying the soil mixture and sowing seeds until you have finished the whole nursery area. For those who prefer not to use a wooden frame, you can use bricks, bamboo or wooden sticks instead. Simply create a fence around the nursery using bamboo pegged with wooden sticks, pour the soil mixture inside the frame and level before sowing. Cover the nursery with rice straw then sprinkle water and then cover with banana leaves or plastic sheeting once you're through.**
- viii. Water the nursery twice a day for 5 days and keep it covered with rice straw, banana leaves or plastic sheets to keep the soil moist in. Make sure that you protect the nursery from heavy rains for the first 5 days after seeding.**
- ix. Five days after seeding, remove the cover and continue the water twice a day.
(If your seedlings show yellowing after 7 days, it means that they lack nitrogen. You can solve this by sprinkling the seedlings with 0.5% urea solution (if green manure fertilizers were not used). Simply dissolve 1.5 kilograms of urea in 300 liters of water to sprinkle over 100 square meters.)**
- x. About 8 to 12 days after seeding and transport them to the field, along with soil. A metal / bakelite (2 mm) / wood / aluminum (1 mm) boards could be used for lifting the seedlings along with soil and transplanting in the field, without any disturbance to the roots.**

4. Transplanting

The process of removing the seedlings from the nursery bed along with soil and planting them singly with wide spacing 10-12 inches square in the main field is called transplanting. When we transplant, we must select those seedlings which have 2 healthy leaves. These are sowed at proper distance from each other. The main field must be ploughed and manured before transplanting. Transplanting of seedlings is a very important practice. Plants roots are able to go deep into the soil and get more nutrients. When seedlings get good food, they grow into healthy plants and give a better yield.

5. Fertilizers

Crops need nutrients like phosphorus, calcium, nitrogen etc. *Farmyard manure*, as the name suggests is a mixture of decomposed cattle dung (excreta) and urine, left over fodder (cattle feed) and litter (bedding provided to cattle in the farm). *Compost* is manure made from vegetable and animal refuse collected from domestic waste, straw, weeds etc., dumped in a deep pit to decompose. *Vermicompost* is compost broken down by earthworms. Like fertilizers manures too add nutrients to soil.

6. Starter Solutions for Crops

Cow dung and cow urine are the sources which are cheapest and most accessible for farmers to increase the biological activity in their soils. The cow dung and urine mixed with a small quantity of jaggery is being extensively used in India under different names like Jeevamritam, Amritapani, starter solution, Janjeevani and so on. This solution is mixed with the irrigation water or spray, is a most effective way.

7. Watering

Water is necessary for proper development of plants. Roots fail to develop and penetrate in the dry soil. Water is essential during the seedling, flowering and grain filling stages of the crop.

System of Fruit Tree Intensification

The objective of fruit tree intensification is to create conditions to increase the productivity and competitiveness of targeted sectors, thus contributing to economic growth and the reduction of poverty.

The system of fruit tree intensification will target, the intensification and rehabilitation of rainfed fruit trees and the expansion of fruit tree production. Ultimately, it aims to increase and stabilize farmers' income in target areas by facilitating the shift to more valuable tree crops. Intensification and rehabilitation of existing trees, expansion of tree crops by converting hillsides planted with annual cereal crops to new high value, terraced, perennial trees.

Intensification of fruit trees help in improving vegetative cover, reduce soil erosion, help in maintaining soil moisture and overall help in maintaining livelihood and environmental security.

Tree intensification will involve fruit / horticulture plantations, forest home gardens, horticulture wadis, agro-forestry and regeneration of traditional tree covers including forest varieties, bamboos, timber, fodder, medicinal plants, shrubs, creepers and grasses.

6. An Understanding – Kisan Sheti Shala – empowering farmers, landless and women

Group Approach to be followed – An Understanding of Kisan Sheti Shala (KSS) for enhancing the knowledge, skills and collective/group approach for Sustainable Agriculture, Livelihood and Environmental Security:

KSS Learners – Famers, Landless and Women

The **KSS** is a group-based learning process that brings together the concepts and methods for rainfed sustainable agriculture, farm planning, water management, livestock, agroecology, experiential education and community development for livelihood and environmental sustainable development.

KSS approach should lead to a deeper understanding of the problem, its causes and appropriate actions by farmers. Sustainable agricultural development required more than just the acquisition of agriculture & ecological knowledge by individual farmers. It also required the development of a capability for generating, adapting and extending this knowledge within farming communities. The weakness in the earlier agricultural development programmes that fostered a dependency on external sources of expertise. Now, the KSS enables farmers to organise new groups, alliances, networks and associations and became involved in planning and implementing their own interventions. These interventions were highly diverse, ranging from self-research, training, sharing, actions, marketing and advocacy work. The landless and women will be trained the new system of agriculture intensification – crop & tree intensification, basic concept of farming, other agricultural systems & methods. KSS further enables the landless and women to initiate their own

Service Centres to give services to farming communities such as nursery raising, tools and equipments for agriculture such as weeders, markers, treadle pumps, etc., services for value addition, marketing the finished products, etc.

Technically strong facilitator: The Person/Facilitator must have certain skills at growing the crop concerned. Training the field staff in season-long courses, which provide basic technical skills for growing and managing the crop. Facilitation skills and group dynamic/group building methods are also included in this season to strengthen the education process in the Farm Schools.

Based on crop phenology and time limited: The Farm Schools and season long training for trainers are based on the crop phenology; seedling issues are studied during the seedling stage, fertiliser issues are discussed during high nutrient demand stages, and so on. This method allows to use the crop as a teacher, and to ensure that farmers can immediately use and practice what is being learned.

