

Resource management in **RAINFED DRYLANDS**

An information kit

IIRR

MYRADA

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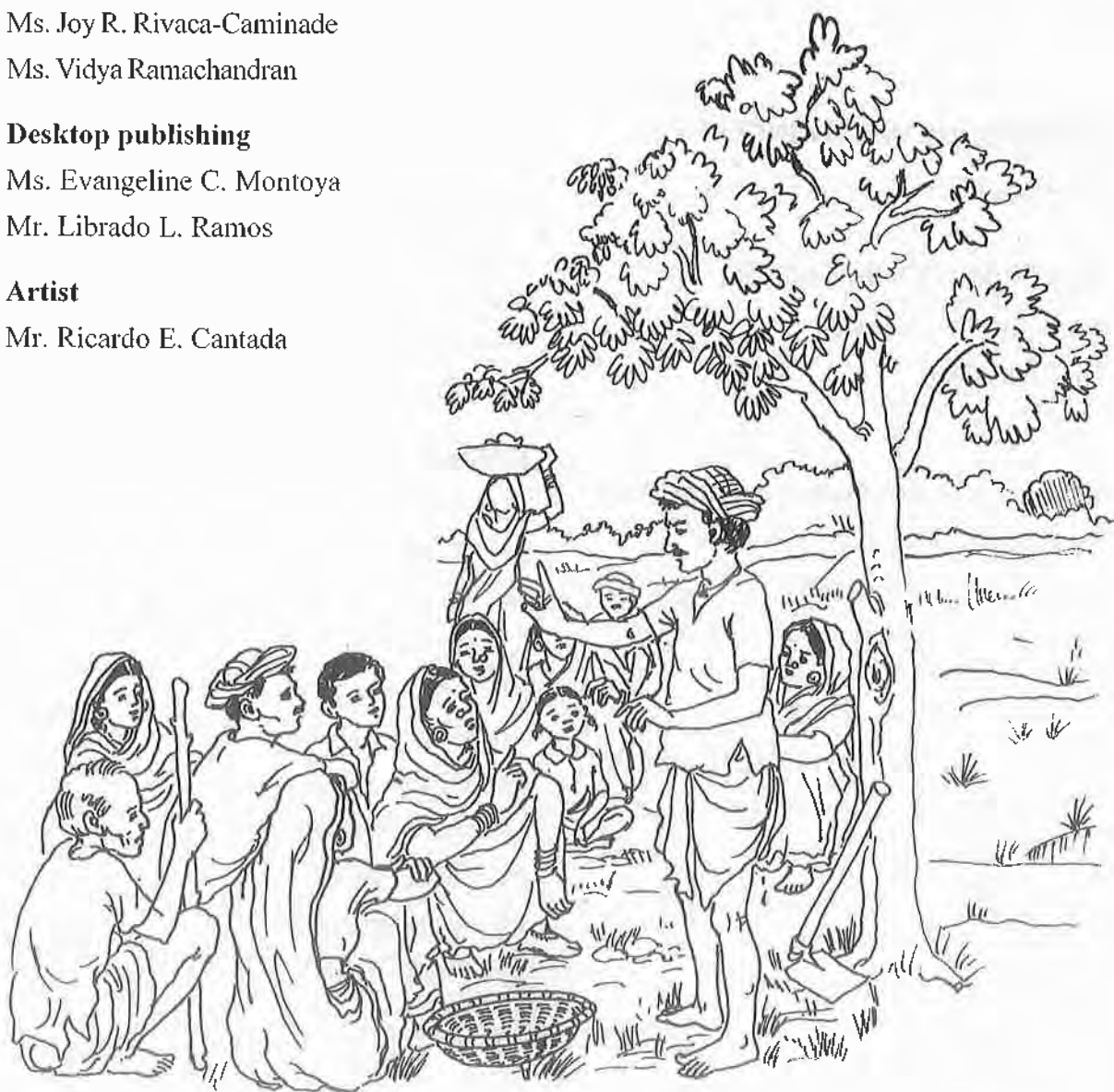
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Introduction

Rainfed drylands refer to areas with less than 800 mm of rainfall per year. Drylands are under increased pressure due to the prevalence of poor agricultural practices, overgrazing and the intensive use of agricultural lands to meet human, animal food and fibre requirements. This has placed unprecedented demands on dryland resources which being characteristically fragile, are subjected to accelerated soil erosion, loss of soil fertility and decreased productivity. An assessment of dryland degradation by the United Nations Environment Program (UNEP) shows that 4,500 million hectares or 35% of the earth's surface are threatened by desertification.

Poverty is often associated with environmental degradation. Some of the poorest people live in fragile environments. A total of 1.2 billion hectares are experiencing moderate, severe and extreme degradation. The largest areas are in Asia (453 million hectares) and Africa (321 million hectares). Poverty increases as rainfall decreases. Drylands alone are home to some 1.5 billion people (37% of the population of Asia, 34% of Sub-saharan Africa and 59% of Arab States). More than 500 million of the world's poorest people live on marginal lands (the number is expected to rise to 800 million in 2020).

In some countries, however, drylands cover more than 50% of the total land area. India, for instance, has a land mass of 329 million hectares, of which 224 million hectares are dryland areas. An estimated 45% of the country's food grain production comes from rainfed drylands.

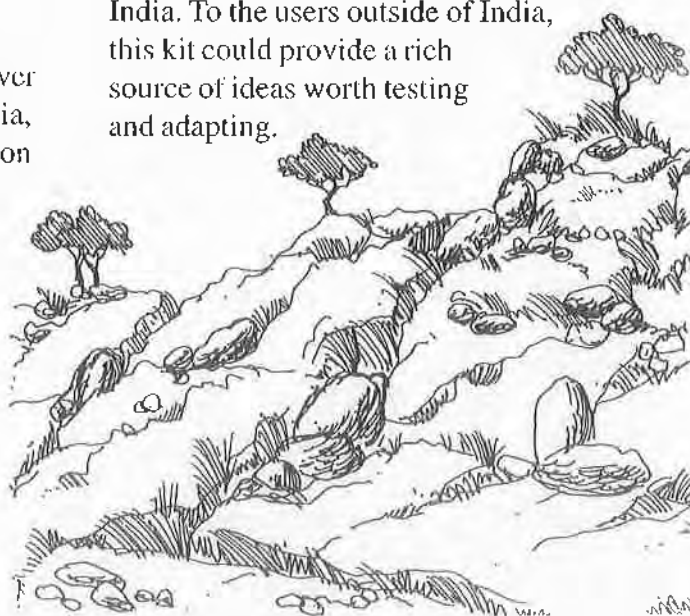
Though India is currently self-sufficient in food grain production, it will need to produce at least 230 million tons of grain by the turn of the century to meet escalations in demand for grains to feed humans and

livestock. Besides, about 65% of the Indian people depend on agriculture for their livelihood.

In recent years, agricultural technologies and practices developed by scientists, farmers and other practitioners involved in improving dryland productivity have emerged in different parts of the world. India, in particular, has undertaken an extraordinary amount of research and successful field action in dryland agriculture. However, little attempt has been made to put information together in a way that could provide broadly applicable practical guidelines rather than location-specific technologies. Thus, too many good ideas or research findings remain underutilised.

This manual is an effort to compile farmer-tested, dryland technologies and practices based on the rich and extensive Indian experiences.

It is our hope that this information kit, written in simple English language with line illustrations, will help planners, field workers farmer leaders and extensionists involved in dryland development in India in promoting these technologies and strategies. This book could also be of use to others involved in dryland agriculture development outside India. To the users outside of India, this kit could provide a rich source of ideas worth testing and adapting.



The purpose of this book is to provide a comprehensive overview of the current state of research in the field of artificial intelligence. It is intended for researchers, students, and practitioners who are interested in the latest developments in this rapidly evolving field.

The book is organized into several parts, each focusing on a different aspect of artificial intelligence. The first part covers the foundations of artificial intelligence, including the history of the field and the basic concepts and techniques used in AI research. The second part focuses on the applications of artificial intelligence, including natural language processing, computer vision, and robotics.

The third part discusses the ethical and social implications of artificial intelligence, including issues such as privacy, security, and the potential for bias and discrimination. The fourth part provides a detailed overview of the current state of research in artificial intelligence, including the latest advances in machine learning, deep learning, and reinforcement learning.

The book is written in a clear and concise style, making it accessible to a wide range of readers. It includes numerous examples, diagrams, and references to help readers understand the concepts and techniques discussed. The book is also available in a digital format, which allows readers to access the content online and download the figures and tables.

We hope that this book will provide a valuable resource for anyone interested in artificial intelligence. It is our goal to make this book as useful and informative as possible, and we welcome any feedback or suggestions from readers. We also hope that this book will inspire new research and discoveries in the field of artificial intelligence.

The authors of this book are grateful to the many people who have supported them throughout the process of writing it. They include their families, friends, and colleagues, as well as the many students and researchers who have provided them with valuable feedback and insights. They also thank the publishers for their support and for making this book available to a wide audience.

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A workshop on resource management for rainfed drylands

This information kit was produced during a national workshop held at the Ecumenical Christian Centre, Bangalore, India from January 17 to 31, 1997.

The workshop was jointly organised by the International Institute of Rural Reconstruction (IIRR), based in the Philippines and MYRADA, a national NGO based in Bangalore, India. An inter-agency project steering committee involving representatives from IIRR, MYRADA, OUTREACH Volunteers for Rural Development, Bangalore, ICRISAT, Society for Promotion of Wastelands Development (SPWD), New Delhi and the University of Agricultural Sciences (UAS), at Hebbal, Bangalore was established in 1994 to provide guidance in developing the information kit.

The aim of the workshop was to produce a set of information material (kit) on successful dryland agricultural strategies. A participatory workshop was conducted involving academicians, researchers, government and non-government staff, extension personnel and farmers. A total of 74 participants attended the workshop (42 from non-government organizations and 32 from government institutions).

The workshop provided opportunity for informal networking among people who ordinarily would not have the opportunity to work together. It also allowed participants to know what human and technical information resources are available for dryland development in the country.

Collaborating organizations

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MYRADA

MYRADA, an NGO based in India, works primarily with small, marginal and landless farmers. Thirteen years ago, MYRADA became concerned about the decline of the productivity of the drylands and the fact that farmers in these environments were falling into debt. While MYRADA continued to provide alternative livelihoods, it soon became evident that the poor still relied heavily on agriculture. In 1985, MYRADA decided to focus on increasing and sustaining the productivity of the drylands. A micro

watershed management strategy was introduced. It fostered people's management systems to control and manage water and soil as well as enrich the soil with biomass. There were two slogans: "Make the water walk" and "Bring the soil back to life". While MYRADA had the confidence that it could foster water conservation efforts, it needed help in bringing the soil back to life. This is when IIRR came forward to start a joint project with MYRADA. The experiment in South India, supported by the Ford Foundation in New Delhi, resulted in wide acceptance by farmers of the need to plant trees, raise their fuelwood needs and use biomass to restore organic matter in the drylands. The project served to modify the micro climate in marginal lands, improving food production efforts and restoring soil fertility in more than 400 farms in otherwise harsh and fragile environments.

MYRADA currently works with 62,679 families and continues to strive to improve the lives of some of the poorest farmers in the world.



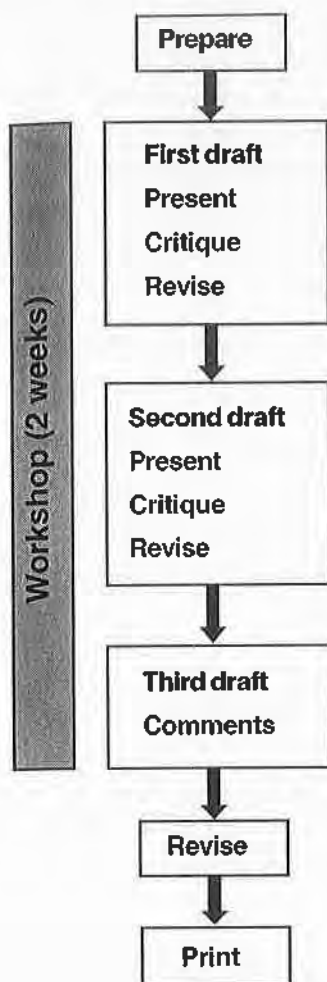
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International Institute of Rural Reconstruction

The International Institute of Rural Reconstruction is a non-profit, non-government organisation devoted to improving the quality of life of the rural poor in the developing nations of Africa, Asia and Latin America. Founded in 1960, IIRR focuses on development strategies that release powers of the rural poor to transform their lives.

IIRR's Environment, Natural Resources and Agriculture Program (ENRA) addresses the interlocking problems of food security, income generation and environmental protection through the development and promotion of economically-viable strategies and practices.

IIRR has conducted workshops to produce kits on several topics related to agriculture and the environment: regenerative agriculture, low-input rice production, integrated aquaculture-agriculture, sustainable agriculture in Nepal, agroforestry in Ghana, biodiversity in Western Ghats of India, environmentally-sound technologies for women in agriculture in India, bio-intensive gardening and resource management for upland areas in Southeast Asia. These kits have achieved wide acclaim because of their practicality and usefulness. They are used in universities, ministries, non-government organisations and training institutions throughout the world (more than 55 countries). Several have been translated into other languages (including Spanish, Thai, Vietnamese, Khmer, Bangla, Telugu and French, among others). IIRR has also trained staff of organisations in several countries how to produce similar kits through such workshops.



The workshop process

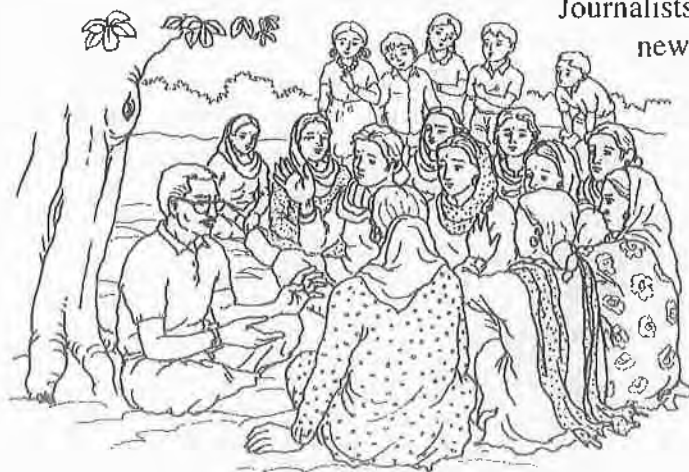
The workshop used a participatory process pioneered by IIRR over the past decade. The Institute has conducted about 20 similar workshops using this process.

Prior to the workshop, a list of potential topics was developed by the project steering committee along with the identification of resource persons on the selected topics. The resource persons prepared the first drafts of their papers using the guidelines provided. These papers were presented at the workshop where they were critiqued by fellow participants. An editor-artist team helped the writer revise the draft which was presented in a modified form a second or even a third time. Further feedback was sought. After the revisions were considered acceptable by most workshop participants, the materials were finalised and desktop published.

The concentration of resource persons, editors, artists and desktop publishing resources at one time and place enabled materials to be produced more quickly than is typical for similar publications. The sharing of experiences among participants fostered exchanges and informal networking.

Who benefits from this kit?

This technical information material was designed for middle level development program managers, agriculture technicians, specialists, field extension personnel of government and non-government organisations working with dryland development projects with a focus on natural resources management. The information kit can also be used as reference material and a source of technology and strategy options. The English language version can be adapted and revised for regions in India, or translated into national languages. The indirect beneficiaries will be the tens of thousands of farmers they work with, who will benefit from improved dryland agricultural strategies.



Journalists can also use the information kit in newspaper columns as there will be no copyright on the publication. Academicians can also use individual materials to support undergraduate courses and other similar training activities.

The chapter contents

The information kit is divided into seven chapters, each containing several interrelated topics. Where necessary, specific examples such as brief case studies were added to help clarify certain concepts. Different ways of doing certain operations are sometimes presented. The kit accommodated most of the views of the workshop participants.



Chapter 1 presents the general issues affecting rainfed dryland development. The chapter begins with an overview of dryland agriculture in India. This is followed by a discussion of the natural resources degradation process and some salient features of biodiversity conservation in the drylands. Also discussed are equity and gender issues, indicators of unsustainability and traditional approaches to natural resources management in India.

Chapter 2 discusses the concepts, strategies and practices employed in addressing problems of soil and water conservation. Setting the discussion is an overview of soil and water conservation, followed by why farmers reject conservation measures. The succeeding topics deal with different soil and water conservation technologies and strategies used in dryland improvement.

Chapter 3 presents the principles, concepts and methods for crop management in the drylands.

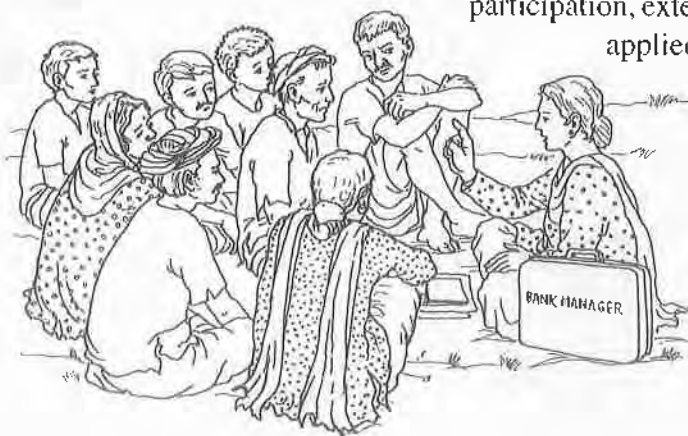
Chapter 4 discusses a wide range of soil management practices suitable for dryland conditions. The strategies presented also include those applicable to problem soils such as vertisol, alfisol and saline soils.

Chapter 5 deals with alternative land use systems in the drylands. The chapter presents some practical strategies for achieving high returns from dryland areas.

Chapter 6 describes some instruments and post-harvest practices suitable for drylands.

Chapter 7 discusses some of the innovative approaches in participation, extension and institutional partnerships as applied to dryland development. Some

concepts and applications of project monitoring, evaluation and review are also presented.



1 Overview of rainfed drylands issues

Rainfed dryland agriculture in India: An overview

- Of the total geographical area of 329 Mha, 175 Mha are under various stages of degradation.
- About 60% of cultivated land suffers from soil erosion, water logging and salinity problems.
- About 30 Mha of fragile land now under cultivation are progressively degrading.
- Per capita net sown area which was 0.38 ha in 1950 is less than 0.2 ha now.
- There are 450 million heads of cattle in India.
- Livestocks require 932 Mt of green and 750 Mt of dry fodder annually.
- Current availability of green and dry fodder is 250 Mt and 414 Mt, respectively.
- Dependence on fuelwood as source of energy for cooking is inversely related to the size of the city.
 - 80% dependence in town of less than 20,000 inhabitants
 - 10% in metropolis
- Gap between demand and supply for fuel now stands at 211 Mt.
- Current dependence on non-commercial sources of energy, at about 40%, is likely to fall to 15%.
- India receives 400 Mha m of rainwater annually.
- Nearly 160 Mha m falls on agricultural land.
- Around 24 Mha m equivalent rainwater is available for harvesting in small-scale water harvesting structures.
- Regions with up to 1000 mm rainfall potentially produce 6.32 Mha m harvestable runoff.
- Nearly one fourth of the total annual rainfall is received during the pre or post cropping season.

Drought

During the last 120 years (1870-1990), drought occurred 425 times across 29 out of 35 meteorological subdivisions of India. About one fifth of the total geographical area was affected once in 5 years, one third, once in 10 years, and one half, once in 50 years.

Current land use in India

Geographical area (Mha)	328.7
Net sown area (Mha)	141.4
Net irrigated area (Mha)	48.8
Net unirrigated area (Mha)	92.6
Unirrigated area (%)	65.5

Source: Agril. Stat. at a Glance (1995)

Distribution of land holdings

Number of holdings (Million ha)

World :	400
India :	105

Distribution (%) of holdings (by category) in India

Small and marginal (< 2 ha):	78.0 (32.2)
Semi-medium to medium (2 to 10 ha):	20.4 (50.4)
Large (>10 ha):	1.6 (17.4)

Figures in parentheses are the net cultivated area.

Source: Agril. Stat. at a Glance (1995)

Review

- A number of technologies to raise the productivity of rainfed regions had been developed.
- The risks inherent to rainfed regions pose a tremendous challenge to research scientists and development functionaries to develop and prescribe appropriate technologies for wider diffusion.
- Given the tremendous diversity existing in India's rainfed regions, technology developed at one location lacks replicability at another.
- Level of technology acceptance vary, particularly those concerning rainwater conservation, harvesting and recycling.
- Conventional extension system, based on the "take it or leave it" approach, is inadequate to convince farmers to accept the introduced technologies.

Where past plans have faltered

- Inadequate dialogue with beneficiaries.
- Limited recognition of indigenous methods of soil and water conservation.
- Limited use of existing technologies for harvesting rainwater.
- Non-availability of seed of improved varieties.
Demand supply gap: 80% with groundnut; 50% with sorghum; 25% with pearl millet; >90% with forage species
- Lack of adequate linkages between crop farming and animal components.
- Vulnerability to pests and diseases.
- Farmers not treated as partners in development.
- Confirmation of technology development on research farms: relevance rarely confirmed through farmers' field tests with farmers as active participants.
- Involvement of farmers in the later stages of the technology development process.
- Poor interfacing of research and development efforts.

Importance of rainfed agriculture in India

- **Contributes 44% of food supplies**
- **Supports 40% population**
- **Supports two out of three cattle**
- **Cultivation of more than 90% coarse cereals depends upon rainfed area**
- **86% groundnut is cultivated in rainfed areas**
- **91% pulses are cultivated in rainfed areas**
- **58% of rice is rain dependent**
- **67% cotton is grown on drylands**
- **Nearly one fourth of wheat cultivation is rain dependent**

Options for future actions

- Increase contribution of cereals from irrigated agriculture.
- In areas with less than 500 mm annual rainfall, establish animal-based millet and silvipastoral systems.
- Increase the emphasis on oilseed and legume-based systems in the not-so-favourable tracts.
- High-value fruits, medicinal and aromatic bushes, dyes and pesticides, high-tech (drip irrigation, processing, extraction and value added products) agriculture in semi-arid regions.
- Forestry in highly degraded and undulating lands.
- Programme prioritization relevant to farmers' needs and socio-economic conditions



Strategy for sustainable rainfed agriculture

- Sustainable natural resources management with water as the nucleus.
- Need for higher resource allocation and new perspective building.
- Emphasis on value of output and not merely on biological productivity.
- Harnessing the inherent comparative advantage of rainfed regions.
- Recognizing site and season specificity of technological needs.
- Need for a multi-disciplinary problem solving approach.
- Developing strategies for conservation and efficient use of resources.

Guiding principles for future research

- Construct agro-ecology relevant technologies based on an understanding of local agricultural and resource management practices.
- Systems research (in an integrated mode) to ensure sustainability and replicability of site specific technologies.
- Improve productivity and profitability by multi-disciplinary, multi-institutional approaches, with water as the nucleus. Diversified land use linking agriculture with animals and the environment.
- Effective feedback mechanisms in setting research priorities relevant to farmers' needs and existing socio-economic conditions.

Scenario 2020

	1994 to 1995	2020
Population (million)	900	1400
Population in rainfed regions (million)	360	560
Animal population (million)	450	650
Land availability per capita (ha)	0.15	0.07
Productivity foodgrains (kg/ha)	770	2000
Water needs (Mha m)	8	24
Fertilizers (NPK million tonnes)	12.5	+45
Land degradation	~60%	
Consequences: Water famine, food famine, fodder famine and energy famine.		

Contributor: J. C. Katyal

The future of rainfed agriculture

With the slow down in the expansion of irrigated area, rainfed agriculture would have to be revisited. The call for the "greening of grey areas" and the need for a second green revolution, support this (Paroda 1995, CRIDA Perspective Plan, 1995, DARE/ICAR IX Plan Document, 1996, ICAR 1996) as 50% of the agricultural land in India will remain rainfed for an indefinite time and population growth as it is. Land availability per capita would decrease to 0.07 ha by 2020 (CRIDA Perspective Plan). This would render conventional cereal crops uneconomical. There is a possibility of large-scale migration, or contrastingly, an enhanced productivity gain at this stage. For a projected population of 1400 million persons by 2020 AD (CRIDA Perspective Plan, 1995), yield per ha must rise to 2 t/ha (4 t/ha, in case of irrigated agriculture) instead of the present 0.8 t/ha. Although this is attainable in areas receiving more than 750 mm rainfall annually, the impending scenario of "global climatic change" makes predictions difficult. However, growing pressure on limited resources and faster depletion of forest and groundwater resources is predictable.