Group study: Most Farm Schools are organised for groups of about 25 persons with common interests can support each other, both with their individual experience and strengths, and to create a “critical mass”. The number of 25 is roughly the number that can comfortably work together with one facilitator. Usually these 25 are sub-divided into groups of five persons so that all members can better participate in field observations, analysis, discussion, and presentations.

KSS Site: The Farm Schools are always held in the community where farmers live so that they can easily attend weekly and maintain the Farm School studies.

Building groups: One of the jobs of the facilitator is to assist the Farm School to develop as a support group so that participants can support one another after the Farm School is over. This is done by having elected officers (head, treasurer, and secretary), and group identity. The Farm School needs its own name. During the season, the Farm School includes group building exercises to build group trust and coherence.

Basic science: Farm Schools try to focus on basic processes through field observations, season-long research studies, hands-on activities. It has been found that when farmers have learned about basics, combined with their own experiences and needs, they make decisions that are effective.

Study fields: The Live Farm Demonstration for group study. This farm is essential for a Farm Schools, for farmers to carry out studies, allowing them to take implementation & management decisions. This provides other farmers a way of observing, learning, testing a new method before applying it to their own fields.

Evaluation and Certification: All Farm Schools include field based pre- and post-tests for the participants. Farmers with high attendance rates and who master the field skill tests are awarded graduation certificates.

Follow-up: All Farm Schools normally have at least one follow-up season. Follow-up has been known to be a little as monthly support sessions for farmers to discuss their own problems in implementing, to as much as farmers running a complete Farm School for other farmers.

Developmental Impacts of the Kisan Sheti Shala		
Domain	Immediate impact	Developmental impact
Technical	Knowledge about ecology	More sustainable production
	Experimentation skills	Improved livelihoods
	Improved crop management	Ability to deal with risks, opportunities
	Pesticide reduction	Innovation
	Yield increase	More cost-effective production
	Profit increase	Reduced water contamination
	Risk reduction	Reduced frequency of farmer poisoning
		Reduced public health risks
		Improved biodiversity
		Improved marketability of produce
Social	Group building	Poverty reduction
	Communication skills	Collaboration between farmers
	Problem solving skills	Farmer associations
		Community agenda setting
		Farmer study groups
		Formation of networks
	Farmer-to-farmer extension	

		Area-wide action
Political	Farmer-extension linkage	Stronger access to service providers
	Negotiating skills	Improved leverage position
	Educational skills	Awareness campaigns
		Protests
		Policy change

Training and Visitation comparison with Farm Schools

Point	Classical Training and Visit	Farm School evolution
Field-level extension officer's job	Deliver pre-packaged "messages" from a research-extension linkage. Primary job is information transfer, not technical expertise, which is reserved for Specialists not at the field level.	Technical Facilitator: Every KSS trainer should have basic technical skills (at least able to grow the crop, or rear animals, etc.). Secondly, every KSS trainer should have group oriented training and management skills. These skills are typically learned in a season-long Training of Trainers where they learn what they will teach.
Experience of trainers	Variable, but most often lacking basic farming skills and experience. Field level staff given communication skills.	Master trainer with farming experience gained during Training of Trainer programmes in which each person is required to grow crops and carry out field studies so that they test what they will use in Farm Schools later.
Information	Primarily top-down messages from distant research stations about situations presumed to be representative of farms.	Recommendations are tested against conventional practices and new information about to the site emerges. Promotes local creativity.
Contact point	Contact farmers that are supposed to train other farmers by passing on external information.	Groups of interested farmers that farm on a daily basis through generating local study circles.
Time frame	Continuously, forever, on a two-week regular cycle not based on any natural phenology.	A pre-defined period. Usually on a weekly basis over a season. KSS may be longer than a season, but never less than one season integrated with the crop phenology.
Pedagogy	Training: Use of static pre-determined demonstrations and in field examples to show and tell.	Education: A focus on underlying principles that allow farmers to derive and adopt recommendations within their own dynamic their ecological, social, and economic realities.
Evaluation	At best indirect: based on measuring delivery and funds spent.	Pre- and post-testing. Community self-surveying. Identifiable indicators defined in terms of system-critical factors. Internal rates of return.
Training site	Demonstration field, training centers, home of Contact Farmer, static not revisited in time or observed in terms of any on going process.	A shared farm in which the KSS uses to dynamically validate and test new management methods over the entire season (e.g. decisions during one part of the season can be verified by yield cuts)
Long term objectives	Increase food production, etc. "Farmer's attitudes, lack of knowledge, and practices are an object/constraint of a development process"	Nurture groups that will continue to address agricultural and community problems on their own and with technical backstopping. "Farmers as the subject of development"
Research	Primary source of information is research stations assumed to develop representative models that are widely applicable.	A process and consequence of local testing and within-community/ecosystem learning.

After successful organising farmers associations and KSS process and field demonstrations, it is visualised that the farmers would promote their own local "Farmer Producer Organisations".

It is visualised that the Farmer Producer Organisation (FPO) would be farmers own organisation actively involved in – local knowledge hub and centre, promoting value addition in order to increase shelf-life, post harvesting, extension service centres, hiring of agricultural equipments & machines, collective & group marketing and leveraging on behalf of all members & other farmers the agricultural government programmes and schemes.

The KSS should also train landless, women and Self-help group members in order to build up the capacities in activities of agriculture development, services, special sustainable development activities as Crop & Tree Intensification, inter & multi cropping, system of rice intensification (SRI) and other services in order to increase the crop and tree agriculture production.