Information kit produced by
MYRADA and the International
Institute of Rural Reconstruction

Natural resource management in ancient India

Respect for nature has been the guiding principle for the human race. Some attributed it to fear while others attribute it to interdependence of all forms of life.

As civilisation progressed and various beliefs began to be institutionalised, the human community — starting with the village — attempted to integrate all such “institutions” to achieve a proper balance between the natural, spiritual and materialistic components of life.

Thus, a code of conduct for common property resource management has evolved. Strict observance of this, through self-imposed discipline or the strength of decisions made by the community, has preserved the common property balance over the centuries. Violations were met with social sanctions, penalties and punishments.

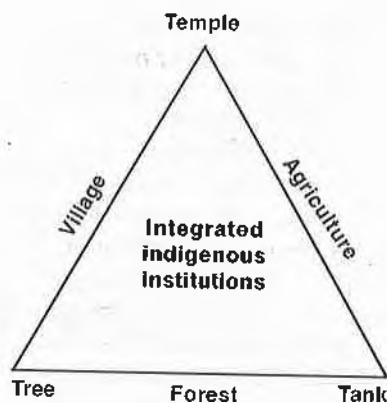
For them, the village tank meant more than a source of water. The temple or a place of worship meant more than divinity, and the tree was more than a source of timber. A natural, resource-oriented approach prevailed.

The decline of this integrated approach has resulted in the over-all degradation of natural resources. Depletion of the ozone layer and the green house effect, the fast disappearing forest cover and the over-exploitation of natural resources are some of the dangers looming large over the world. With the realisation of this stark reality, efforts are initiated to restore the balance.

In a multi-pronged approach, concerted attempts are being made to revive several of our age-old indigenous institutions and practices to reverse the degradation trends.

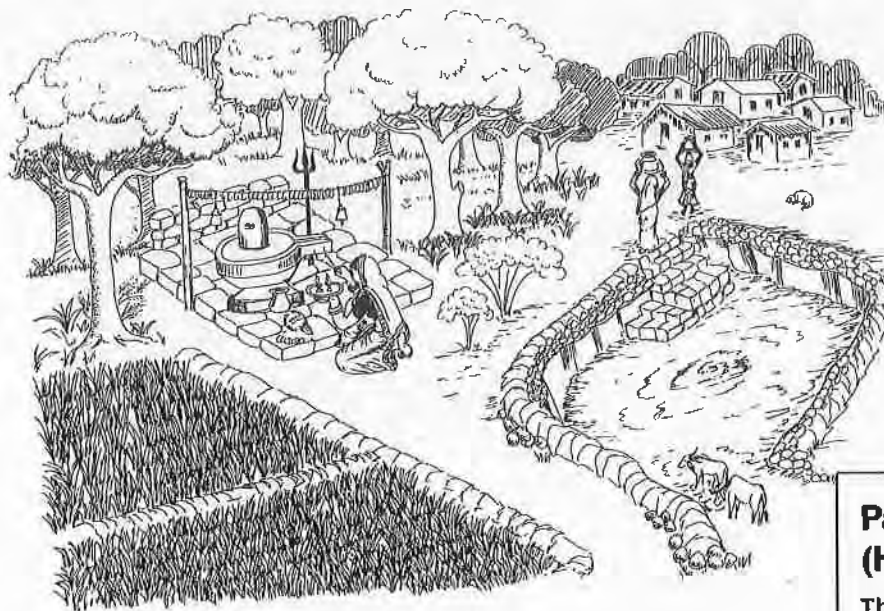
For this purpose, the effort must begin with a firm belief in what the villagers possess rather than focus on what they don't have. Fortunately, the villagers are still endowed with a rich biodiversity, indigenous knowledge systems and socio-cultural heritage.

This proposal may be considered as one more component in the total approach to revive these institutions.



'Devarakadu' in Coorg (Temple forest)

Even as far back as 1860, revenue records mention of temple forests being maintained in Coorg, Karnataka. They were known by different names such as Basadi, Jinakadu, Devara Painaaddi, Suddidevara Vana, Hole devara kadu, etc. This indicates the involvement of different communities in maintaining these forests.



At the village level, three institutions support life. The **temple** (place of worship) represents the spiritual element, the **tank** is identified with the materialistic side while the **forest** is associated with the ecological element, all integrated into one. Over the years, these relationships were forgotten. There is need to revive this link between the tank, temple and tree as one pursues an integrated approach to village life.

Tree God

Trees and the forest have been revered from early on as God. Some species of planted trees/plants like Tulasi, Neem, Sami and Pipal are worshipped. When planted near temples or other places of worship, these plants are also revered. These are multipurpose plants and trees, useful in medicine, agriculture, ecological balance, etc.

Temple forest

Forests serve a larger spiritual and non-materialistic role. They sustain temples, life-saving water sources and are sources of medicines, fodder and timber, besides controlling soil erosion, etc. They are the repositories of flowers, fruits, birds and wildlife.

When specific species of plants are grown in an area, generally around a temple, it is revered at a grove level - Tulasi vana, mulika vana, etc. These groves acquire prominence because of their location, history or association with religious or social functions like Vana bhojana (feast in such groves during the month of Kartika). The sacred groves of Kodagu, Naga Banas of South Kanara and Malnad are recognised to serve ecological and landscaping functions by their location.

Pavithra Vana (Holy forest)

The Karnataka Government promoted the concept of Pavitra Vana to inculcate in the younger generation a sense of reverence towards trees and nature. Deva Vana, Star forest, Dhanwantari vana are some of these. They are attracting large numbers of visitors in Ramanagaram, Bakkala and other places.

In Kalyanakere watershed, Pavithra Vana was successfully established by the Karnataka Government as a component of social forestry.

Almost all temples, educational and religious institutions own lands to sustain their maintenance. Appropriate sacred trees along with other trees can be grown on these lands which will serve as home for all kinds of flora and fauna. Because of their proximity to temples or other institutions, people would hesitate to cut trees, for reasons of reverence and social (constraints) control.

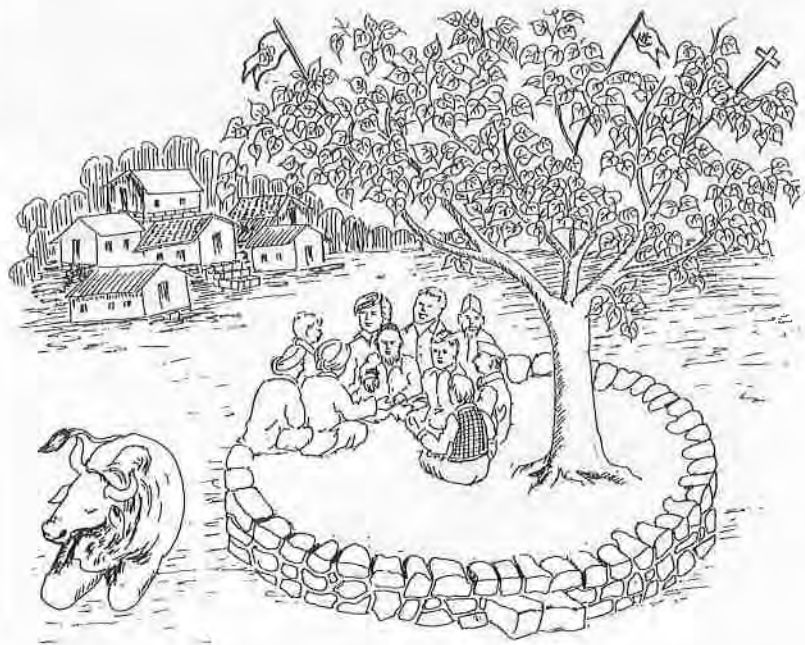
Social fencing

People who realise the sacred place of temple, tank or the forest, in re-establishing equilibrium in the spiritual, ecological and materialistic aspects of life, have to take the lead. The examples of village communities in Shantalli and Garvale, of Kodagu district where people forced the return of misappropriated common property resources back to the people are worth emulating. The social sanctions imposed by the people — we can call it **social fencing** — were successful.

Karnataka has more than 40,000 tanks in about 26,000 villages, most of them associated with temples or as a common property resource. Most of them are not properly used for a variety of reasons.

If the committees of the temples or other institutions are motivated, through appeal, persuasion or even pressure, enough resources can be mobilised to bring the tanks back to their original health. This will surely be a small but significant step to restore the system of interdependence in managing this common property resource.

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The tank

Since time immemorial, the village tank served not only as a source of water, but also as a meeting place of the villagers — both men and women. The tank provided water to humans, animals, plants and also for irrigation as well as recharging of wells.

A tank precedes the construction of a village

In the past, whenever any new village was being located, the first activity was the construction of a tank, signifying the central role assigned to a tank in the development of the village. Along with the tank came the trees, even before farm-level cultivation. The next was the temple, emphasizing the vital link between the tank and temple. This developed an interdependant code of conduct for tanks, trees and temples and their proper maintenance. As a part of this, the desilting of the tank at regular intervals, was considered a community activity where everybody contributed labour and shared the valuable silt as manure for fields. The old traditional institution grants for the construction and maintenance of tanks, ensured proper upkeep of the tank, bunds and canal systems.

The decline in moral value systems and greed to amass wealth by fair or foul means, resulted in individuals misappropriating common property resources. People in positions bent the rules to their advantage. Today, however, there is a growing recognition of the role of tanks in community life and the need to revive these structures and related social arrangements.

Contributors: T.N. Prakash, M.G. Nagaraja and M.G. Chandrakanth

Natural resources degradation process: An overview

Rainfed drylands are areas with less than 800 mm annual rainfall, where crop production depends entirely on rain water.

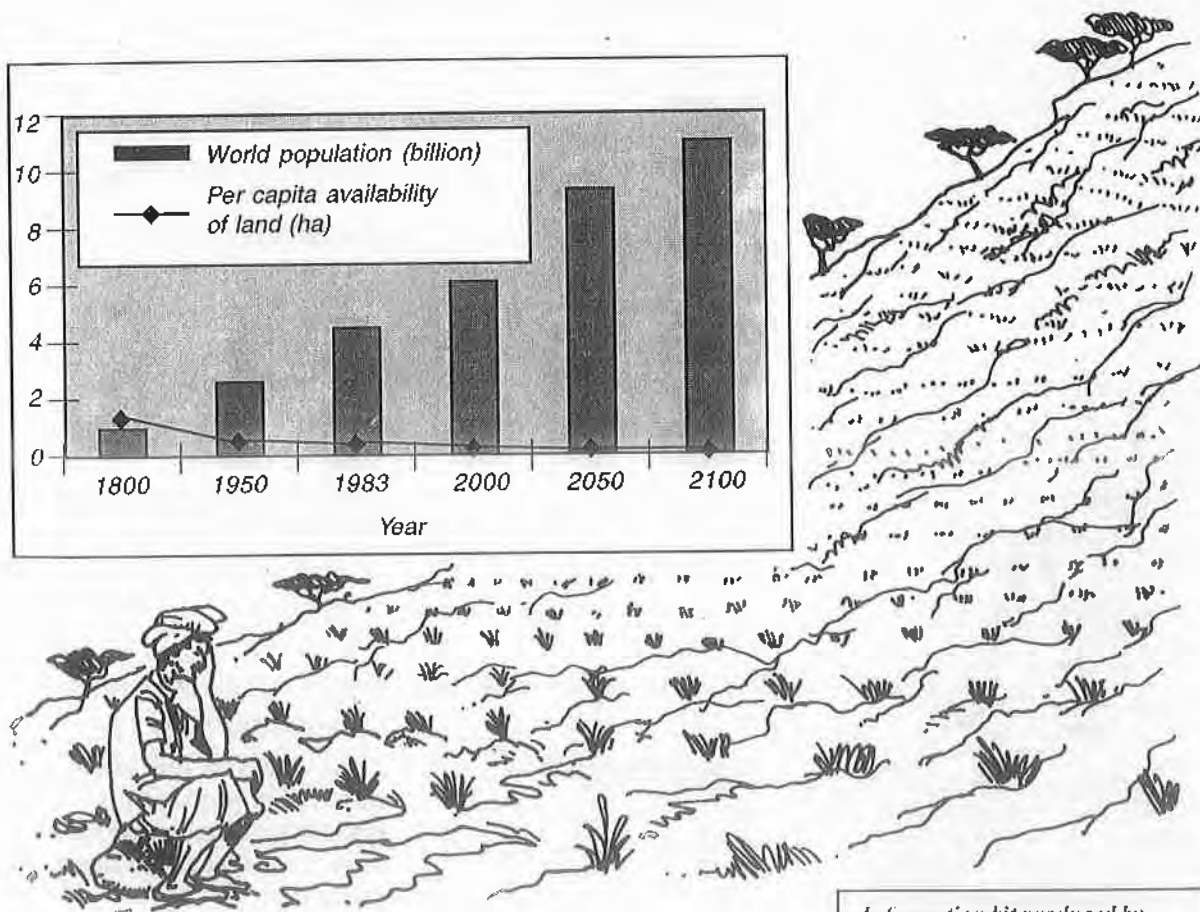
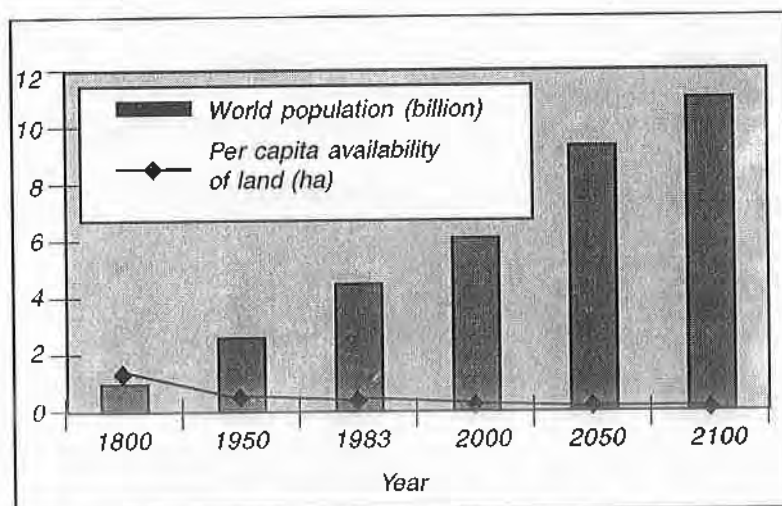
The important natural resources that support the production system in drylands are soil, water and vegetation. Improper use and misuse of these resources over the years have made these lands less productive.

Degradation is a process which occurs when resources are overused or misused either naturally or through human action. Population pressure is the major cause for the overuse of land resulting in its degradation. The availability of useful lands, globally, has decreased over the years and will reduce further in the years to come.

The only way to provide for the needs of the life system on earth would be to reverse the process of degradation and improve productivity.

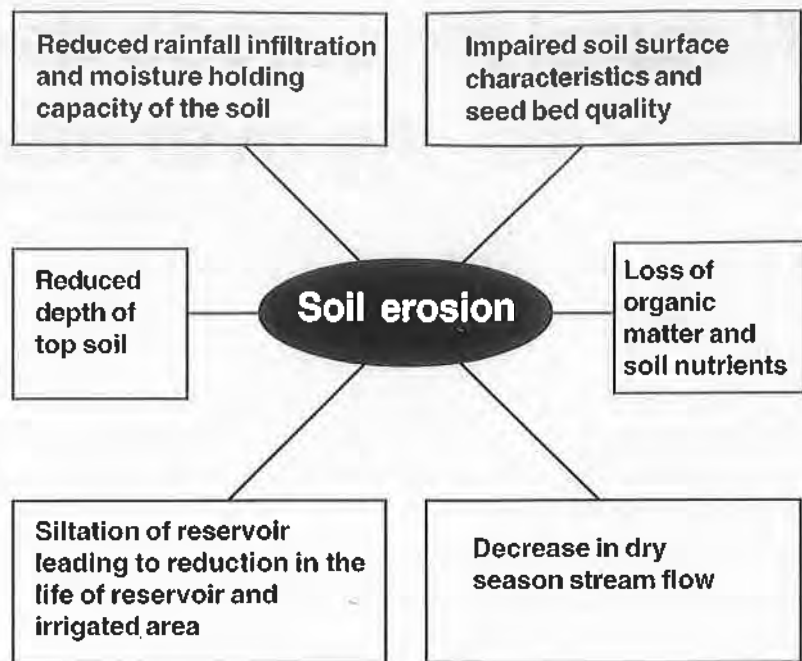
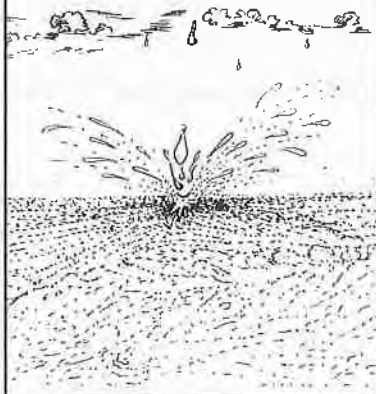
Globally, over 15% of farm land is degraded due to human induced factors.

The task ahead is to increase the present level of food production with the decreased per capita availability of land for agricultural purposes.



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Soil erosion is the detachment of soil particles due to impact and their transportation to other sites by water or wind. Water erosion is a process where soil is detached, transported and deposited by raindrop impact or overland flow. Although it is a natural process, it is often aggravated by agricultural management practices, resulting in decreased crop productivity.



Soil degradation

Soil degradation is caused by erosion, salinization, depletion of nutrients, accumulation of toxic substances, oxidation of organic matter, loss of vegetative cover on soil surface and deterioration of physical conditions.



Problems	Causes
Soil erosion	• Raindrop impact and overland flow • Intensive agriculture involving excessive tillage without protection
Salinization	• Poor drainage • High evaporation
Depletion of soil nutrients	• Intensive cropping using high yielding varieties • Repeated tillage leading to oxidation of organic matter
Toxicity and pollution	• Dumping of industrial wastes • Direct sewage disposal in the field
Loss of vegetative cover	• Indiscriminate deforestation • Overgrazing or fire
Physical degradation	• Compaction of soil at the depth of plough furrow (plough pan) and on the surface due to movement of heavy machinery • Soil crusting due to reduced organic matter

Over-exploitation of groundwater

Water level has sunk to deeper levels due to over-exploitation of groundwater mainly for agricultural purposes. As a result, tapping of groundwater has become costly and uneconomical.

Vegetative cover

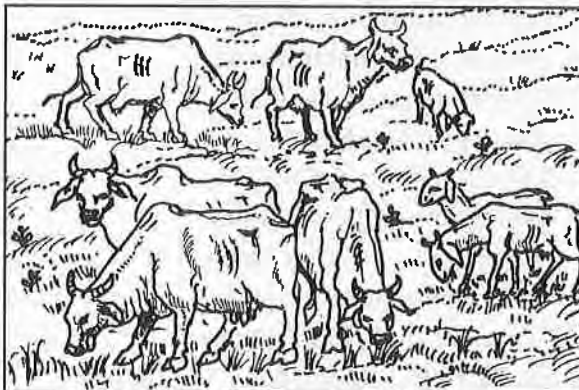
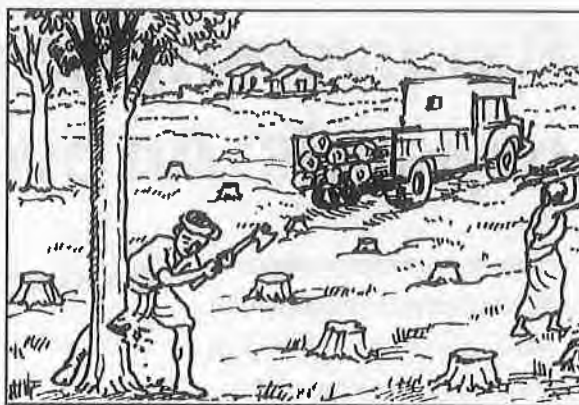
Vegetative cover, either dead or living, is important in reducing the impact of raindrops on soil, increasing infiltration and improving the soils' water holding capacity. When this protective cover is removed, high intensity rains common in drylands, cause accelerated erosion.

Challenge

Not more than 50% of the cultivable area in India can be irrigated in the near future. Moreover, the cost of creating irrigation facilities is exorbitant and the crop yields in irrigated areas have almost reached their potential. Therefore, it is essential to look to drylands for additional production through soil conservation and effective utilisation of rain water on a watershed basis.

Strategies for restoration

- Need-based soil conservation measures both in arable and non-arable areas.
- Afforestation of waste lands and development of grasslands.
- Recharging of underground water through nala bunds, gully checks and percolation tanks.
- Introduction of measures to prevent land and water pollution through appropriate waste treatment and disposal.
- Recycling of organic wastes to maintain soil health.
- Practice of regenerative agriculture.



Do you know that?

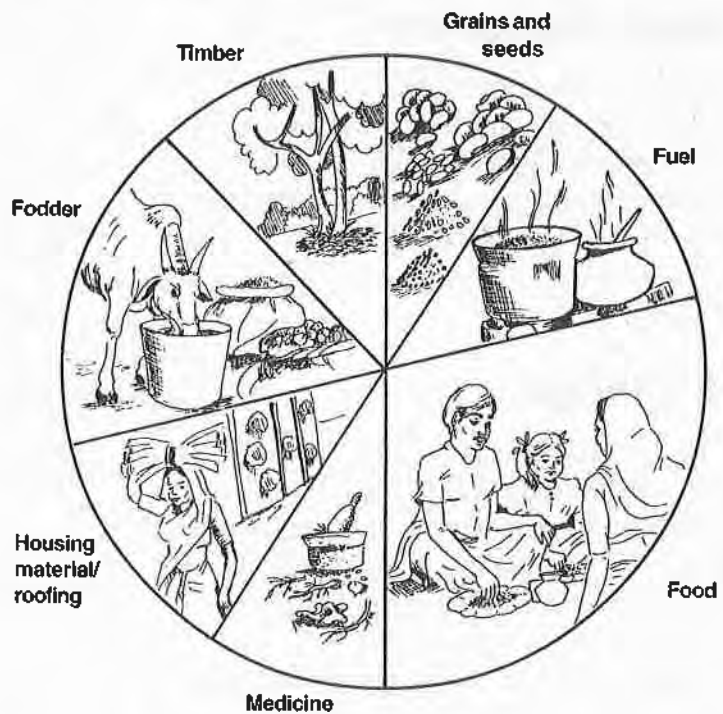
- At present, the world is losing 5 to 7 Mha of arable land every year due to soil degradation.
- About 177 Mha of land in India are degraded. Of this area, 113 Mha are affected by water erosion, and 39 Mha by wind erosion.
- The average soil loss in India is estimated to be 16.3 tonnes/ha/year (slightly more than 1 mm depth of soil).
- For every tonne of grains, about 105 kg of nutrients are removed from the soil.
- Soil erosion is estimated to cause a yield decline of 0.14 tonnes/ha/mm of soil loss.
- The observed average rate of sedimentation in Indian reservoirs is 8.51 ha m/100 sq km/year as against the assumed rate of 3.02 ha m/100 sq km/year.
- India lost about 3.37 Mha of forest area from 1980 to 1990 at a rate of 0.6% per year.

Contributors: M. S. Rama Mohan Rao and
B. R. Hegde

Biodiversity conservation for drylands: An overview

Biodiversity in plant genetic materials is one of the most basic resources needed for survival. It is a source of a rich variety of food, medicines, fodder, manure and other raw materials used in providing man's basic needs. It has also been the source of breeding material for new crop varieties all over the world. The richest diversity of annual food crops in India can be found among its dryland farms. Dryland farmers are indeed the best curators of such germplasm.

Biodiversity and its multiple uses



Note

- New varieties are more prone to pests and diseases when compared to the indigenous. This is especially so in rainfed dryland tracts.
- High yielding and hybrid varieties are water intensive and dependent on high chemical inputs to express their full genetic potential. Such inputs are not normally accessible by dryland farmers.

Reasons for biodiversity erosion

- Displacement of multicropping system by monoculture leading to a loss of diversity in food crops.
- Farmers' varieties (i.e., indigenous or native seeds) being replaced by commercially-evolved new varieties.
- Pressure to bring large tracts of land under watersheds in the dryland areas for cultivation of hybrid varieties.

Why biodiversity conservation?

- To maintain essential ecological process and life-support systems.
- To preserve genetic diversity.
- To ensure that utilisation of species and ecosystems is sustainable.

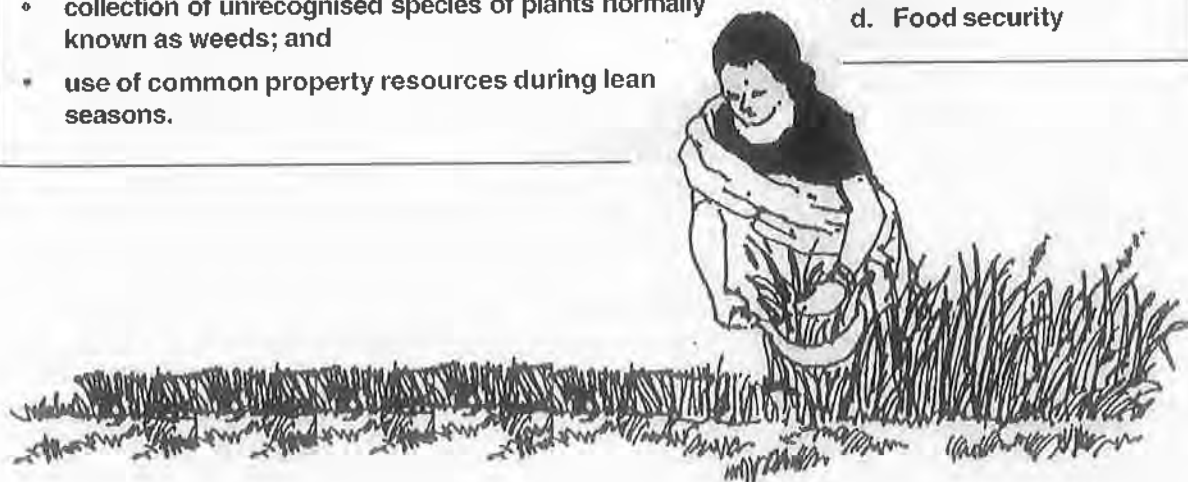
Importance of biodiversity

- Provides internal inputs or nutrients and pest control agents on the farm.
- Crop combinations adopted by farmers consider factors like space, time and labour management. Good examples of these are the Navadanya in the south and Baranaja in the north of India.
- The multiple cropping system, which is the basis of conserving the diversity of crop inputs, follows the multiple principle of optimising the use of water, soil and nutrients.
- Nutrition and food security are imperative.
- Many highly nutritious crops (like different millets) are threatened by extinction and have been devalued in the food markets. The thrust for monocultures came from the need to supply cheap food for urban consumers.



Food security by:

- maintaining diversity of food crops;
- collection of unrecognised species of plants normally known as weeds; and
- use of common property resources during lean seasons.



Traditional methods of seed testing: A cultural event

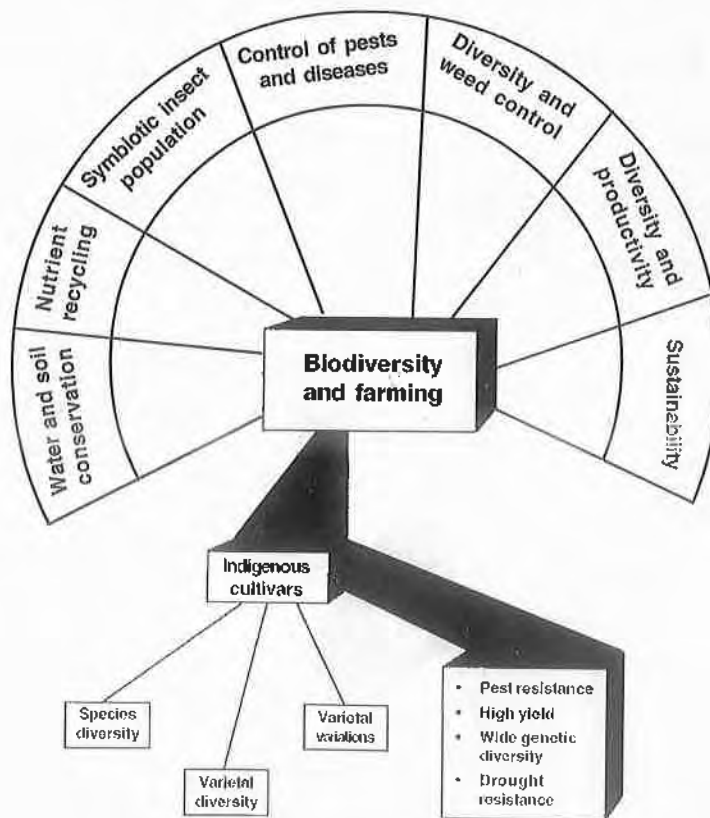
Women farmers, who are often the primary seed custodians, select seeds from their storage and conduct germination tests as a cultural and ritual aspect of farming. In Karnataka, this germination test is built into the festival of ugadi. Seeds are sown in a flat clay pot or basket in wet sand, or mud from the field itself, and observed over a period of nine days. Seed germination is assessed on the 9th day. The pot is worshiped and taken to a nearby water source where it is floated on the water. If germination is poor, farmers do not use their seeds in the field, but they borrow or exchange seeds with other farmers.

Role of women

- a. Selection of seeds
- b. Conservation
- c. Utilisation
- d. Food security

Political factors impacting on biodiversity

- There is an unequal exchange of biological resources between developed and developing countries.
- Farmers' rights to seeds are important especially in the light of new international legislations having direct impacts on food security and livelihood.
- New developments in other parts of the world have recognised patenting of plants and animals. Patenting of plants raises serious concerns about monopolies over food and agricultural systems.
- Every country is permitted to protect plant varieties through its own system. Unfortunately, it is interpreted to be the same system as what is adopted by European countries, which have given exclusive rights to breeders and exclude researchers and farmers.
- Will our government use the opportunity to evolve a policy beyond the European model to recognise farmers' contributions and farmers' rights?



Conservation of biodiversity in drylands is necessary to create a sustainable farming environment at five levels:

1. the ecosystem level;
2. the farming system level;
3. the species level;
4. varietal genetic diversity; and
5. output diversity.

Biodiversity not only means diverse species, but also the relationships among plants, animals, microorganisms, soil and water which gives rise to ecological and cultural diversity. Genetic diversity is not mere breeding material, but a product of interaction between inherited traits and the environment — a result of co-evolution.

The Green Foundation, working in the drylands of South India, collects numerous indigenous varieties of millets, paddy (rice) and pulses. These are being characterised and multiplied with the help of farmer-cooperators. The following dryland crops are being conserved:

- 40 varieties of finger millets;
- 45 varieties of foxtail millets;
- 9 varieties of sorghum; and,
- several varieties of dryland paddy.

What has to be done?

- Identify valuable dryland varieties of crops.
- Multiply them among farmer-cooperators.
- Characterise these varieties using farmer-participatory research (field-based trials of grain/straw yield, pest tolerance, agronomic measures to improve productivity, etc.)
- Promote *in-situ* conservation on small farms through the encouragement of diversified (multi-crop) cropping systems.
- Combine the reintroduction of indigenous varieties with improved and ecologically sound soil, water and nutrient management to further improve the productivity of these local varieties.

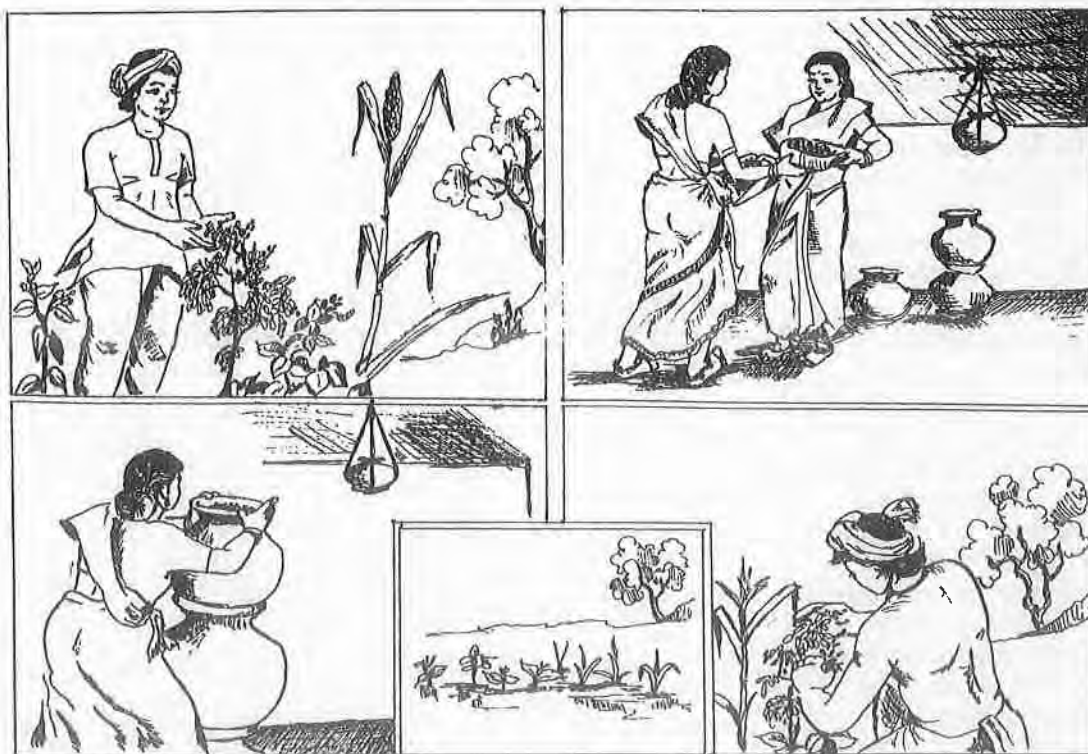
Farmers' varieties of finger millet

Example:

- *Mitta Ragi*
- *Majjiga Ragi*
- *Jenu Goodu Ragi*
- *Kari Gidda Ragi*
- *Hasiru Kaddi Ragi*
- *Sanna Kaddi Ragi*
- *Biddappu Ragi*
- *Tidalu*

Some of the paddy varieties

- *Goodu Nellu*
- *Putta Baththa*
- *Dodda Baira Nellu*
- *Belli Nellu*
- *Belli Mandige*
- *Mara Nellu*
- *Poongar*
- *Aryan*
- *Nooth Pathu*



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Contributor: Vanaja Ramprasad

Equity in watershed management

Meetings mirror inequalities

(Gulbarga project - 1985)

When people gathered and settled down, the emerging picture projected the class distinctions operating in the community. On the floor, in front, sat those farmers who own lands in the lower reaches of the watershed. They were fertile and benefitted from protective irrigation. Behind them sat or stood those farmers with lands in the middle reaches. Though their landholdings are larger than those of the first category, the lands were not as productive, aside from being more vulnerable to drought and long dry spells. Protective irrigation is not also available. People who stood on the periphery were mostly tribals with landholdings on the upper reaches. The landless hung around. There were no women present initially; but as the meeting went on, they strolled in, more as inquisitive bystanders than as participants.

The discussions were initiated and dominated by farmers with holdings in the lower reaches who were sitting in front of the group. They also belonged to a caste higher than the others. It was evident that if the marginalised groups were to be given an opportunity to participate effectively, they would have to meet in a different situation.

Equity is perhaps the most difficult objective to achieve within the context of a watershed programme, and even more difficult to sustain.

There is adequate experience in MYRADA's watershed projects indicating that if the objective of equity was not adhered to, pressures would erode the management of the watershed's resources and prevent sustained productivity increases in the long run. It is also clear that people are unable to pursue the three objectives of productivity, sustainability and equity. They primarily responded to productivity once they perceived that the risks of increased investments were lowered and linkages increased. The objective of sustainability requires a far greater level of intervention from the NGO because it concerned processes leading to institution building, which demands considerable time and effort and cooperation from the people. People avoided issues related with equity which have a high potential for conflict in the initial years. To achieve and sustain equity in managing and sharing of watershed resources, strategic intervention throughout the process is required, as well as empowerment of institutions of the poor.



The picture that emerged in the Gulbarga project showed that although the watershed was one geographical entity in which all landholdings (whether public or private) large or small were interlinked, it was not a community. Several interests collided and relations in some cases were exploitative. Loyal ties were far stronger at the level of small sub-groups than at the level of the watershed "community". Attempts to introduce treatment measures, therefore, had to consider this complex set of relationships. If equity was to be achieved, the strategy had to make adequate space where these sub-groups could grow and create opportunities for members to attain the skills and confidence required to achieve "effective" participation in watershed management and linkages in the wider community.

Self help group

It was in this social context that MYRADA's Self Help Group (SHG) strategy became relevant. Members of SHGs did not require outside intervention to stay together because they have common interests, belong to the same community, a common ancestry, occupation and generally the same economic status. They were called "socially viable" or "affinity" groups. MYRADA's strategy was to work with each group to provide members with opportunities for training and self improvement, to build up their own institutions and to use credit as an instrument. In the process of managing credit (saving, lending and recovery) as well as during group training, they acquired the skills and confidence required for institution building and sustainability.

The situation of the landless

The landless, especially those who do not provide traditional services like barbers and shopkeepers, tend to be marginalised in a watershed programme. Efforts were made by MYRADA to persuade large absentee landlords to lease land to landless families, but these have not been successful, mainly due to existing laws which favour the tenant. The landless, however, are all members of SHGs; they avail of loans for consumption and income generation. In several watersheds, they even took loans for milch animals because the Watershed Association gave them access to fodder from protected areas in the watershed. As areas for cash crops in the lower reaches increased, the need for labour also grew and nowadays, it is almost double of what it was in 1987. This has helped provide increased labour opportunities to landless and marginal farmers in the watersheds. However, while they are much less dependent for consumption loans from larger farmers than before, they still cannot bargain for higher wages which continue to fall below the official rates.

A strategy for empowerment

At the end of 1993, there were 103 SHGs in the Gulbarga Project area and eight SHGs in the surrounding villages where people had come forward to start SHGs on their own. Of these 103 groups, 58 SHGs were composed of socially or economically marginalised groups like tribals (23 men's groups, 20 women's groups) and scheduled castes (15 groups). Women's SHGs numbered 40, of which 20 were tribal groups. The landless were included in these SHGs.

Tribal SHGs have taken a major role in watershed planning and implementation through their SHGs and have asserted their rights through lobbying for infrastructural benefits like roads connecting their villages and for bus services. They also decided to form an Apex Association of the tribal SHGs and put up candidates for the Gram Panchayat elections.

Several surveys in MYRADA projects indicated that the landless/marginal farmers find it difficult to broaden their livelihood source base because land-related investment in terms of capital, skills, linkages to input sources, technology and marketing tends to get high priority, leaving limited resources for livelihoods in non-farm related areas. Watershed programmes, therefore, need to provide resources to support livelihood in non-farm related areas from the beginning.

The trickle down effect favours those comparatively better off

Productivity of farms in the upper reaches hardly increased, while increase was significant (20 to 100%) in the lower reaches after 2 to 3 years.

It was evident to people with holdings on the upper reaches that they would not benefit as much from water conservation measures as those in the lower reaches. The trickle down effect, in this case, would favour the better off sections.

The project became aware that the physical structure of a watershed and the location of treatment measures tend to favour the lower reaches strongly, at least in the short run. Furthermore, conservation measures are generally introduced first in the middle and lower reaches where titles and land use are clear. It is only later that the upper reaches are treated. Reasons for these are many: in some cases, because the lands are encroached upon, people are unwilling to invest in them; in others, they are degraded forest lands and the Forest Department is not able or unwilling to allow people to regenerate these areas. Likewise, the lands belong to the Revenue Department and there has been open access to them, people are aware that efforts to restrict access can lead to local conflicts. Where lands are privately owned, farmers on the upper reaches who usually belong to the poorer sections, give priority to food crops. Hence, efforts to grow trees or use space for conservation and regeneration in the area are not easily accepted.

The close relationship between forestry and agriculture is a critical element in a watershed development strategy. The recent Joint Forestry Management policy is suitable for the upper reaches and fosters a more equitable distribution of resources. Private lands lying fallow also need treatment. In the Gulbarga Project, there are 75 agreements between the Watershed Associations and fallow land owners allowing regeneration and sharing of produce with the poor.

The introduction of treatment measures in the middle reaches moves comparatively faster as titles and land use are usually clear. As a result, holdings in the lower reaches benefit and the impact in these areas is visible in the short term. Those with holdings in the middle reaches often state explicitly that they do not benefit as much as those lower down especially in the short term. These are major constraints in the strategy for watershed management which do not foster equity. On the contrary, they tend to increase the gap between the income of the upper and lower sectors of the population. It is only when farmers in the lower reaches realise the value of structures higher up that they can be motivated to maintain them.

Equitable distribution of benefits — a condition for cooperation

When planning for watershed measures was discussed, another relevant equity-related issue arose. The subject was the need to introduce contour bunds instead of boundary bunds which already existed in most cases. Contour bunding requires the cooperation of all farmers, as they cross private farm boundaries. It was clear that people were reluctant to cooperate because the benefits were not perceived to be equal. It turned out that even those who would benefit more were reluctant to agree because if contour bunds were introduced, they would :

- lose the clear demarcation of their property, which, to them, is the highest priority; besides their own conservation structures would be destroyed.
- have to cooperate with their neighbours over a long period for sustainable benefits, which they were uncertain of.

The approach adopted by the project after discussion with all concerned was to focus on boundary bunds and integrate them with the contours wherever possible. The project also decided to compensate farmers in kind for conservation structures that they had constructed on their own fields instead of leveling them or replacing them with contour bunds or structures with approved (official) dimensions.

The lessons that intervenors learned were to place value on conservation work already in place and not to impose a technology whose benefits were perceived to be unequal and which demanded a level of cooperation for a long time.

Traditional practices could increase inequity

Traditional practices also have to be reviewed if the basis for equity is to be strengthened. For example, the traditional practice in drought prone areas is to harvest silt, rather than to prevent erosion. The larger farmers and more powerful sections of the community usually own lands in the lower reaches where silt can be harvested. They have often objected to erosion control structures on the upper reaches. They also have the resources to invest in silt harvesting measures; this is often the only area where they have an assured crop as they excavate shallow wells alongside for protective irrigation.

The traditional measure of diversion drains to protect fields from flooding is partially motivated by the objective of harvesting silt in the lower reaches. This is done even though it deprives the upper reaches of the potential to collect water through protection measures which encourage holding of

The upper reaches require higher investment

The strong message that emerges from experience in watersheds where holdings in the upper reaches belong to marginal groups is that the project must be able and willing to invest in improving the depth and soil quality in the upper reaches. This requires a higher level of investment than what is adequate for lower areas. It would also require new measures like land shaping which is not accepted in the official guidelines for watershed treatment. Alongside, training of farmers in management practices, which may be new to them and may require much more time and effort on their part than they are presently investing, is required. Unless these decisions are taken and implemented, any significant increase in productivity in these areas will not be achieved. Consequently, the gap in sustainable income between farming groups in the upper and lower reaches will increase and equity will suffer.

water *in situ* and increased seepage. Attempts by farmers in the upper reaches to use diversion drains to store water have been resisted.

Investment in conservation measures

Investment in conservation measures is often related to the size of land holdings, hence, it is unequally distributed. The larger the land holding, the greater the investment in conservation measures. This situation is aggravated when all investment is from outside with little or no contribution from the land owner, or when the entire investment is given as a grant. MYRADA's efforts to motivate farmers to return investment on their lands to the SHGs and/or Watershed Associations have been successful in MYRADA's Huthur and Holalkere projects. This has also built up a fund for maintenance.

In MYRADA's Huthur project, farmers took loans from SHGs for physical measures that assured quick increases in productivity. The shift from grants to loans should be encouraged particularly for large farmers.

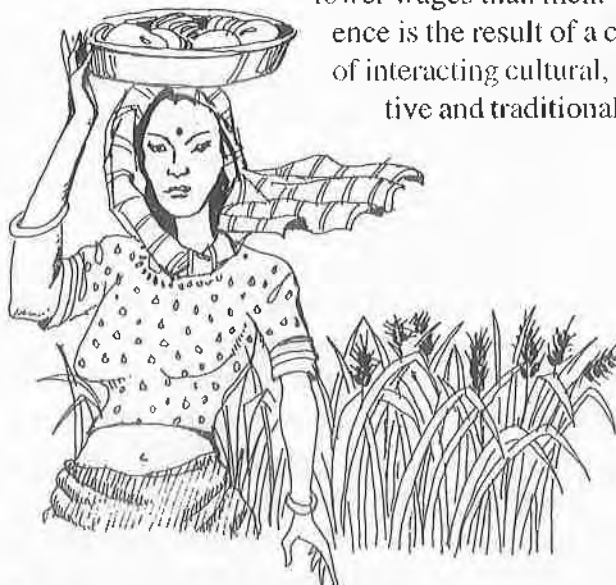
Women's role in watershed management

Evidence from various studies of the Gulbarga experience and from reports of outside visitors is adequate to confirm that women had no voice in watershed management until SHGs gave them the confidence to assert themselves. The SHGs also provided space to discuss their problems, to work towards solutions and to meet their credit needs. One women's SHG has taken the lead in planning and implementing a complete micro-watershed programme.

On the issue of equity in wages, evidence from all sources clearly indicates that women's wages are, on the average, 50% less than what men earn. The distinction between skilled work done by men and unskilled work undertaken by women continuously operate, resulting in women receiving lower wages than men. This difference is the result of a complex set of interacting cultural, administrative and traditional factors.

In activities related to soil and water conservation where women's work is still considered unskilled while men are the "key players". Though women's and men's contribution in terms of resource involvement is equal, the economic compensation women receive is only 40% of the total whereas men receive 60%.

In the case of forestry, there is a significant change. Women have been identified as the "key players" in this sector. The "resource involvement" of men is 30% and that of women is 70%. The economic compensation of women is 70% and that of men is 30%. This presents an equitable picture.



Contributor: Aloysius P. Fernandez

Information kit produced by MYRADA and the International Institute of Rural Reconstruction.

Gender issues in rainfed drylands

What is gender?

Within every society or community, women and men do different types of work. Women, however, have a major role in the reproduction and maintenance of the family. Women and men also have very specific tasks or roles in productive activities, especially in the field of agriculture. These do not depend on biological factors but on cultural practices specific to the area. And these different roles define gender. For example, in ploughing — in most places, it is a man's job but in Dharmapuri district, this task is done by women.

Complexities in dryland agriculture

The landscape in rainfed dryland areas is never static, with factors like deforestation, intensive cultivation and urbanisation having influence. People also change the agricultural landscape by changing farming practices. Changes in the agricultural production systems change the lives of women and men involved in agriculture.

Why this concern for gender in development and agriculture?

Following tradition, agricultural extension has not paid much attention to how development interventions/technologies affect both women and men.

If analysed critically, technology has most often affected both men and women. But in agriculture, effects are often adverse to women. Technology introduced in agriculture is more male-oriented, e.g., the threshing machine, the tractor, the groundnut sheller, etc. But what was done by women in early times is now taken over by men. Hence, there is displacement of women labour. Her economic situation fluctuates and women stand in a weaker position.

People working in development have realised that women are marginalised with the advent of technology. Hence, there have been increasing attempts to focus on women as beneficiaries of change. But due to lack of clarity on the different role women and men in agriculture, desired results are not often realised.



Changes in rainfed drylands

With the advent of technological interventions many changes affected the lives of women and men.



- Women have to trudge longer distances to get fuel, fodder and supplementary food for the family.
- Introduced technologies are often not truly gender-friendly. They are biased against women and are often more male-oriented. Women also have reduced access to information about the new packages in technology.
 - Often, these modern technologies either fail or cause harm. In such instances, it is the men who migrate to urban areas in search of work and women are left to look after the family and the land.
- This entails further responsibility for women in meeting household food security needs.
- Even though most of the work in the field is done by women, they do not have access to the market. It is invariably the men who have access to the market.

Such responsibilities within the household reinstate and reinforce the traditional role of women.



Gender sensitive technology

There is need to have gender-sensitive extension workers and researchers while evolving and disseminating any technology. The criteria should be to critically attempt to analyse:

- the existing gender roles and tasks;
- the benefits which men and women receive from the technology;
- how it affects the decision-making powers of women and men in families;
- planning gender-sensitive interventions/projects which take into account concerns of both women and men;
- both women and men should be covered under extension, not just men;
- carry out a gender impact assessment of the technology introduced to evaluate whether it has caused disturbances within a household/community, etc.; and
- because many issues are location/region-specific, it is essential to evolve a small scale, location-specific technologies based on the needs of both women and men and in consultation with them.

Note

Gender issues are not always women's problems.

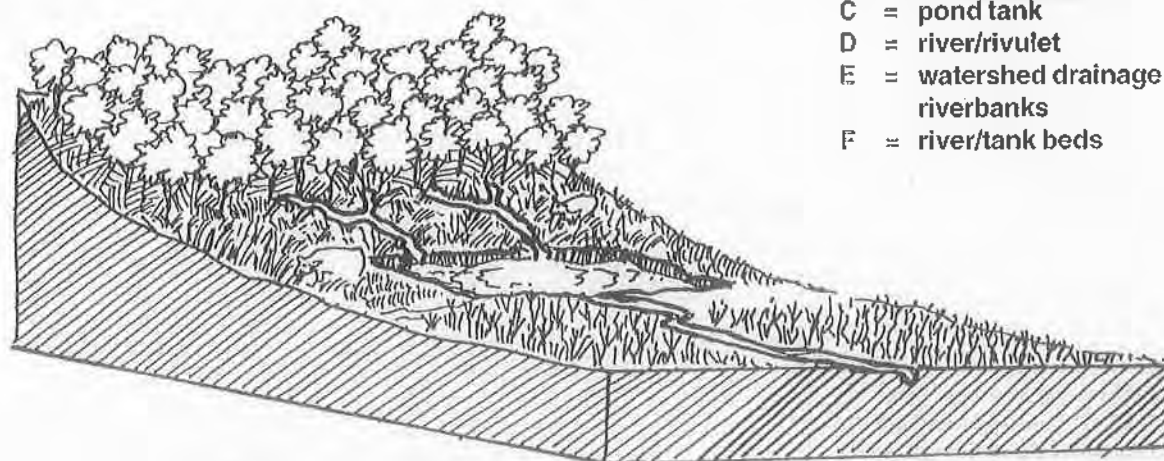
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Contributor: Gandhimati

Common property resources in India's dry regions

Contribution of common property resources to village economies in dry regions of India

Contributions	Common property resources					
	A	B	C	D	E	F
Physical Products						
Food, fibres	X		X	X		
Fodder, fuel, timber etc.	X	X	X		X	X
Water				X	X	
Manure, silt, space	X	X	X			X
Income and employment benefits						
Off-season activities	X				X	X
Drought period sustenance	X	X				X
Additional crop activities			X	X		X
Additional animals	X	X				
Petty trading and handicrafts	X					X
Broader social and ecological benefits						
Resource conservation	X	X				
Drainage and recharge of groundwater			X	X	X	
Sustainability of farming systems	X	X	X		X	X
Renewable resource supply	X	X	X			
Better microclimate and environment	X	X		X	X	



- A = community forest
- B = pasture/wasteland
- C = pond tank
- D = river/rivulet
- E = watershed drainage riverbanks
- F = river/tank beds

Extent of households' dependence on common property resources in dry regions of India

States	Household categories (%)	Common property resources contribution per household				
		Fuel supplies** (%)	Animal grazing***	Employment days (Rupees)	Annual income	Income as proportion of total income (%)
Andhra Pradesh (1.2)*	Poor	84	-	139	534	17
	Others	13	-	35	62	1
Gujarat (2.4)	Poor	66	82	196	774	18
	Others	8	14	80	185	1
Karnataka (1.2)	Poor	-	83	185	649	20
	Others	-	29	34	170	3
Madhya Pradesh (2.4)	Poor	74	79	183	733	22
	Others	32	34	52	386	2
Maharashtra (3.6)	Poor	75	69	128	557	14
	Others	12	27	43	177	1
Rajasthan (2.4)	Poor	71	84	165	770	23
	Others	23	38	61	413	2
Tamil Nadu (1.2)	Poor	-	-	137	738	22
	Others	-	-	31	164	2

* In parentheses is the number of districts and villages included for each state.

** Fuel gathered from common property resources as a proportion of total fuel used during three seasons covering the whole year.

*** Animal unit grazing days on common property as a proportion of total animal unit grazing days.

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Source: N.S. Jodha. Wasteland News, Vol. XII, No.2.

Negative changes as indicators of unsustainable agriculture

(Dry tropical areas)

Visibility of changes	Changes related to: ¹		
	Resource base	Production flows	Resource use/management practices
Directly visible changes	Various forms of resource degradation: emergence of salinity; coverage of fertile soil by shifting sands; vanishing top soils due to water/wind erosion; deepening of water tables; ground water salinisation; emerging plantlessness; reduced perennials; increase in inferior annuals and thorny bushes; and reduced per capita availability of productive resources.	Reduced total and per capita biomass availability; reduced average productivity of different crops; increased cropping in sub-marginal lands; reduced enterprise product recycling; higher dependence on inferior options, (e.g., harvesting/lopping premature trees); rising severity of successive drought-impacts; increased dependence on public relief; increased migration.	Changes in land-use pattern: cropping on sub-marginal lands; decline in common property resources; reduced diversity of agriculture (e.g., number of crops/enterprises and their interlinkages); reduced feasibility and effectiveness of traditional adaptation strategies (e.g., rotations, intercropping strategies).
Changes concealed by responses to negative changes	Substitution of cattle/camels by small ruminants; increased emphasis on mechanisation of cultivation and water lifting; large-scale reclamation of wastelands; shift from local to external inputs (e.g., from manure to chemical fertilizers, wooden tyre to rubber tyres for bullock carts) ² .	Higher coverage by public distribution system (food, inputs) and other anti-poverty programs ² ; reduced reliance on self-provisioning systems and greater dependence on external market sources; changes in land-use patterns favoring grain production.	Discarding of minor crops, shift towards monocropping with standardization of inputs/practices; increased land-use intensity; shift from two-oxen to one ox plough; tractorization ² ; replacement of self-help systems by public support systems.

Visibility of changes	Changes related to:		
	Resource base	Production flows	Resource use/management practices
Development initiatives, etc., potentially negative changes ³	Research and development focus on crops rather than on resources; techniques rather than user-perspectives (e.g., methods/species/inputs rather than group action for watershed/range development); resource upgrading ignoring its limitations(e.g., irrigation in impeded drainage areas); inducing high-intensity use of erodible soils, and other resource extractive	measures(e.g., tractorization). Highly subsidized, narrowly focused production programs: focus on crops ignoring other land-based activities; grain yield ignoring diversification; relief operations focused on people and livestock ignoring resource base, thus, promoting high	pressure on poor resource base. Sectoral focus of research and development and other support systems ignoring flexibility and diversified needs; privatisation of common property resources; extension of generalized external approaches to specific areas; disregard of folk knowledge in formal interventions; replacing local informal arrangements by rigid legal/administrative measures.

¹ Most of the changes are interrelated and they could not fit into more than one block.

² Because many changes could be for reasons other than unsustainability, a fuller understanding of the underlying circumstances of changes will be necessary.

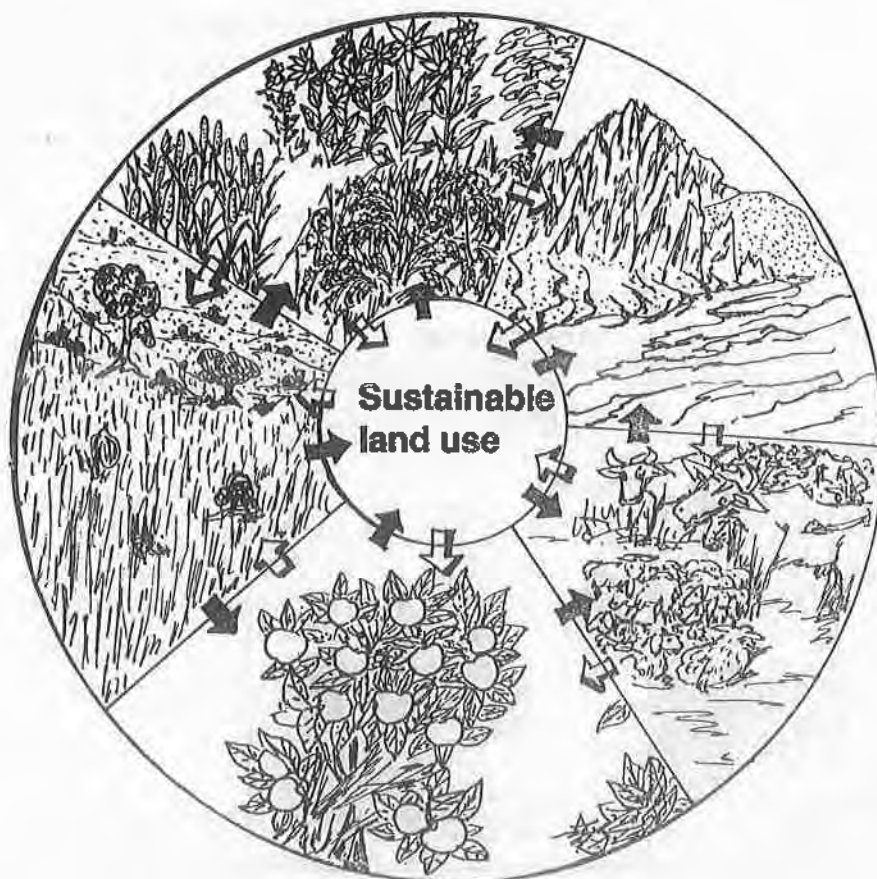
³ Changes under this category differ from the ones under the number two categories, such that they are yet to take place, and their potential emergence could be understood by examining the involved resource use practices in relation to specific area-resource characteristics.

Reducing the production gap for sustainability

Improving farmer acceptance through the farming systems approach

In arid and semi-arid regions, the synergy among technology components is at a very low level. Water, the most important input, is a scarce and uncertain commodity. Moreover, farmers are poor and cannot cope with the risk factor. Inputs like fertilisers are seldom used. In such circumstances, farmer's interest in improved technology is ensured only when there is a substantial increase in productivity. It is for this reason that technologies (in isolation) have not been accepted by the farmers in dryland areas despite vigorous extension efforts (LLP, ORPs, Integrated Watershed Management projects) throughout India in the last two decades.

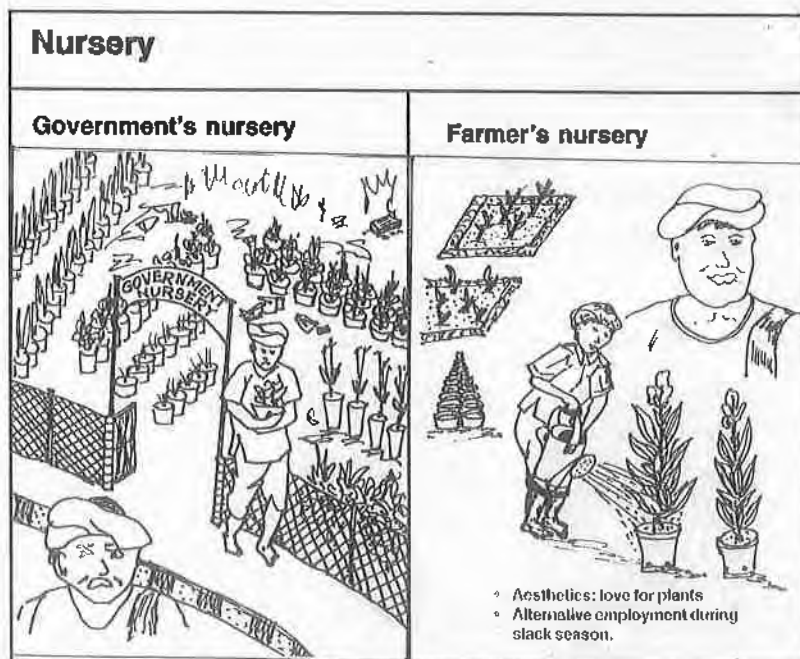
Synergistic Integration of farming system components



Socio-economic conditions of the community must be seriously considered for programme planning and implementation. Such data along with PRA output; will reveal the priorities/requirements of the farmers and the resources at their command. Land capability and engineering surveys are no doubt useful. Such data alone, however, are not adequate to develop a management plan. Socio-economic/PRA output must be dovetailed on to the resource survey inventories (if available).

Farming systems approach

1. Crops alone cannot meet the challenge of sustainable dryland farming. We have to look into the whole production/farming system to ensure synergy among its components, i.e., arable cropping, livestock management, alternate land use systems and management of village commons/degraded lands. With such a synergistic integration, the farming systems (FS) approach can meet the objective of productivity increases in drylands.
2. Improved animal husbandry may promote the planting of fodder trees and grasses, specially on field boundaries and low-capability lands. Dryland horticulture may also add to permanent vegetative cover. Such vegetation and the associated advantage of reduced tillage input may help control soil erosion. Furthermore, reduced arable crop area can be managed more efficiently.
3. Greater availability of manure through better livestock and organic wastes (from weed control) can help boost productivity when applied to the "reduced area" under arable crops.
4. Agroforestry is the best bet for the efficient management of drylands. It can only succeed if there is a provision to supplement irrigation to support the establishment of trees one year after planting. Hence, provision of water bodies is a must. Experience has shown that water bodies with a capacity of 8 to 10 m³ (soil cement lined small ponds) can meet this objective. Poor farmers do need financial support to develop this vital resource on their fields.



5. Tree plantation is more successful if saplings are raised within the village through farmer nurseries. This increases farmer's involvement in a creative activity making them key adoptors of agroforestry. Besides, alternative employment is also generated.

In India and many other countries, dryland farmers do not have much agricultural work opportunities during this period.

6. Agroforestry and silvipasture technologies — so vital to control land degradation and desertification — can be adopted only if they provide real economic benefits to the farmer. Fodder production through these technologies is one of the foremost benefits to farmers. To realise this, the farmer must have good quality animals which will readily respond to better nutrition. Livestock management, therefore, must be an integral component of the FS approach for sustainable management of drylands in arid and semi-arid regions. In this context, uncontrolled grazing must be checked by sustained community action.
7. Begin with simple interventions, e.g., ITKs (Indigenous Technical Knowledge), improved crop varieties, crop rotations, introduction of pure-bred animal males (including cattle), tree plantation on field boundaries and compost making. Use of weeds in compost-making may encourage their timely removal, an important component in drylands.
8. Build up the FS module in the following years with an increase in farmers' confidence. Phase the component technologies as per clients' needs/choices and resources.

Dryland crops

- Intercropping
- Judicious fertiliser use (including bio-fertilisers) in highly responsive crops (cereals)
- New crops

Alternate land use systems — grass/crop/tree mixed in different combinations/proportions

- Silvipasture
- Grass + crop + tree systems
- Dryland horticulture: crops like ber (*Jujube*)
- Lay farming
- Introduction of rain-fed economic/medicinal plants

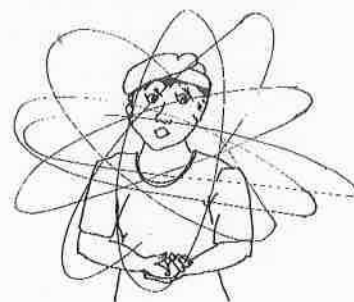
Livestock management (Sheep, goat, cattle and buffaloes)

- Breed restoration
- Nutrition, silage making, mineral mixtures, etc.
- Health cover

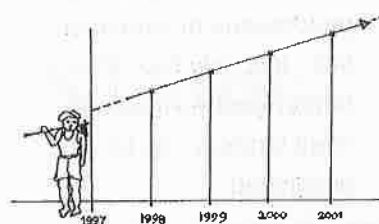
Water harvesting — soil and water conservation

- Small water bodies for supporting establishment of tree crops.

Graded technology transfer begins with I.T.K.



Scattered technologies



Graded and integrated technology diffusion

- Vegetative barriers — forage grasses/shrubs, Vetiver
- Bunding contour cultivation
- Ridge and furrow planting
- Micro catchments for runoff harvesting

More technologies, e.g., solar-driven appliances and value-addition activities, can be introduced in later years depending on the response and interest of the farmers. The reversal of the current degradation trend is indeed a challenging and uphill task. The technology dissemination strategy should be farmer-centered and oriented towards farming systems approach.

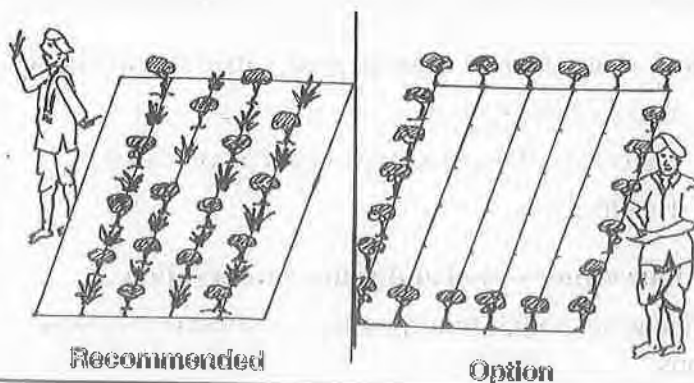
Farmers must be given technological options to choose from, depending on their resources and priorities. It is only then that a farmer-centred management strategy can be developed.

Case study on agroforestry technology options

Farmer A has more than 50% holdings in sand dunes. A resource inventory recommends the planting of *Acacia tortilis* at a space of 2 x 2 m. Farmer will not accept this because it adversely affects his first priority, i.e., production of food for the family. Give him an alternative. Accordingly, if he is told to plant two row strips of the trees at 15 to 20 m intervals, against the direction of the wind and to continue crop production in the inter-tree shelter area, he may eventually agree. Such wind-breaks also can substantially reduce the sand drift. Micro-climate for crop production is also improved.



Farmer B has 5 ha of land. The family of 10 persons is dependent on the land for their livelihood. Alley-cropping was suggested to him to stabilise production and reduce erosion, based on the land's characteristics. He will not accept, as trees growing in the field will reduce the areas for crops and reduce his food production target. One alternative could be to plant the trees on all sides of the field boundary. He may be willing to accept this.



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2 Soil and water conservation in drylands

2. Conservation of soil and water

Soil and water conservation: An overview

Soil and water are natural resources. They are essential for the survival of humans who depend on these for basic needs such as food, medicine, fuel, fibre, fodder, timber, etc. However, continued pressure and over-exploitation to meet the demands of an ever increasing population depletes these resources.

- Water is the biggest eroding agent; wind is the next most significant.
- Drylands are far more prone to erosion since they are devoid of vegetative cover for longer periods of time.

Soil erosion

Surface runoff and the concomitant soil erosion result in:

On-site

- loss of agricultural production through reduced rainfall infiltration and moisture-holding capacity of the soil, reduced depth of top soil and loss of soil nutrients;

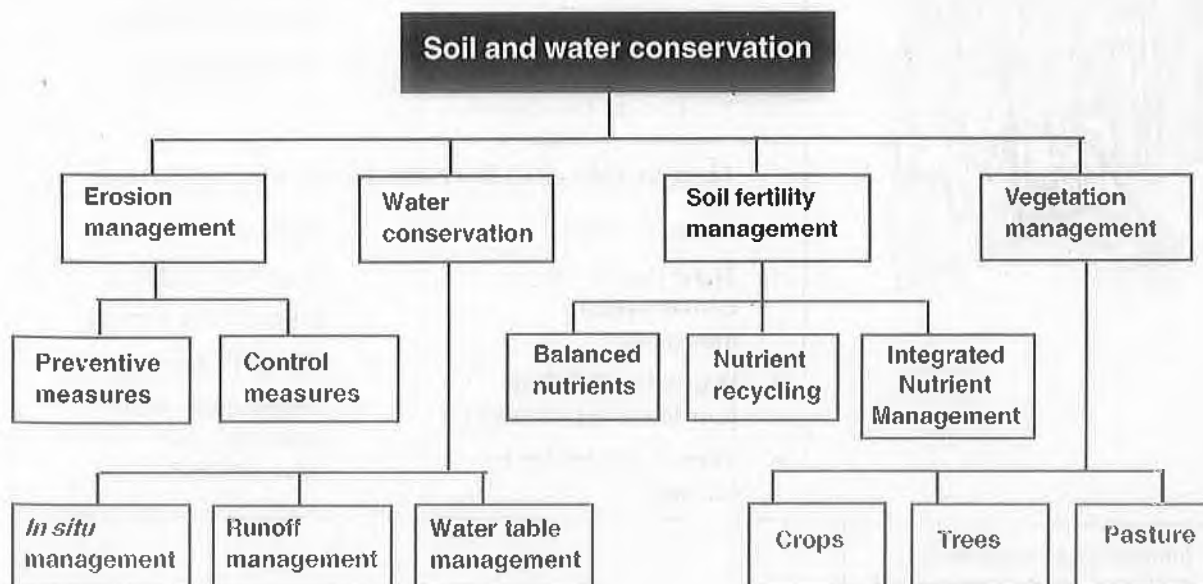
Off-site

- increased sedimentation through downstream siltation of irrigation canals, farm lands, water bodies, reservoirs, thus, affecting water quality and fisheries, etc.;
- flooding and decrease in dry season stream flow.

Hence, an imbalanced ecosystem will have a long range adverse effect on sustainable crop production. The estimated annual productivity losses due to land degradation range from 4.0 to 6.3 % of the total agricultural output, accounting for an annual production loss of Rs. 52,500 to 84,000 lakhs.

Soil and water conservation practices are based on the following principles:

- rain water management — reduction of splash erosion, detachment and transport of soil particles; and
- control of run-off — to check sheet, rill and gully erosion.



Adapted from: R. Lal, "Soil Conservation" in *Stressed Ecosystems and Sustainable Agriculture* (Virmani, et al)

The choice and design of soil and water conservation measures for agricultural lands depend mainly on the soil, land slope, rainfall and wind characteristics of the area. The measures adopted are broadly classified as:

- agronomical and biological measures; and
- engineering measures.

Often, both engineering and biological methods are used together.



Arable land management

Agronomical measures

Wind erosion control measures

- Vegetative cover
- Strip cropping
- Stubble mulching
- Tillage practices
- Sand dune stabilization
- Windbreaks and shelterbelts

Water erosion control measures

- Contour farming
- Strip cropping:
 - Field strip cropping
 - Contour strip cropping
 - Buffer strip cropping
- Conservation cropping system (ley farming)
- Mulching and crop residue management
- Critical area planning
- Vegetative barriers or live bunds
- Land smoothening
- Ridges and furrows/ dead furrows

Engineering measures

- Contour/graded bunds
- Stone wall terrace
- Water ways with vegetative cover
- Gully plugging

Non-arable and denuded land management

- Drainage lines
- *In situ* moisture conservation measures
- Vegetative fencing (bio-fencing or hedge)
- Trench and mound fencing
- Stone wall fencing
- Mud wall fencing
- Barbed wire fencing
- "Social" fencing
- Vegetative cover - pastures and afforestation

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Contributors: A. M. Krishnappa and P. Ramanagowda

Why farmers reject soil and water conservation measures

Farmers have multiple objectives

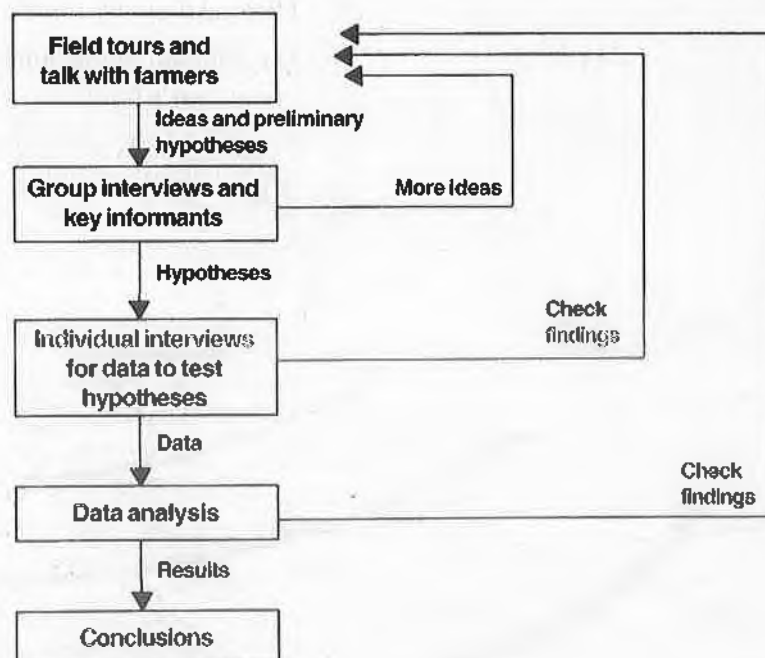
Farmers may have several reasons for **bunding** in a particular way and soil conservation may be one of these reasons. Farmers are most likely to accept improved SWC techniques that address their priorities. As a result, the soil conservation technique that is best for the farmer may not be that which conserves the most soil. This usually results in two major differences at the implementation level.

First, the recommended SWC structures are positioned on the contour while farmers' choice of technologies are boundary based. Second, the recommended SWC practices emphasise long-term productivity benefits from maximum protection of the soil, whereas farmers' preferred choices are for technologies emphasizing short-term productivity gains as well as conservation.

Both soil conservation professionals and farmers are aware of soil erosion and the need to control it, but their perceptions of the problems and approaches differ. It remains a challenge why farmers reject recommended Soil and Water Conservation (SWC) techniques in favor of indigenous conservation methods.

Research methods

In the field work for this research, rapid rural appraisal methods were combined with more formal individual farmer interviews. Where possible, work with an agricultural scientist, a social scientist and a person who could communicate with the farmers.



Farmers invest in conservation as a by-product of productivity

Conservation methods are likely to be adopted with increased productivity. Soil conservation methods that produce the most rapid return on investment are the most favored. Methods to increase productivity include:

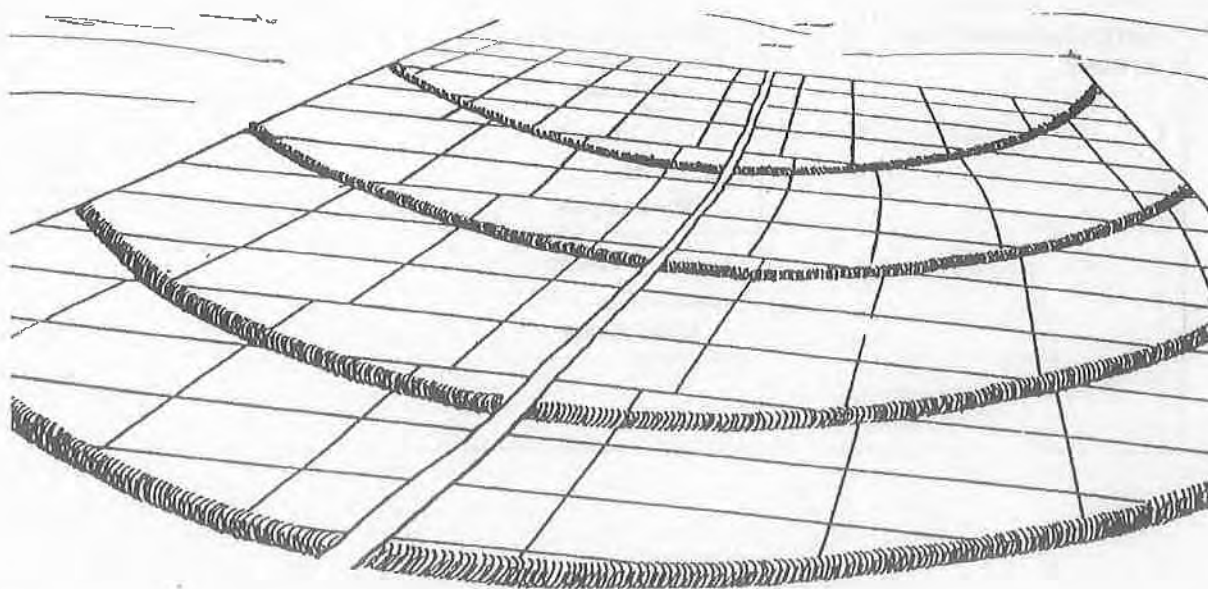
- concentrating soil at appropriate locations rather than merely conserving it;
- gully control measures that concentrate soil to increase productivity;
- lining field bunds with fodder grass or other useful plants, both to strengthen them and to provide additional income.

Why farmers prefer boundary bunds

- Boundary bunds enable individuals to invest without having to cooperate in large groups. In boundary-based runoff disposal, waterways are decentralized and the associated costs are reduced. Land and maintenance time are shared more widely. This reduces conflict and increase the likelihood of adoption.
- They serve the dual purpose of demarcating property and conserving soil. This type of partitioning also indicates land for inheritance.
- They make plowing more convenient than winding contour bunds.
- They may create new fields or protected environments.
- They may be lined with vegetation to produce fuel, fodder or fruit.

Why farmers reject contour bunds

- Contour bunds cut across farm boundaries leaving corners in some fields and creating the risk of losing a piece of land to the neighboring field.
- Contour farming also reduces the efficiency of operations (where traditional *desi* plows are used) because it requires repeated cultivation in the same direction.
- They take up too much space on small farms.
- The soil below the contour bunds may move downhill to a neighbor's field.
- Contour bunds are best suited where land holdings are large or tractors are used.



Economic determinants of investment in indigenous SWC practices

Most farmers do not undertake sufficient measures to control soil erosion effectively. In this section of the paper we attempt to explain why this is so. We propose seven hypotheses regarding the determinants of investment in soil and water conservation (SWC) which are based on field observations.

1. Awareness of soil erosion and its consequences

Farmers clearly perceive soil erosion and believe that it reduces yields. They are more concerned about the loss of water and nutrients associated with soil erosion than the reduced depth of soil itself. Farmers prioritize erosion in terms of reversibility. Nutrient loss is seen as reversible with fertilizer application. Based on a survey conducted on farmers, generous application of fertilizer and organic matter can rebuild eroded soil within five years. Gully erosion is seen as reversible, because it only affects a small portion of the field. Once the gully is plugged, it is gradually filled by soil from the upper fields and within the same field. Sheet erosion is seen as irreversible, especially where the soil is shallow. Farmers are likely to invest in conservation methods where the cost of inputs is low and where the period of rehabilitation is shortest.

2. Opportunity cost of time

This refers to the cost of foregoing an alternative opportunity and the gains obtainable from it. Farmers with off-farm income tend to invest less on SWC measures. They find that they can spend their time more profitably pursuing activities other than soil conservation.

Farmers may engage in SWC when labour is available. A farmer will hire labour if two conditions hold. First, the returns must be higher than the wage. Second, they must have the cash (or grain) available to pay the wage. If neither of these conditions hold, soil conservation work will only be done using family labour, if it is done at all. The feasibility of using labour for SWC depends on two factors independent of the above.

- Seasonal variations — SWC work is attended to during the slack season when the wages are the lowest and regular labourers have less to do on the farm.
- Daily fluctuations — People may attend to SWC when they have little else to do during the day. This way, land care is spread over a long period of time.

Note

Farmers recognize the efficiency of contour-based systems for conserving soil and water but they feel that on rainfed lands, the benefits are not great enough to justify foregoing the other advantages of indigenous, boundary-based systems.

Off farm employment

The relationship between SWC and off farm employment need not be antagonistic. Employment in the non-farming sector need not be discouraged for fear that people will cease to be concerned about SWC. Rather, ways must be sought to support such progress without resulting in neglecting the land.

Implementation of loan programmes

There are several steps in the successful implementation of loan programmes.

- Recognize that SWC is normally carried out in stages.
- Spread the loan out over several years.
- Give farmers the flexibility to use hired or family labour.

Land tenancy reforms

- Encourage long term tenancy agreements that do not threaten the landlord's ownership rights.
- Induce absentee landlords to adopt SWC measures.
- Allow neighboring farmers to implement SWC on adjoining eroding lands, if the erosion is affecting their own land.
- Encourage absentee landowners to sell their land. This may be done by levying a tax on their land to increase the incentive to sell.

3. Access to resources

Farmers often say that they do not invest in SWC because they lack the resources to do so. Farmers who do not possess the inputs for SWC must hire them out at market rates. The cost of hiring may be higher than the projected returns on SWC. One must be conscious whether farmers are reluctant to undertake SWC because:

- they lack access to credit/resources; or
- soil conservation is simply not profitable.

Improving access to credit

Encourage the farmer to invest in SWC techniques where market rate for implementation is equal to or less than the projected returns from SWC. Such techniques include silt harvesting structures, terracing and minor runoff disposal systems. This way, farmers may be able to secure loans for more profitable SWC techniques, leaving the less profitable ones to be covered by government subsidies.

Farmers may not be willing to secure SWC loans for two main reasons:

- there is no credit facilities for farmers seeking to invest in indigenous technologies; and
- farmers may have more pressing investment priorities.

4. Land tenure

Farmers cultivating their own land are more likely to invest in SWC than those renting or sharecropping someone else's land. The question of land tenure as it relates to SWC, can be addressed using three main factors:

Tenants

Short-term tenancy rights discourage long-term investment. Long-term leases attract SWC implementation.

Landlords

Land leased out for shorter durations and maintained by absentee landlords is not likely to be treated with SWC techniques.

Land value

The actual difference in economic value between degraded land and those treated with SWC methods is negligible.

Cooperation and distribution of benefits

Observations show that there is much potential for cooperation by two adjacent farmers sharing a common boundary as long as the activity relates to that boundary.

There needs to be an even distribution of the benefits derived from SWC cooperation. In general, SWC technologies are likely to fail if they divide the benefits unevenly but require nearly universal cooperation to make them work. In this way, equity becomes a prerequisite to efficiency.

7. Collective action

Soil conservation requires collective action by farmers. This is the case when an erosion problem transcends farm boundaries. Farmers' willingness to cooperate is an important determinant of soil conservation investment. There are several concerns surrounding cooperation.

- Cooperation may result in the increase in the cost of SWC due to the need for organisation and administration.
- It may also impose sociological costs on the community if there are people who prefer not to associate with other members from their community or others.

Recommendations

The main lessons from farmers' indigenous practices are as follows:

- Farmers' objectives should be clearly understood so that SWC programmes can be designed to ensure that farmers will accept rather than reject.
- SWC programmes should minimize expenditures that farmers would be willing to make on their own. They should provide enabling conditions to increase SWC investment in a cost-effective manner.

*Information kit produced by
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Source: Indigenous Soil and Water Conservation in India's Semi-Arid Tropics. John Kerr, Sanghi, N.K., IIED. Gatekeeper Series no. 34.

Repackaged by: Yourrick Da Silva

Watershed management

Soil, water and vegetation are the basic resources on which humans and animals depend. However, the demand for food, fibre and fuel to meet the needs of a teeming population amid the use of inappropriate technologies has resulted in excessive exploitation of these land-based resources and increased number of people undertaking activities which may not be consistent with sustainable development.

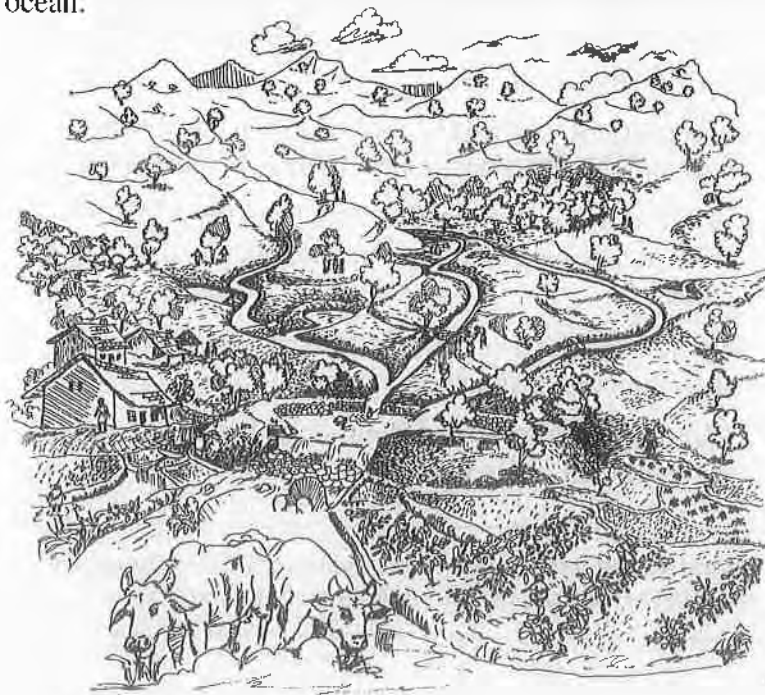
The impact of these disturbing activities led to several problems like soil erosion, nutrient loss, diminishing stream flow and water scarcity. These, in turn, have led to decline in crop yield and food security problems.

Concept

A watershed is defined as any surface area from which rainfall is collected and drained through a common point. It is synonymous with a drainage basin or catchment area. A drainage basin, however, can involve several towns or regions and even countries.

There is no definite size for a watershed as it may vary from a few hectares to several thousands of hectares. In fact, even an individual field can be considered as a watershed provided there is an independent drainage point.

However, watershed sizes are classified into three, namely: micro, mini and macro watersheds. A combination of micro watersheds makes a mini watershed which forms part of the macro watershed before finally discharging into the sea or ocean.



Watershed management is the integration of technologies within the natural boundaries of a drainage area for optimum development of land, water and plant resources to meet the basic needs of people and animals in a sustainable manner.

Objectives

- Effectively conserve soil, rain water and vegetation and harvest the surplus water to create water sources in addition to ground water recharge.
- Promote sustainable farming and stabilise crop yields by adopting suitable cropping and crop management systems.
- Cover the non-arable area effectively through afforestation, horticulture and pasture land development based on land capability class (refer to page 43).
- Enhance the income of individuals by adopting alternative enterprises.
- Restore ecological balance.

Watershed management

Soil, water and vegetation are the basic resources on which humans and animals depend. However, the demand for food, fibre and fuel to meet the needs of a teeming population amid the use of inappropriate technologies has resulted in excessive exploitation of these land-based resources and increased number of people undertaking activities which may not be consistent with sustainable development.

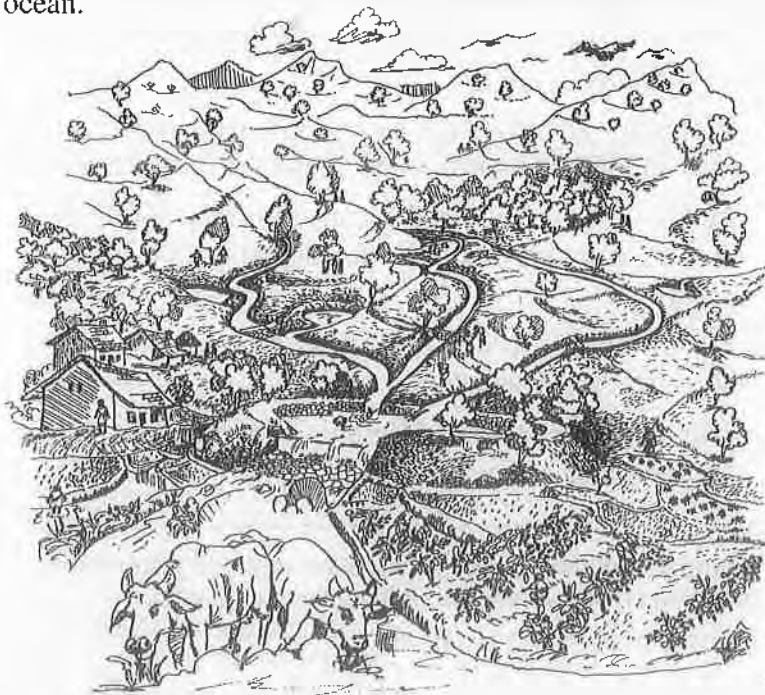
The impact of these disturbing activities led to several problems like soil erosion, nutrient loss, diminishing stream flow and water scarcity. These, in turn, have led to decline in crop yield and food security problems.

Concept

A watershed is defined as any surface area from which rainfall is collected and drained through a common point. It is synonymous with a drainage basin or catchment area. A drainage basin, however, can involve several towns or regions and even countries.

There is no definite size for a watershed as it may vary from a few hectares to several thousands of hectares. In fact, even an individual field can be considered as a watershed provided there is an independent drainage point.

However, watershed sizes are classified into three, namely: micro, mini and macro watersheds. A combination of micro watersheds makes a mini watershed which forms part of the macro watershed before finally discharging into the sea or ocean.



Watershed management is the integration of technologies within the natural boundaries of a drainage area for optimum development of land, water and plant resources to meet the basic needs of people and animals in a sustainable manner.

Objectives

- Effectively conserve soil, rain water and vegetation and harvest the surplus water to create water sources in addition to ground water recharge.
- Promote sustainable farming and stabilise crop yields by adopting suitable cropping and crop management systems.
- Cover the non-arable area effectively through afforestation, horticulture and pasture land development based on land capability class (*refer to page 43*).
- Enhance the income of individuals by adopting alternative enterprises.
- Restore ecological balance.

Components of watershed management

The following are the criteria to facilitate watershed management objectives:

- treatment of arable and non-arable land as well as drainage lines for effective *in situ* and *ex-situ* moisture conservation;
- implementation of programmes like afforestation, horticulture, agroforestry, pasture production and aquaculture in stored water;
- identification of a sound crop production system and its implementation through the involvement of developmental and input agencies; and
- developing suitable infrastructural facilities and people's organisations to maintain developed resources.

People's participation in correctly identified and applied technologies will help sustain high outputs from cultivated, grazing and forest land as well as other plant and animal resources. Small ponds, check dams and gully plugs will reduce the hardships of rain deficient periods, conserve and restore soil health and prevent flooding downstream.

The watershed is a topographically delineated area with boundaries. It is considered as a system divided into three components namely; upland, lowland and coastal ecosystems.

Each ecosystem has its distinct functions and characteristics. The upland ecosystem is the main water catchment and flow regulator. The lowland is the main distributor and water consumer, and coastal ecosystem functions as the main water resource system. The linkage between these ecosystems made the watershed a hydrologic unit. Thus, the watershed is a natural ecosystem and a logical unit that integrates the social and economic forces as well as the biophysical factors that have led to environmental degradation and food insecurity.

Principles of watershed management

- Utilising the land according to its capability.
- Adequate vegetative cover during the rainy season.
- Conserving as much rain water as possible at the place where it falls.
- Draining out excess water with a safe velocity and diverting it to storage ponds for future use.
- Avoiding gully formation and checking at suitable intervals to control soil erosion and recharge ground water.
- Maximising productivity per unit area, per unit time and per unit of water.
- Increase cropping intensity and land equivalent ratio through intercropping and sequence cropping.
- Safe utilisation of marginal lands through alternative land use systems.
- Ensuring sustainability of the ecosystem benefitting the man-animal-plant-land-water complex in the watershed.
- Maximising the combined income from the interrelated and dynamic crop-livestock-tree-labour complex over the years.
- Stabilising total income and cutting down risks during aberrant weather situations.
- Improving infrastructural facilities with regard to storage, transportation and marketing.

Sound watershed management means controlling floods and reducing erosion as well as sediment accumulation.

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Land capability classifications

Class I

Soils with few limitations requiring ordinary crop managements.

Class II

Gentle slope, moderate erosion hazards. Soils require moderate conservation practices.

Class III

Moderately steep slopes, high erosion hazards, shallow soil depth. Soil requires special conservation practices.

Class IV

Steep slopes, severe erosion hazards, shallow soil depth. Soil requires careful management practices

Class V

Frequent stream overflow, ponded/stony/rocky area. Generally not suited to cultivation.

Class VI

Steep slopes, severe erosion susceptibility. Generally suited for pasture and afforestation.

Class VII

Soils have severe limitations and hazards; even pasture improvement may be impracticable.

Class VIII

Sand beaches, rock outcrop. Use is restricted to wildlife, recreation or aesthetic purposes.

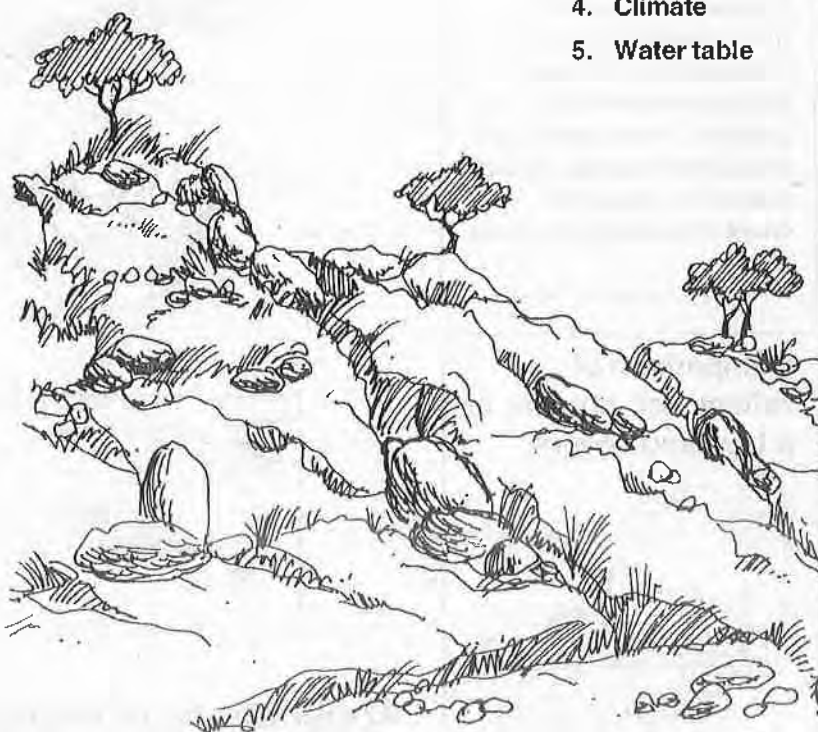
Increased limitation and hazards
Decreased choice of users

Increased land use intensity →

Land capability class	Wildlife	Forestry	Grazing			Cultivation			
			Limited	Moderate	Intense	Limited	Moderate	Intense	Very intense
I									
II									
III									
IV									
V									
VI									
VII									
VIII									

Major criteria

1. Topography
2. Soil depth
3. Texture
4. Climate
5. Water table



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Contributors : Koushik Mukherjee, P. Ramanagowda and
A.M. Krishnappa

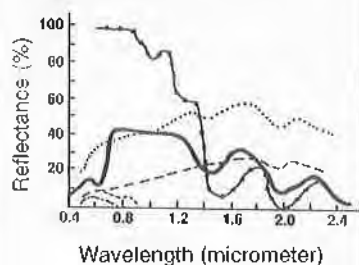
Satellite imagery for planning in drylands

Remote sensing

Remote sensing is the art and science of obtaining information about an object/area through satellites orbiting in space. The information received from the satellites is processed at the earth stations and converted into pictures called satellite images.

The special cameras (sensors) fitted within satellites revolving around the earth measure the responses of natural features like soil, vegetation and water to the sunlight. These responses, being characteristic of each feature on the earth, enable to identify and study them.

Comparison of reflectance spectra of a few land covers

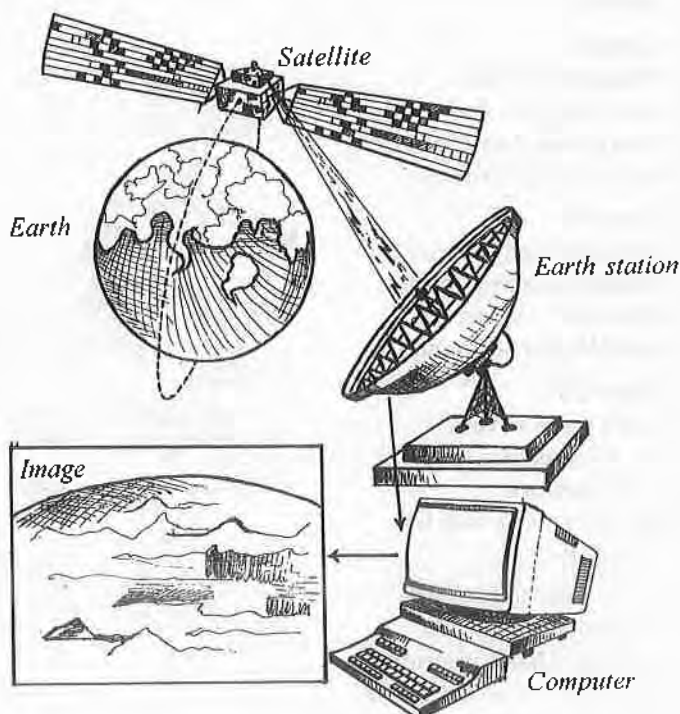


Legend

- Fresh snow
- △— Green vegetation
- - - Dark toned soil
- ... Light toned soil
- Clear water
- - -○- Turbid water

Information kit produced by MYRADA and the International Institute of Rural Reconstruction

Dryland areas are not only prone to chronic drought but also to severe soil erosion. Enhancing the productivity of drylands is possible only when proper soil and water conservation and optimum land use strategies are adopted. Watershed-based approaches have been found to be more appropriate where individual watersheds are characterised in terms of natural resources. Characterisation of natural resources requires a synoptic view of a particular area so that the land, water, vegetation and the interrelationships between them can be studied. Remote sensing techniques help in obtaining a synoptic picture of any particular region/area. With the new satellites (IRS-1C), it is possible to identify and study an object as small as 6m on the earth's surface.



Applications of remote sensing

Remote sensing helps in deriving baseline information about natural resources. The application can be divided as:

- mapping of area covered, distribution pattern and assessment of status of natural resources (land, water and vegetation) on a particular day; and
- monitoring of the status, area covered and distribution pattern of natural resources.

Natural resources mapping

Satellite imagery can be used to prepare the following resources maps with the help of limited field information:

- land use/land cover;
- soil resources;
- water resources (surface water and groundwater);
- land forms/drainage on different scale;

In addition to resource mapping, satellite imagery can be used for:

- estimating the area covered by major crops and the crop yield in advance;
- estimating the area affected by crop pests and diseases; and
- assessing drought conditions on a regional level.

Important Satellites used for remote sensing

IRS Series	:	India
Landsat	:	NASA (USA)
SPOT	:	France

Scale of maps Minimum area that can be shown on map

1:250,000	56.65 ha
1:50,000	2.22 ha
1:25,000	0.56 ha
1:12,500	0.14 ha

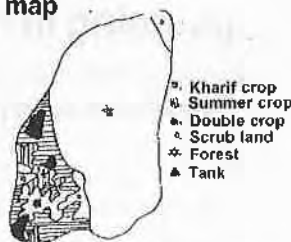
Village survey map



Drainage map



Land use/land cover map



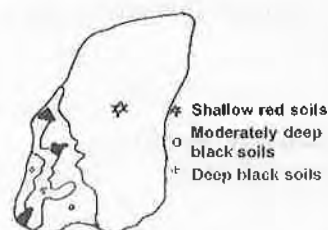
Water resources map



Natural resources monitoring

All natural resources are prone to depletion or change either by natural causes or by over-exploitation. Assessment of change is an important factor for planning. Each satellite has the capacity of revisiting an area once in 16-26 days. One can monitor the change using satellite imagery. This is more effectively done with a combination of two to three satellites.

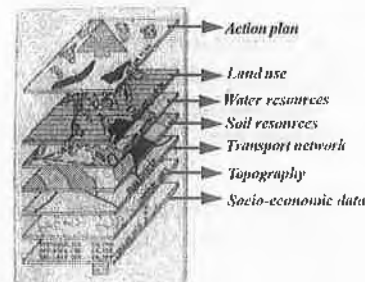
Soil resources map



Comprehensive planning in drylands

Land, water and vegetation are the basic natural resources which determine the activities of life on the earth. Furthermore, the extent, the status and distribution patterns of these resources are the fundamental requirements for planning. For example, understanding the pattern of soil cover and dividing this pattern into relatively homogeneous units is a prerequisite for planning. Similarly, mapping the extent and distribution pattern of tanks and delineating the groundwater potential zones is important. Study of extent, status and distribution patterns of natural vegetation or croplands gives an idea about the fertility status of soil and availability of water.

Integration of resource maps

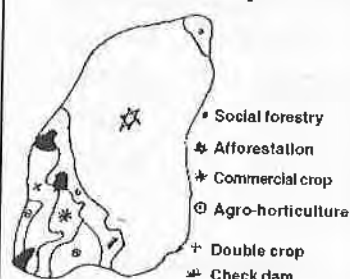


Geographic Information System (GIS)

Action plans that can be generated

- Groundwater recharge
- Rainwater harvesting
- Social forestry
- Wasteland reclamation
- Soil conservation measures
- Crop rotation strategies

Action plan map



Mapping of landforms is also important because it gives an idea of terrain morphology and indirectly, one can assess the nature of soil erosion, run-off and groundwater recharge.

Natural resources information derived from satellite data need to be integrated with conventional meteorological data and socio-economic parameters to arrive at locale-specific plans that ensure sustainable development. These action plans are decided upon in consultation with agricultural scientists and local experts to ensure technical feasibility and socio-cultural acceptability. With the availability of computer-based geographic information system (GIS) softwares, the integration of resources information (map data) and socio-economic data has been much easier.

Parameters commonly used for planning in drylands

Parameter	Relevance for drylands	Satellite from which information can be obtained
Physiography: Relief information and geomorphic units (Landforms)	Understanding the surface run-off and erosion prone areas; ground prospects	
Drainage: Drainage pattern	Estimation of run-off, sedimentation, surface storage	IRS, SPOT
Geology: Rock type, stratigraphy	Sedimentation, run-off, ground water prospects	IRS, Landsat, SPOT
Soil: Soil classes, land capability, land irrigability, soil suitability and soil moisture regime	Run-off and sedimentation production potential, conservation measures, land use revisions, etc.	IRS, Landsat, SPOT
Land use/land cover: Current land use, canopy cover, surface-water bodies, etc.	Run-off, sedimentation, land revision, wasteland reclamation and extension of agriculture	IRS, Landsat, SPOT
Ground water: Ground water potential zones, quality	Recharge, irrigation IRS-series, Landsat, SPOT	IRS, Landsat, SPOT

Contributors: V. R. Hegde, S. Adiga and H. M. Ravishankar

Agronomic measures in dryland agriculture: An overview



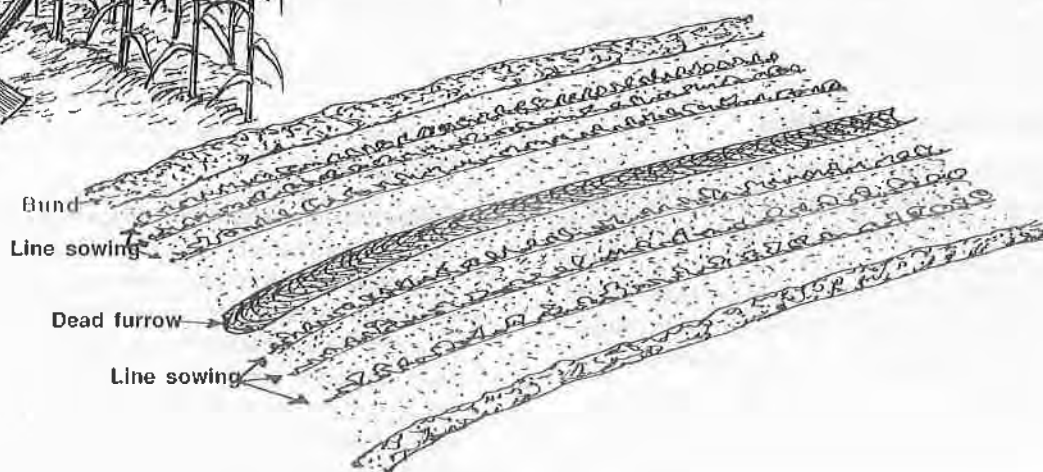
Soil and water conservation measures consist of agronomical and mechanical methods. Agronomic methods are supported with mechanical measures where land slope exceeds permissible limits and runoff gains erosive velocities.

The following boxes explain the nature of agronomic measures which are essential in inter-banded or terraced areas. These practices enhance the utility value of all kinds of mechanical structures.

Contour tillage

All agricultural operations such as ridging, ploughing, harrowing, sowing, trenching, etc., are recommended to be done on the contour wherever possible or at least generally across the direction of the slope where holdings are very small. Even though the operation is very simple, it plays a major role in retarding the process of soil erosion through runoff. It also conserves soil and due to increased time of concentration, more rainwater seeps through the soil profile to recharge ground water. Summer ploughing leaves the soil highly absorbent of initial rains.

Contour cultivation in inter-banded area



Dead furrows

When all tillage operations are complete, it is advisable to leave a deep dead furrow at every 10 m interval. This should remain in position until the crop is harvested. Dead furrows 'aid' in reducing the runoff velocity and they also conserve water.

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Organic matter

Indian soils are very poor in organic matter, especially in drought-prone areas. This can be improved by leaving the crop residue *in situ*.

Adding organic manures, such as farmyard manure and compost every year as basal application to the soil, improves the physical condition of the soil considerably. Soil - Air, Soil - Temperature, Soil - Moisture relationships are well balanced with the presence of organic matter. Organic matter improves the activities of soil microorganisms and also provides the much needed micro plant nutrients of all kinds, besides nitrogen, phosphorus and potash.

Addition of large amounts of chemical fertilizers to dryland crops should be discouraged as it damages the soil due to:

- excessive depletion of scarce soil moisture for its own transformation;
- reduction in all soil microorganism activity; and
- destruction of soil structure.

Selection of drought-resistant varieties

It is important that varieties which have proven genetic character to withstand longer periods of drought are chosen so that the crops can do well even in situations where the intervals between rainy days are long.

Early maturing varieties

Where the distribution and the amount of rain is unpredictable, it is important to select varieties which have a shorter duration life cycle (seed to seed) to cut down the water requirements of the crop. In drought-prone areas, the success rate of short duration crops is greater than long-duration crops.

Seed rates

Normal season: Sowing is done with the normal seed rate. However, if there is a drought during the plant's growth period and wilting is likely to occur, selective thinning is recommended to reduce the plant population to effectively use the scarce soil moisture among fewer plants.

Late season: Where the monsoon is moderately delayed, normal cropping with reduced seed rate is advised.

Line sowing

Line-sowing on contours is essential. It arrests runoff and conserves soil being eroded. It helps in the use of labour-efficient implements in weeding. (i.e., removal of unwanted vegetation through use of different sizes of blade harrows between the rows).

Wider spacing

In all drought-prone areas, the most important objective is to raise a successful crop under scarce soil moisture conditions. One of the recommended practices is wider spacing between rows and between plants within the row. This reduces plant population and competition between plants for scarce soil moisture. Fewer plants have greater access to limited available soil moisture.

Weeding

Frequent weeding is an important part of dryland agriculture. Line sowing and mechanical weeding, with appropriate size of blade harrows, remove unwanted vegetation which competes with the main crop. It is not uncommon to see the dryland farmer hitching several blade harrows to one yoke and a pair of bullocks. Weeding within rows can be done using hand hoes. Removal of unwanted vegetation helps the main crop obtain greater accessibility to soil moisture and plant nutrients for its own growth.

Strip cropping

Raising Erosion Permitting Crops (EPC) with Erosion Resistant Crops (ERC) having abundant adventitious root system and providing high percentage of canopy in strips at a ratio of 2:1 or 3:1 (i.e., 20 to 10 rows or 30 to 10 rows) helps in trapping soil from EPC strips to ERC strips.

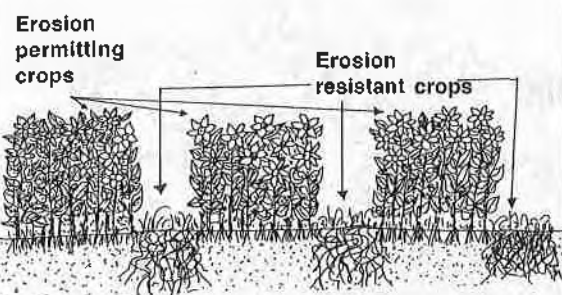
The increased resistance to runoff in ERC results in higher volume of water percolating through soil profile, due to increased time of (on-ground) concentration.

The close-growing ERC strips are generally legumes which fix nitrogen in the soil and enrich it.

The canopy of the ERC also protects the soil from the beating action of rain drops.

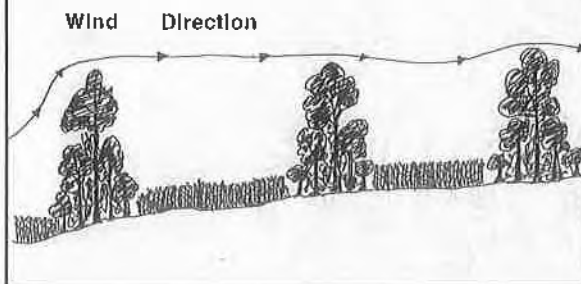
Strip cropping also helps in stabilizing crop production.

Wind erosion



Where wind erosion is as important as water erosion, the same system of cropping is recommended to be adopted, generally across the wind direction. Farmers can also raise wind belts across the wind direction. Alley cropping with rows of trees at 30 to 45 m intervals also controls the desiccating effects of hot and dry winds.

Windbreaks



Mixed/Inter cropping

Mixed cropping of different crops along with the main crops, such as millets and different legumes, is an insurance against the vagaries of monsoon. The different root systems of mixed crop feed at different depths of the soil. Moreover, mixed cropping provides small quantities of grain of different kinds for home consumption at different times.

Mulching

Mulches are ground covers that prevent the soil from blowing or being washed away, reduce evaporation, increase infiltration, and control the growth of unwanted weeds. Mulch can be organic crop residue, pebbles and/or materials such as polythene sheets. Mulching prevents the formation of hard crust after each rain. Organic mulches add plant nutrients to soil upon decomposition.

Use of blade harrows between rows also creates "dust mulch" by breaking the continuity of capillary tubes of soil moisture.

Contingent planning

With every care taken to undertake timely agricultural operations, it is still possible that the whole operation becomes a gamble due to unpredictable monsoons. The main crop could fail in the early part of its life cycle. In such cases, the farmer should come up with an alternate crop that can mature in a very short time and under hard conditions to take advantage of what is left of the rainy season. Contingent planning helps catch and make the best use of late rains. Advance planning is necessary in selecting a contingent crop. And all the requisites for its sowing should be ready within the main season itself. Credit for farmers must be made available at the right time.

Buffer strips

In steep slopes and highly-eroded soils, raising permanent vegetation in small strips at appropriate intervals along the contour helps in arresting soil erosion and conservation of rain water. Raising trees in buffer strips is an asset to counter unpredictable monsoons.

Agro-horticulture

Marginal lands do not produce good annual crop returns even in normal seasons. These kinds of soils are best used for raising trees of economic value and creating permanent assets. Some of these lands are also very good for raising dryland horticultural crops such as mango, *ber*, pomogranate, tamarind, etc. A part of the land could be earmarked specially for planting mixed tree species known in the area for providing fuel, fodder and timber for household needs and agricultural implements. Trees provide stable and sustained income every year, especially in drought years.

Role of vegetation

Vegetation is crucial in preserving productive soil and conserving rain water for sustaining life. Soil and water need to be preserved for crop production (both annual and plantation crops) as well as for plants that give fuel, fodder, fruits, industrial raw materials, medicinal and aromatic products and the like.

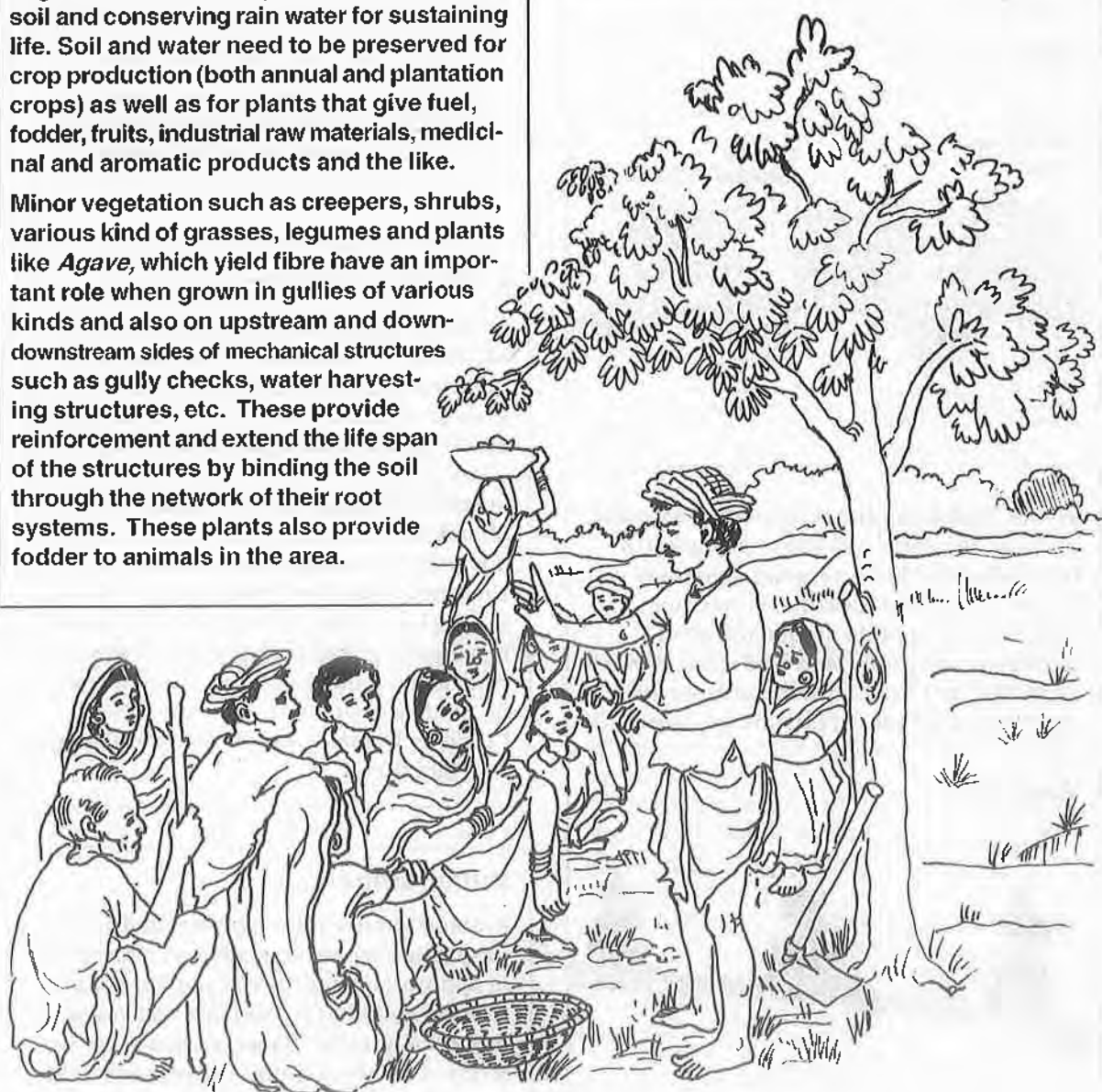
Minor vegetation such as creepers, shrubs, various kind of grasses, legumes and plants like *Agave*, which yield fibre have an important role when grown in gullies of various kinds and also on upstream and downstream sides of mechanical structures such as gully checks, water harvesting structures, etc. These provide reinforcement and extend the life span of the structures by binding the soil through the network of their root systems. These plants also provide fodder to animals in the area.

Mechanical methods

Where the slope of the soil is more than permissible, mechanical measures such as bunding, terracing and trenching are recommended in addition to agronomic methods. Agronomic methods are used in inter-bunded areas and mechanical practices complement to help boost crop yields in rainfed drylands.

Indigenous technical knowledge

Local technologies evolved by people over generations of experience should be used before any new recommendation is made.



Contributor: K. V. Rao

Regeneration of vegetation: Natural and assisted approach

Land

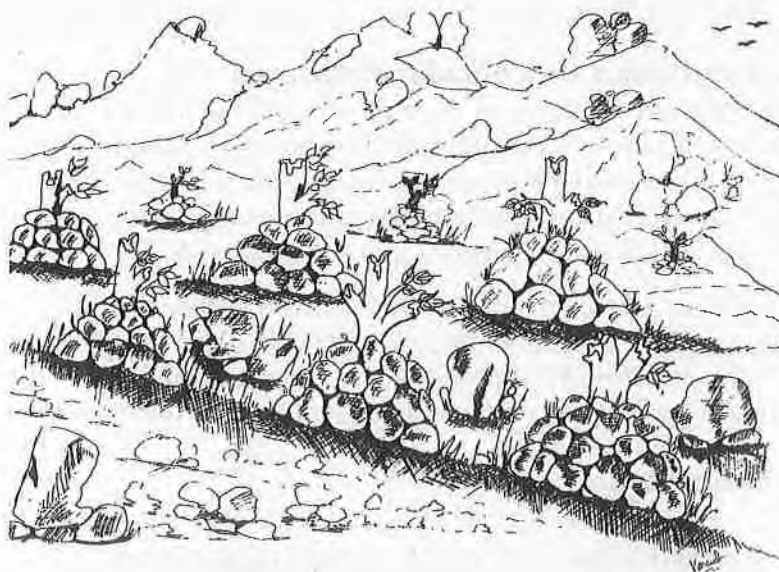
Characteristics: Shallow, degraded red loamy soils, very stony, no tree cover, few thorny bushes, vast uncultivated areas.

Water resources condition: Data from the past 25 years show 25 to 45 rainy days per year and a rainfall of between 400 mm to 600 mm per year. Few tanks, mostly silted, dry for 9-10 months of the year. Poor ground water availability.

Under these circumstances, and because barren lands are too expensive to reclaim and bring under agricultural use, it was decided to promote the idea of other forms of permanent vegetative cover on these lands with the involvement of local communities.

The presence or absence of vegetation is the most decisive factor on erosion and land degradation.

This example of an attempt to improve the status of vegetation through natural and assisted means is from Kadiri taluk of Ananthapur District, Andhra Pradesh.



Assisting nature to regenerate itself

Stump protection

To enable live stumps of destroyed trees to heal themselves and revive, stumps were identified through discussion, transect walks and observations. Small boulders (abundantly available) were piled around the stumps up to a height of 0.6 to 0.9 m. A white "X" mark on the boulders indicated that this was a protected stump.

Plot protection

Areas ranging from two to 20 ha were protected with boulder wall fencing to restrict entry of animals and allow all live vegetation in the enclosed areas to regenerate.

Steps followed

- Organising village communities.
- Joint identification and demarcation of plots to be protected.
- Survey of existing species in demarcated areas.
- Planning: identifying the tasks involved and responsibility sharing.
- Implementation by the communities (with some external financial support).
- Community-based management of the plots and the produce.

Impact

141.64 ha in 12 plots

No. of families: approx. 250

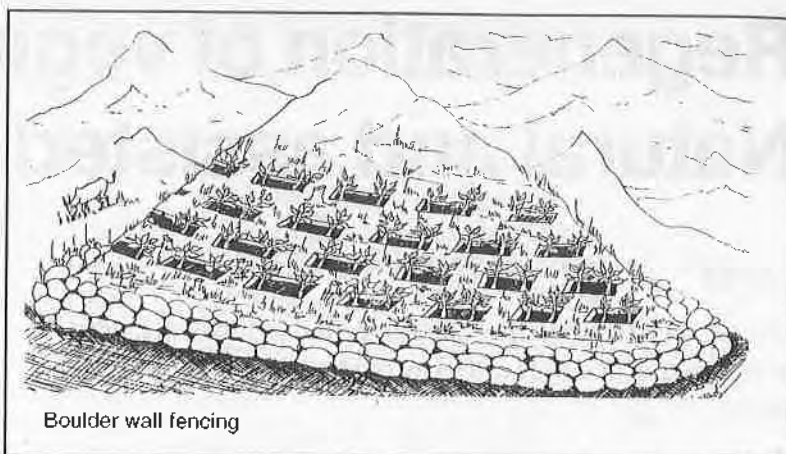
1st year: Fodder and roofing grass available.

2nd year: Small quantities of fuel and green manure were collected. The latter mainly as a result of adapting pruning and thinning methods.

5th year: Timber collected for making agricultural implements; fruits and vegetables gathered.

7th year: Timber (tall growing varieties) and fruits and vegetables.

*Information kit produced by
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Boulder wall fencing

Seeding of fodder varieties

Broadcasting of fodder grass seeds was done extensively in the protected plots during the rainy season.

Planting seedlings

Hardy, drought-tolerant trees like neem, tamarind, custard apple, acacia, eucalyptus, etc. were planted in the protected plots to create a source of income for future maintenance of the protected plots.

Soil and water conservation measures

Trenches were mainly dug to conserve water and minimise run-off and soil erosion (most of the protected areas are on barren hill slopes). Farm ponds were excavated in suitable locations from which one or two waterings were possible in the smaller plots to enable the saplings to establish.

Surveys of protected plots in 1989 and 1995 showed an increase in the number of trees from 1,428 (1989) to 30,397 (1995) apart from the saplings planted. These are reviving primarily on account of the protection offered by the fencing.

Management

In most cases where the plot sizes are small, self-help groups of women (that had been earlier organised to address the credit needs of poor families) have assumed leadership of planning, implementing and managing each protected plot. In two villages, more than one self-help group (of both men and women) engaged in managing the same plots because the plot sizes are much larger. Apart from engaging in building protective barriers and planting new seeds and saplings (on part wage payment and part labour contribution basis), management also introduced watch and ward, auctioning the right to collect grasses and fruits, cut trees, and the management of revenue accruing to the group's common funds from the sale of the produce from these protected plots.

Contributor: Y. Ramesh

Improving vegetative cover on dryland farms

It is generally perceived that rainfall patterns alone determine the success or failure of crops. What happens to the received rain water is as important as the quantum of rainfall itself. Equally important is the pattern of utilisation and influence of other natural resources and life forms such as sunshine, soil, soil microbes, type of crops, local vegetation, livestock, birds, etc.

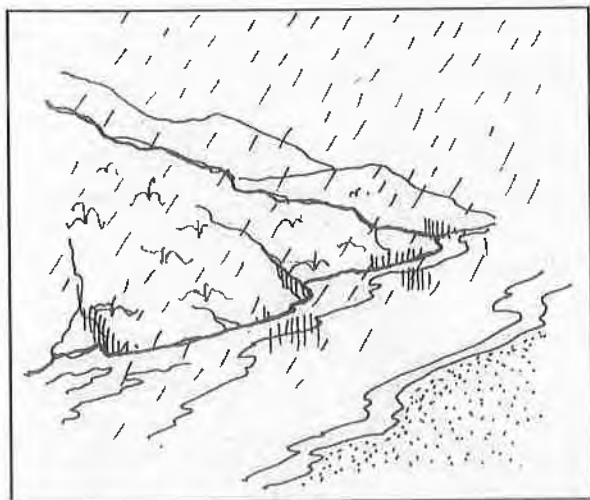
Benefits of vegetative cover

Vegetative cover in the form of trees, shrubs, creepers, grasses, etc, helps intercept raindrops and retain maximum water in their canopy. Excess rainwater slowly runs down the leaves, branches and the main trunk, avoiding splash erosion and resulting in increased percolation. Vegetation also deflects wind, thereby reducing wind erosion and moisture loss. A grass cover will reduce the velocity of water flow over the ground and allow for increased percolation.

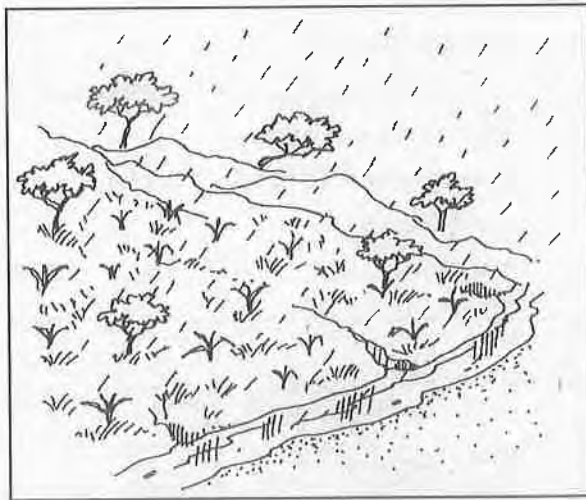
A vegetative cover also provides home for a variety of insects and birds. This helps increase the biodiversity and reduce the presence of pests and diseases. Droppings and decomposition of flora and fauna add nutrients and organic matter to the soil which change the structure of soil particles. These activities enhance the water holding capacity of soils which improves the survival prospects of crops during dry spells.

What happens to rain water

In a typical dryland area, rainfall is the primary source of water. Without adequate vegetation a substantial proportion of this rainwater will be lost as runoff. Estimates of this wastage range from 40% to 90% depending on soil type, land slope and existing vegetation. The proportion of rain water retained *in situ* increases with increased vegetative cover. Promotion of vegetative cover in the form of trees, shrubs, creepers, grasses etc., is essential in improving the utilization and quality of natural dryland systems.



Low vegetative cover — high run-off



High vegetative cover — low run-off

Trees for boundary bunds

Trees that can be considered for boundary bunds are:

- *Eucalyptus* spp (Niligiri)
- *Tectona grandis* (Teak)
- *Thespesia populnea* (Huvarsi); *Albizia lebbek* (Bage)
- *Leucaena leucocephala* (Subabul)
- *Annona squamosa* (Seetaphal)

Trees for internal bunds

Tree that can be promoted on the internal bunds are:

- *Glyricidia sepium*
- *Leucaena leucocephala*
- *Cassia siamea* (Seme thangadi)
- *Sesbania sesban* (Chogache)
- *Erythrina indica* (Halvana)
- *Moringa petrigosperma* (Nugge)
- *Pongamia pinnata* (Honge)

Horticultural species to be planted in the field

In addition to planting vegetation on the bunds, horticultural species should be planted in the field itself. Some of the horticultural species that can be considered are:

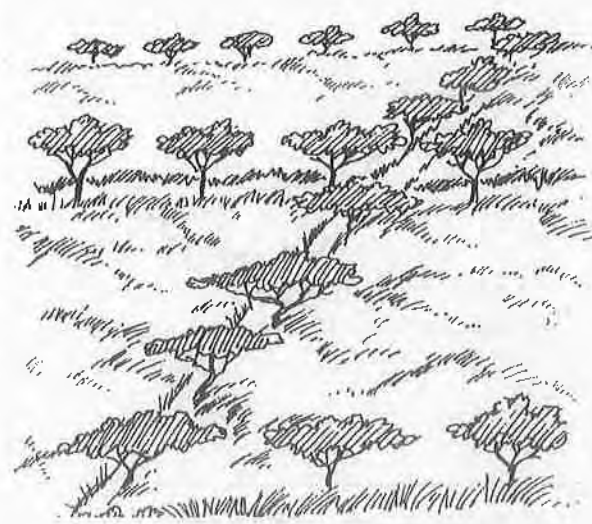
- Mango, 30 to 50 plants per hectare
- Tamarind (grafted), 10 to 20 per hectare
- Papaya, 20 per hectare
- Pomegranate, 10 to 15 per hectare
- Curry leaves
- Emblica

In addition to enhancing the quality of natural systems, high vegetative cover also provides economic security for farmers. Trees and other plants are seen as means to gain wealth for poor farmers as they provide food, fuel, fodder and building materials. They are liquid assets which can be sold in cases of crop failure as they are much less vulnerable to the vagaries of weather and markets. Increasing vegetation, therefore, provides income and reduces farmers' dependence on money lenders and unsustainable accumulation of debt.

How to increase vegetative cover in cultivated land

Farmers' fields are normally divided into several sub-plots using bunds. A hectare of land can have 800 to 1200 m of bunds including the boundaries. All these bunds can be covered with perennial fodders like *Stylo hamata* and other local grasses which will help to stabilise the bunds.

Trees with long rotation period can be planted on the boundary bunds with a planting distance of 2 m. Internal bunds can be planted with trees of short rotation period and those which can produce maximum leaf biomass. The number of each species depends on the purpose of plantation, the cropping system being followed, soil characteristics and level of precipitation.



Steps involved in establishing tree cover in drylands

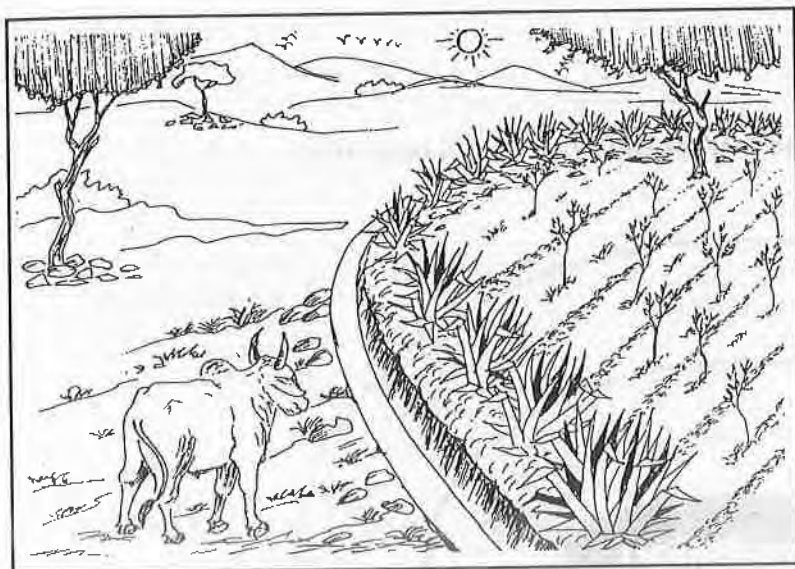
A systematic and planned approach should be adopted in establishing effective tree cover in drylands. Farmers should make a provision of three to five years to achieve the desired vegetative cover. Actions to be taken from year to year are detailed below.

Year 1

In the first year, the following activities should be done in the field where vegetative cover will be established.

Livehedge fencing

Establishing protection from stray cattle is absolutely essential. Normally it takes about one year to establish a fence. Some species such as cactus, *Euphorbia* species, *Lantana*, *Agave* and others can be used for this purpose. The live hedge should also be reinforced with thorny bushes for added protection. Non-browsable plants are preferable for a livehedge fence.



Bunding

Creation of internal bunds in the cultivated plots is advisable. Cultivated plots should be divided into smaller plots by erecting bunds. These will help soil and water conservation and promote better tree growth. The optimal interbund distance should be kept around 20 to 30 m, depending on the slope of the land.

Excavating a farm pond

Excavating a small farm pond measuring 10 x 10 x 3 m in a hectare of land will facilitate the collection of run-off rain-water and will help improve the microclimate.

Note

It is essential to water the plants immediately after planting. Water the plants diligently on the first two years after planting to improve chances of survival.

Tree management practices for an agroforestry plot

- Prune trees on internal bunds to a height of about 5 ft to avoid shading of crops.
- Trees on the boundary should be allowed to grow straight by pruning the side branches only.
- Reintroduce all leaf biomass into the soil. This increases soil organic content and promotes soil humus content and growth of soil microflora and fauna.
- Maintain a trench of half a foot at a distance of half a metre from the trees to cut surface roots and keep them from spreading into the field.

Nursery

A good nursery of desired forest trees should be planned and established in the first year. Pelleting of seeds using cowdung and dry sowing of pelleted seed helps establish forestry trees at a comparatively lower cost.

Pitting

Pitting should be completed and allowed to wither before the onset of rains. The pits should be filled with organic manure, neemcake, rockphosphate and covered with top soil.

Pit size required for various tree species

Tree species	Dimension (ft)		
	length	width	depth
Mango	3	3	3
Tamarind	3	3	3
Other fruit species	2	2	2
Other forestry species	1	1	1

Year 2

Planting should commence with the onset of rains. Weeding, watering and basin preparation should be done at regular intervals if the rain fails.

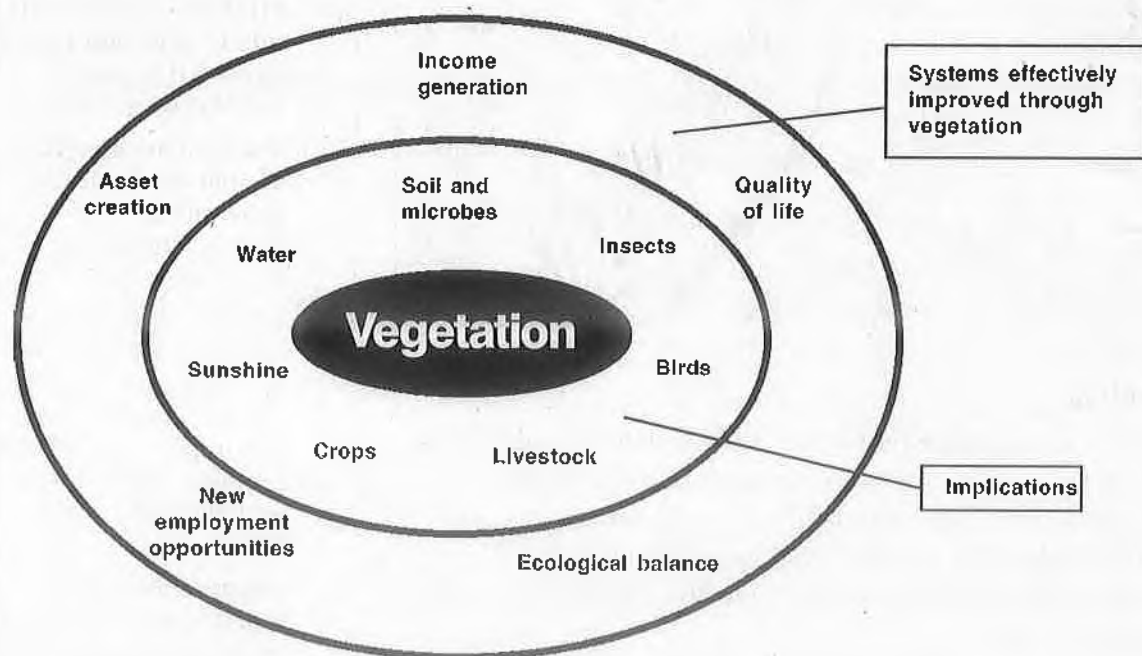
Year 3

Gap filling, weeding, watering and basin preparation should continue. Replace weak plants with healthy seedlings. Organic manure should be applied for horticultural plants.

Years 4 and 5

Weeding, watering and basin preparation should be continued. Depending on the survival rates, thin out closely-placed plants. Pruning of the side branches of forestry species planted on the boundary should also be done.

The judicious and sustainable utilization of natural resources adds to our quality of life



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Contributors: G. N. S. Reddy and G. M. Vanaja

Protective measures for non-arable lands

Soil degradation results in an appreciable loss of productivity and lowers the current and/or potential capacity of soil to produce goods or services. The major degradation problems in the South Asian region are erosion by water and wind, loss of fertility, chemical degradation and water logging.

Factors of degradation

- Deforestation of lands for fuelwood and fodder — leads to increased erosion.
- Uncontrolled grazing — increases erosion by exposing the top soil.
- Hazardous mining practices — increases erosion in hilly areas causing degradation of vegetation in arable lands. This leads to siltation of tanks and reservoirs.
- Surface runoff along the slope — concentrates and increases in volume and velocity, causing erosion in the arable lands situated downstream.

This paper focuses on control of degradation occurring through surface runoff.

Protective soil and water conservation measures

Catch pits/dug-outs

These are large dug-out pits situated at rill points and waterways to trap runoff. It is adoptable in rocky areas. Pits are planted with suitable trees. This is both a mechanical and vegetative measure.

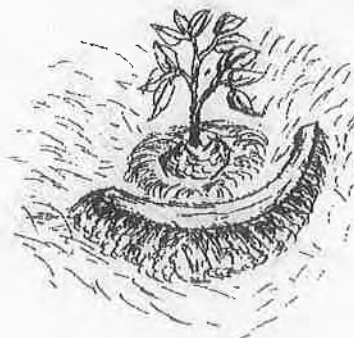
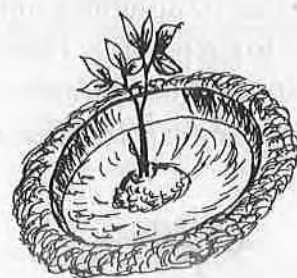
Pits with crescent

These are crescent-shaped bunds formed across the slope with a vegetative pit inside. The bunds control runoff and soil erosion and facilitate the development of vegetative cover.

This is a mechanical measure.

On an average, India loses 5,333 million tonne of soil annually, equivalent to 16.5 tonne/hectare.

In non-arable lands, water is held in suitable trenches, pits or different suitable land configurations, to improve the establishment and growth of grass, trees, fruit plants, etc. Mechanical or vegetative measures are used to restore degradation. However, protective enclosures themselves can promote the regeneration of non-arable lands.



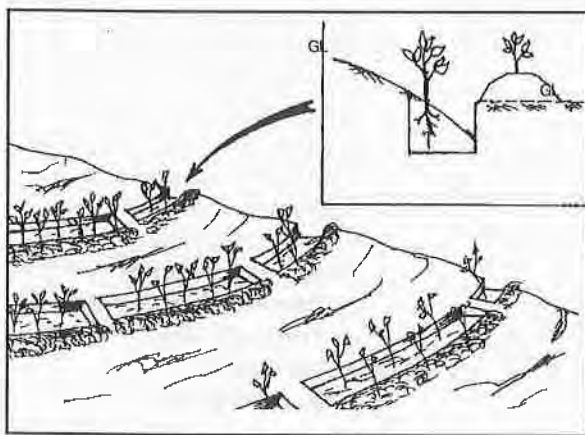
Contour trenches/V ditches

These are trapezoidal/v-shaped dug-out trenches made along contours to hold rainwater for conservation.

The trenches have a width of 0.6 to 1 m at the top and 0.4 m at the bottom. They are 0.4 m deep.

They can either be staggered or continuous at 5 to 10 m horizontal intervals. Trenches are planted with suitable trees.

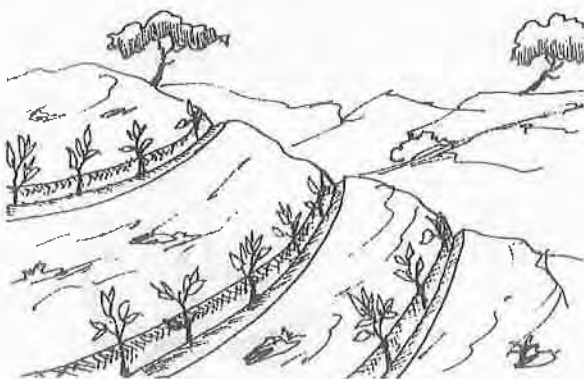
This is a mechanical as well as a vegetative measure.



Gradonis

These are benches of small width formed on contours by disturbing soil in areas having mild to steep slopes. These are planted with bushy vegetation or trees.

This is a mechanical measure.

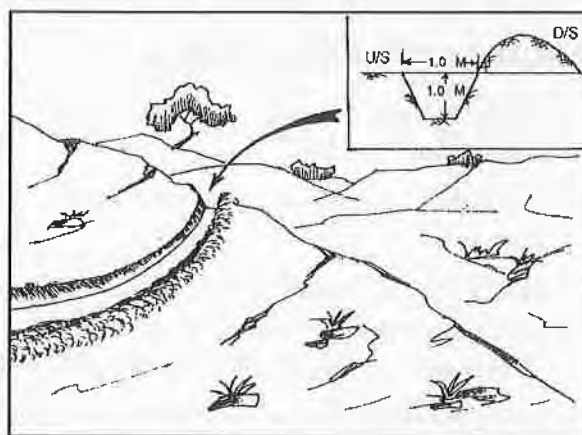


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Diversion drains

This is an individually-designed channel placed across the slope to intercept and divert surface runoff and to save arable lands from being damaged due to overflow from non-arable lands. The channel is trapezoidal in shape and grown with suitable vegetative species. These are adoptable in all areas irrespective of soil and climatic conditions.

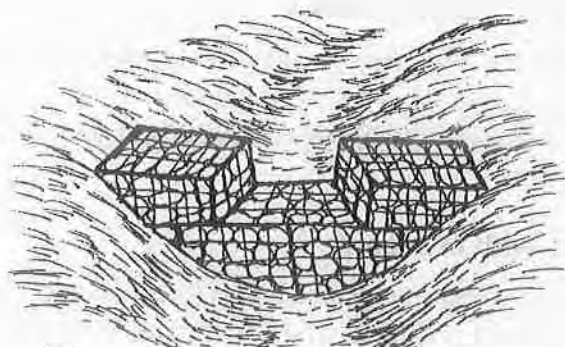
This is a mechanical measure.



Gabion structures

These are dams made of wire-woven baskets filled with stones constructed across non-arable lands to control silt erosion in steep slopes.

This is a mechanical measure.

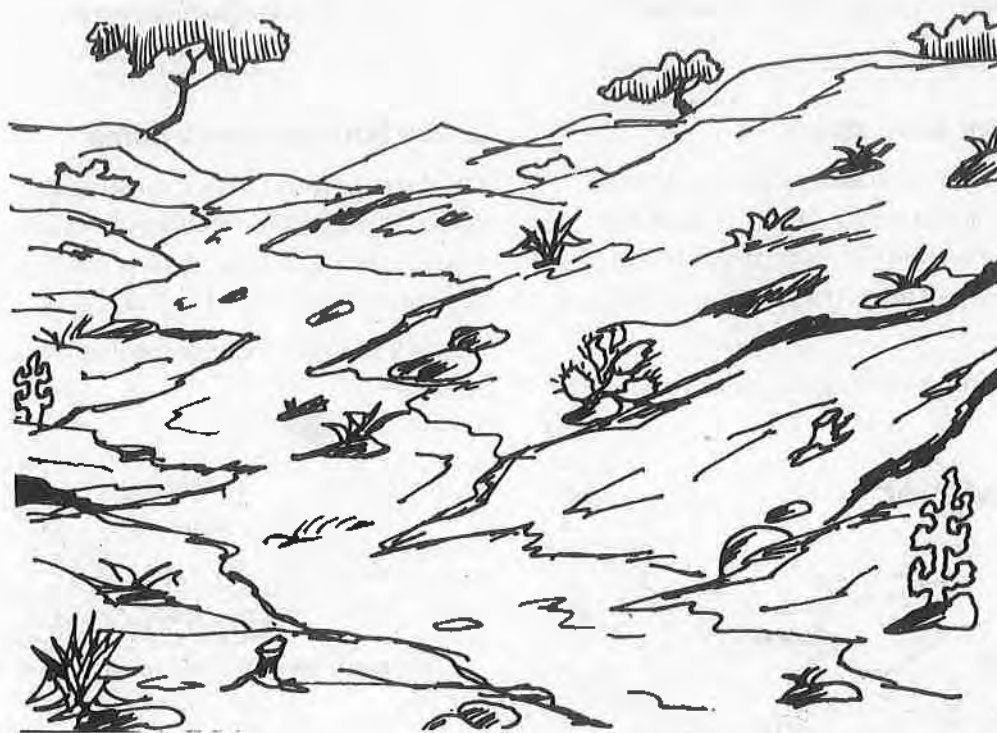


Note

Run-off from non-arable lands cannot be reduced to zero despite appropriate measures.

Contributors: M. S. Rama Mohan Rao,
R. N. Adhikari, S. K. Nalawadmath and S. L. Patil

Gully control measures



Improper soil and water conservation measures in non-arable and arable lands lead to sheet and rill erosion which result in gullies.

Gully formation

Sheet and rill erosion, if not controlled in the initial years through vegetative measures, result in gullies (within five years). These are often 1 to 5 m deep depending on the rainfall, topography and soil conditions.

Results

- Increases the area under degradation and reduces cultivable areas.
- Increases the velocity of runoff water, leading to silt deposits in dams.
- Reduces storage capacity of reservoirs and dams, threatening lives and crops downstream.

The forms of soil erosion noticed in India are sheet and rill erosion in red and laterite soils, sheet erosion in black soils, rill and gully erosion in loamy soils and wind erosion in sandy soils.

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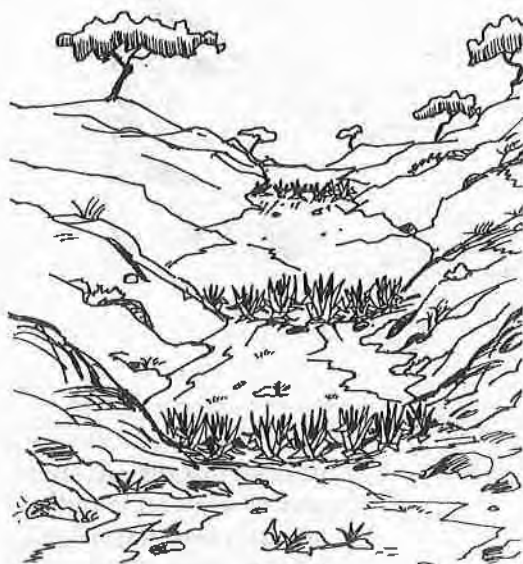
Control measures

Mechanical — Any earthen, stone or masonry structure constructed across the slope as a preventive measure to arrest soil and water flows.

Vegetative filter strips

Strips of suitable plant species are planted across the water course/nala to check the velocity of water flow, arresting silt. This is adoptable in all areas irrespective of soil and rainfall.

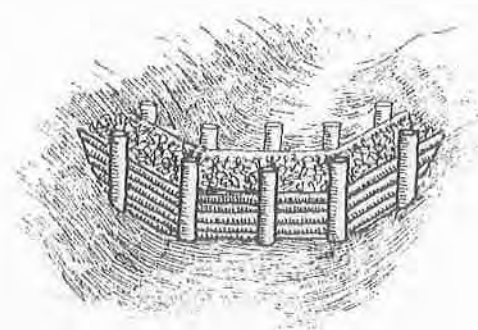
This is a semi-permanent vegetative measure.



Brush-wood check dams

These are constructed across the gullies by driving wooden pegs into the ground and then intertwining brush-wood along the driven pegs. This is adoptable in all areas irrespective of soil and rainfall.

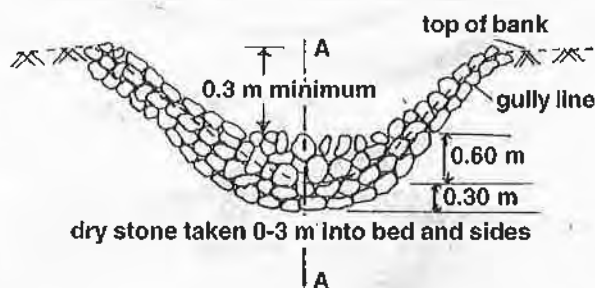
This is a semi-permanent vegetative and mechanical measure.



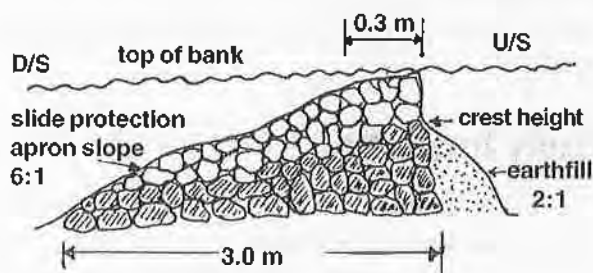
Loose boulder check dams

These are porous checks constructed across the nala using loose boulders to check water velocity and arrest silt. This is adoptable in all areas irrespective of soil and rainfall.

This is a semi-permanent mechanical measure.



Cross section of a dry stone check



Section on "AA"

Rubble dams

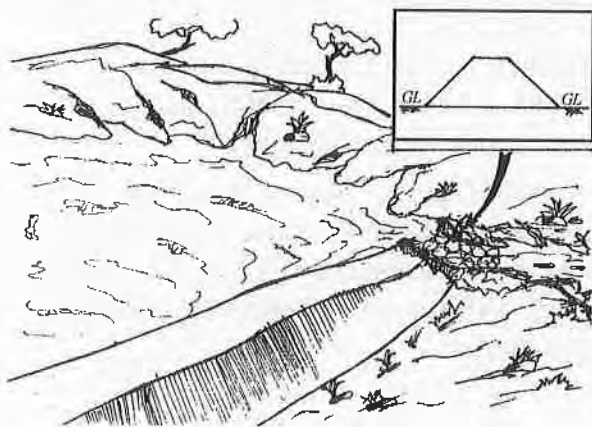
These are rubble obstructions across the water course to check water velocity. This is adoptable in all areas irrespective of soil and rainfall.

This is a semi-permanent mechanical measure.

Nala bunds

These are earthen embankments across the nala to impound water and regulate excess flow through surplus weir/channel and can be adopted in low to medium rainfall areas. These embankments are constructed using the engineering principles involved in constructing dams.

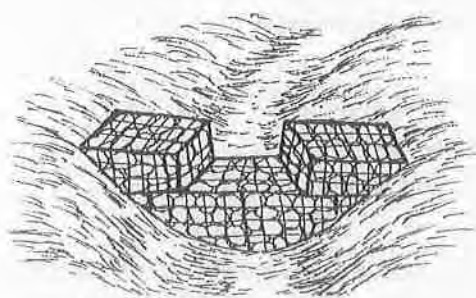
This is a permanent mechanical measure.



Gabion structures

These are dams made of wire woven baskets filled with stones, constructed across steep-sloped gullies to trap erosion debris during heavy rains. These are adoptable in areas with high slope and rainfall. They are located in active gullies conducting high velocity runoff, carrying large sediments and causing scouring and cutting of banks.

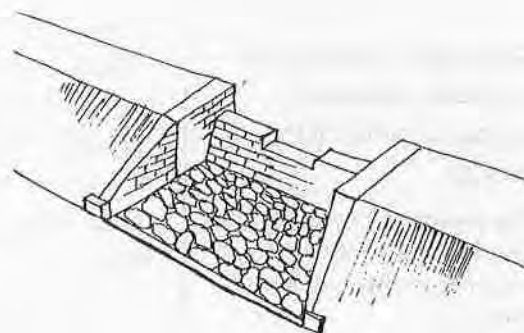
This is a semi-permanent mechanical measure.



Drop structures

These are dams constructed across the nala to check water velocity and permit storage. Excess runoff will pass through the weir.

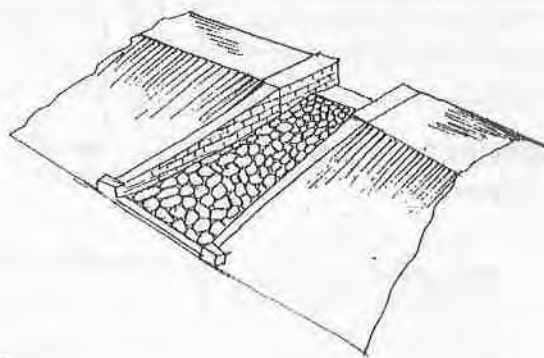
This is a permanent mechanical measure.



Chute spillways

These are open channels with steep slopes consisting of an inlet, vertical curve section, steep-sloped channel and an outlet. These can be constructed in all areas irrespective of rainfall and soil characteristics when runoff is carried along the steep slopes and sudden drops.

This is a permanent mechanical measure.



Percolation tanks

These are embankments constructed across natural depressions/valleys in arable, non-arable and community lands to store runoff for percolation so as to recharge ground water and make water available for social and agricultural use at the surface level.

This is a permanent mechanical measure.

Contributors: R. N. Adhikari, M. S. Rama Mohan Rao, S. K. Nalakwadmath and S. L. Patil

Indigenous rainwater management

Rainfall in semi-arid tropical and arid tropical lands (dry lands)

The rainfall is limited to just 3 or 4 months followed by a long dry winter and summer.

There are limited number of rainy days, mostly of unpredictable intensity.

During summer months, intense radiation, high wind velocity and desiccating heat cause a high rate of evaporation.

These result in increased demands for water for human, animal and plant life.

Hence, the need for rain water management.

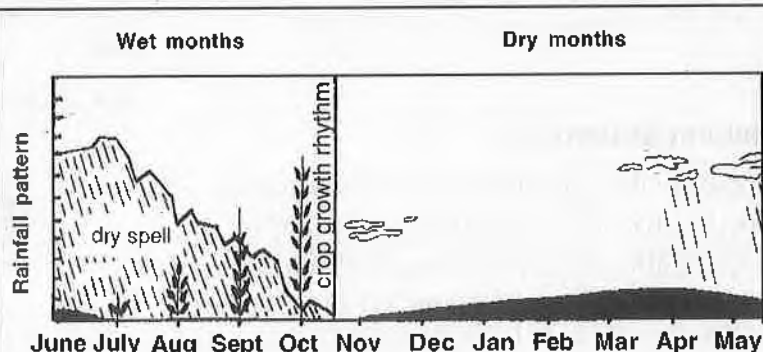
Why indigenous system?

- It has a holistic approach that takes care of drinking water, domestic, cattle and agricultural needs.
- Process starts at the village and expands to all depressions on culturable and non-culturable lands.
- It is based on the principle of collect, recharge and survive.

Out of the 329 million ha constituting the total land mass of India, about 154 million ha are drylands — cultivated drylands, culturable and unculturable waste lands. Such drylands are under different degrees of degradation and pose serious economic and ecological problems. Management of scanty rainwater holds the key for any development in these areas.

For ages, our forefathers had been adopting appropriate practices to deal with water limitations. Unfortunately, some of these practices have slowly been abandoned.

Several new schemes such as the Drought Prone Areas and Desert Development Programs have been initiated. During the last 20 years, nearly Rs. 1,500 crores have been invested on such projects. The performance and results have sometimes been disappointing.



Tropical and sub-tropical hydrology (one year)

- 3-4 months — wet; 8-9 months — dry
- The major portion of rainfall comes in July-August when crop plants are small and need less water.
- In September to October — when plants are grown up and need more water for vital physiological progress — rainfall tapers off.
- Late onset of monsoon.
- Early withdrawal of monsoon.
- Long dry spells between two rains.

Problem

- How to re-allocate water in time to meet water needs in winter and summer?
- How to provide adequate moisture to crop plants throughout the cropping season?

The present day approach and technology for water management is fragmented and compartmentalised. One department takes care of drinking water only, another manages irrigation water, etc.

The real challenge in water management in semi-arid and arid tropical lands boils down to **how to conserve rain water of three to four months for use over the subsequent eight to nine months**. Many indigenous practices have been developed in the past which effectively harvested rainwater.

Indigenous practices

For years, people utilized a number of devices like ponds and recharge wells to improve water availability through the year.

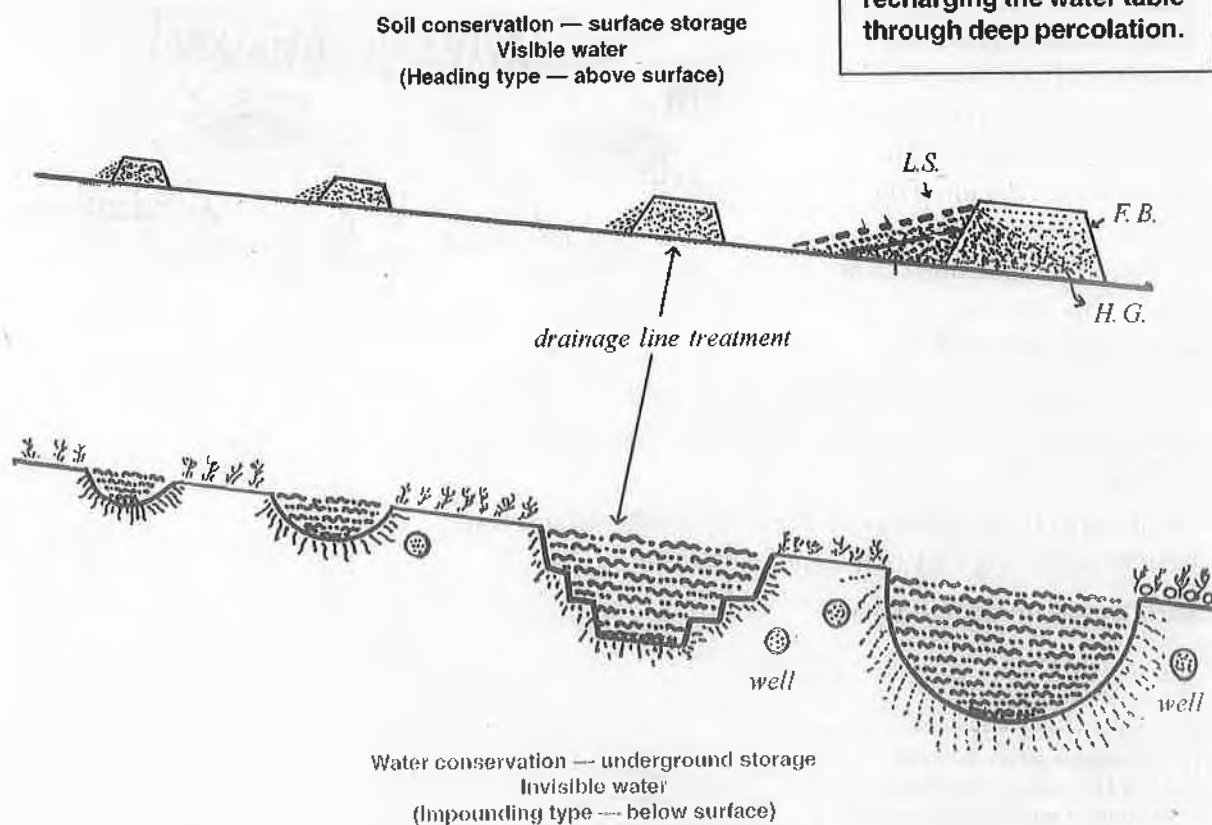
Ponds

Run-off water, whenever it rains, is collected into ponds located on natural land depressions. These are further deepened and the dug out earth is used to raise a high mound around the pond. This is different from the bund type, which is built at the ground level.

Advantages of sunken ponds

1. Occupies less area and much less submergence of land, small exposed water surface.
2. Deep water column — less evaporation and greater recharge of surrounding areas.
3. High rise earthen mounds prevent high velocity winds directly hitting the water surface — minimises evaporation.
4. Trees surrounding mounds provide cool shade — lessens evaporation.
5. No danger of breaching — it is lower than ground level. Any excess water flows into drainage lines slowly.

All the collected water is available for consumption of human beings, animals and plant life, besides recharging the water table through deep percolation.



Recharge wells or seepage wells

Another complementary device is the sunken or recharge well.

These are man made cavities or large diameter seepage wells. They receive water through capillary movement, seepage and percolation which is stored in the well and in the recharge zone around the well. Surface water is safely stored as sub-surface water, which is available for use in dry winter and summer months. This water has better quality because of percolation through soil layers.

Seepage wells are basically water resource development devices and they should be left alone as such. They are **not** used to directly exploit ground water.

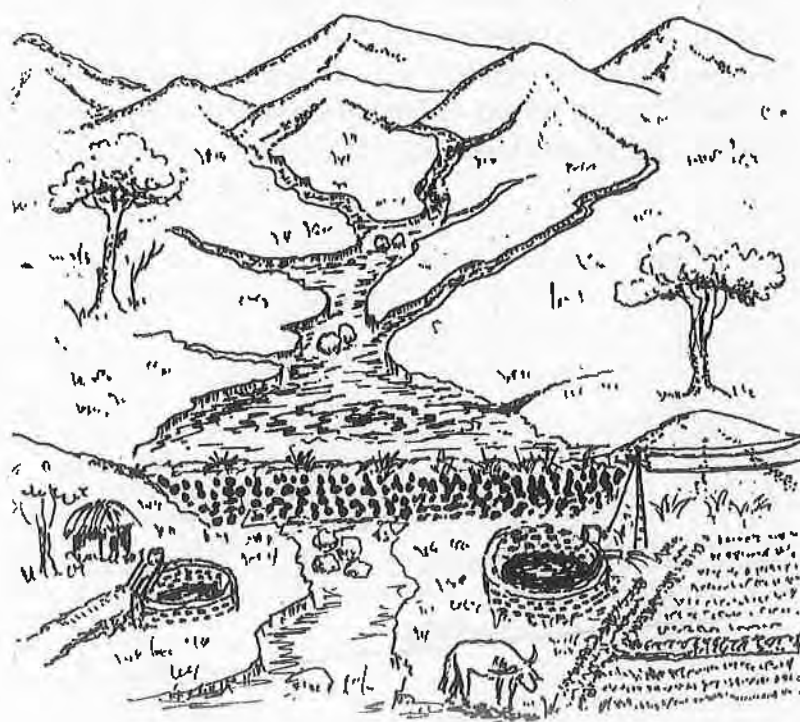
Community ponds

In the past, rulers, rich men, philanthropists, charity and religious trusts funded and built dug-out community ponds in natural depressions to conserve water. This enlivened the neighbourhood: animal drinking points, greened grazing lands, water for cultivation, etc. They served as the central point for all wells in the zone. There could be ponds on individual lands also. The maintenance was undertaken by the beneficiary community. Besides deciding on water usage, they also took up periodical desilting of the pond. This was viewed as a community responsibility.

Some of these ponds are currently being used, though their maintenance is neglected, thus drastically reducing the water holding capacity.

Desilting of these community ponds enhances water storage, besides providing very rich manure to the fields.

Desilting is an urgent need.



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Contributor: S. L. Seth

Water harvesting: Indigenous

Water harvesting is a practice for collecting and retaining rainfall above or below the land surface for beneficial use later on. This is accomplished by manipulating the land surface physiography or by creating vegetative barriers and engineering structures, such that runoff from rainfall is intercepted or slowed down and induced to infiltrate the soil profile or percolate down to recharge groundwater.

Water harvesting will greatly benefit the productivity of crops, more critically in the arid and semi-arid regions of the country.

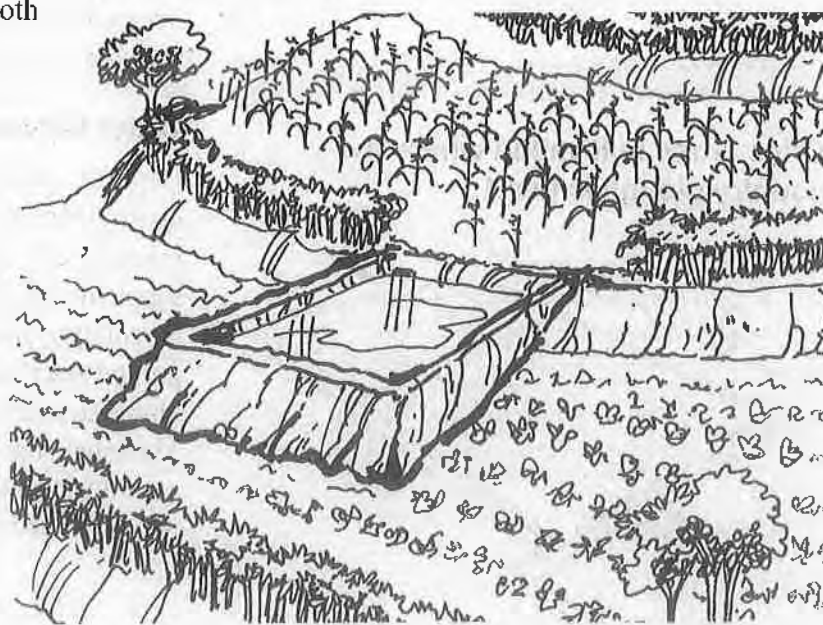
Huge seasonal water losses occur due to surface runoff. This can be minimised through water harvesting.

Because of India's distinctive climate — intense monsoons followed by protracted droughts — storage of water at appropriate natural sites becomes indispensable. However, storage over ground necessarily involves large losses, of which the most important are evaporation and seepage. Seepage losses depend on geological, stratigraphical and other local features. To a large extent, these are controllable with present day technology. On the other hand, evaporation losses are very high, particularly in tropical countries because of high temperatures, larger overall aridity and long dry periods.

For small, shallow, water reservoirs and tanks, individual losses may be as high as 30 to 50% of stored water. Therefore, sub-surface water storage, either as moisture in the soil profile (root zone of crops) or as groundwater, is the most efficient way of conserving harvested rainwater. Water harvesting techniques have been developed, both indigenously by farmers as well as introduced by scientists. The indigenous techniques have evolved based on local knowledge and materials which are cost-effective, simple and easy to operate and maintain.

Note

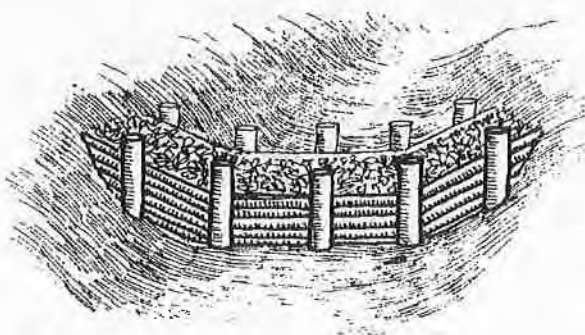
Even after all water resources are harvested for irrigation, about 50 to 60% of India's cultivated area will remain rainfed.



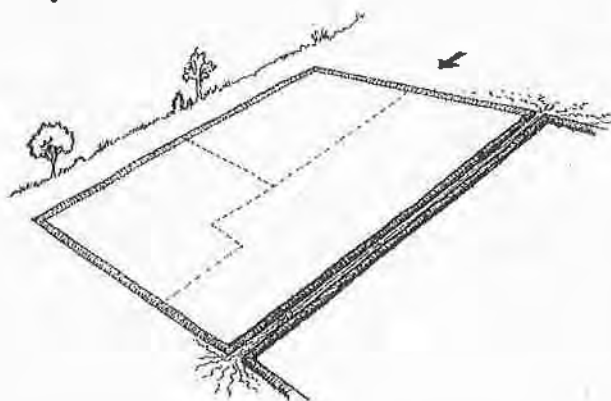
Indigenous practices

The main features of farmers' soil and water conservation efforts encompassing water harvesting measures are:

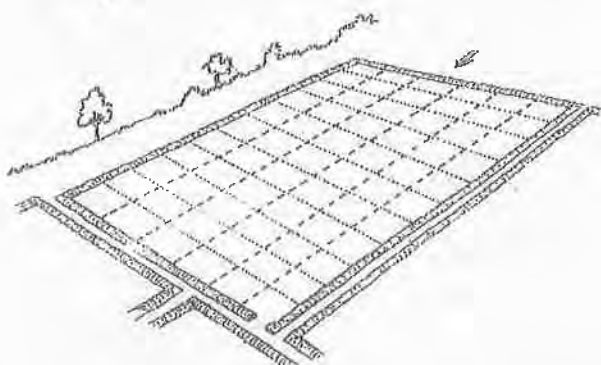
Field bunds and drains on boundaries



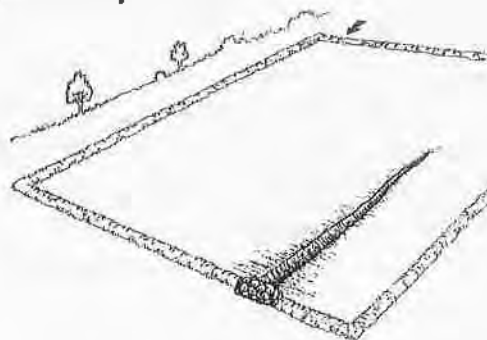
Boundary waterways along the major slopes



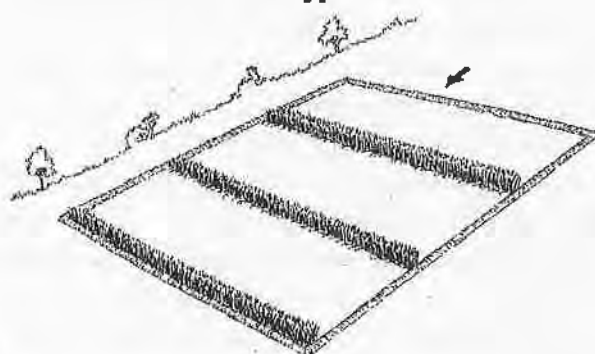
Criss cross cultivation where the country plough is used



Gully control structures on boundaries for soil deposition



Water harvesting measures depending on rainfall and soil type



Moisture conservation

The major indigenous water conservation practices include: deep ploughing in summer; sowing and planting across the major slope; furrowing and cross ploughing; shallow interculture or tied ridging; compartment bunding; and short-term or rainy season fallowing.

Water harvesting

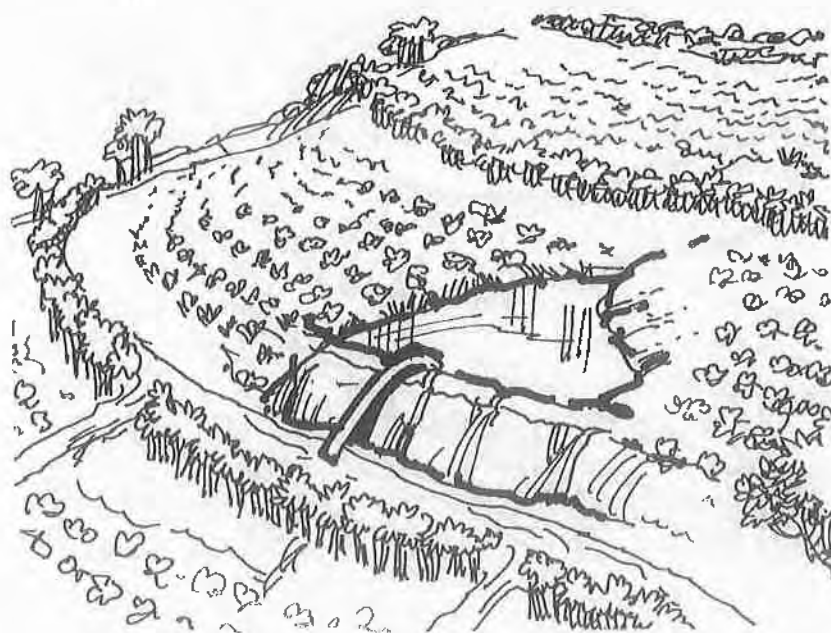
Depending on rainfall and soil type, farmers have evolved different water harvesting systems. In high rainfall areas, individual farm ponds are used for supplemental irrigation. In medium rainfall areas, percolation ponds are constructed to recharge groundwater aquifers. Earthen embankments are observed in areas with low rainfall and deep soil. These help harvest water and store it in the root zone during the rainy seasons, to raise a crop with residual moisture in the post rainy season.

Farmers' water harvesting practices

Rajasthan

In areas with 100-400 mm of annual rainfall

- Large peripheral bunds (about 75 cm wide at base and 1 m high) with grass *Sachcharum munja* grown on the bunds to strengthen them.
- In highly arid situations, intra-plot water conservation practices are followed for *in-situ* rain water harvesting.
- In *khadin* system of farming, rocky catchment areas are used to collect runoff water by constructing a bund across the flow. The water collected is allowed to percolate, after which, an assured post rainy season crop is grown.
- *Rela* farming is another water conservation practice that channels the water from ephemeral *nalas* (streams) to terraced farms at the foot hills. The water enters the upper fields and gradually flows down into the lower reaches. Good management is required to ensure that the *rela* system distributes water equitably.
- *Tal* farming is found where rainwater runoff flows into low lying valleys, forming stagnant pools. During the monsoon, water is sometimes lifted and used in adjacent fields. After the monsoon, a crop is sown under residual moisture in the *tal* bed when water has evaporated and percolated. It appears that, to date, these practices have sustained crop production in Rajasthan, despite low and variable rainfall.



Note

Several case studies reveal that farmers are generally knowledgeable about the beneficial effects of water harvesting.

Water harvesting practices

Water harvesting practices commonly observed in red soil regions are:

- diversion drains to separate arable lands from non-arable lands;
- bunds of various sizes provided with outlets to prevent water stagnation. These outlets are generally provided on bunds at a slightly higher level than the lowest point. These outlets allow water to stand before spilling over, leaving the silt behind;
- waterways along field boundaries;
- water harvested in private or community ponds and channeled along the gradient towards cultivated land; and
- *khus* (Vetiver grass) often grown on the boundary to strengthen earthen bunds and to provide fodder.

The experiences of several voluntary agencies such as AKRSP, MYRADA, YFA, CASAD, DRDAs and WDPs with the local communities in water harvesting projects suggest the importance of providing several options with cost comparisons. Farmers then select one or more and adapt them to their settings.

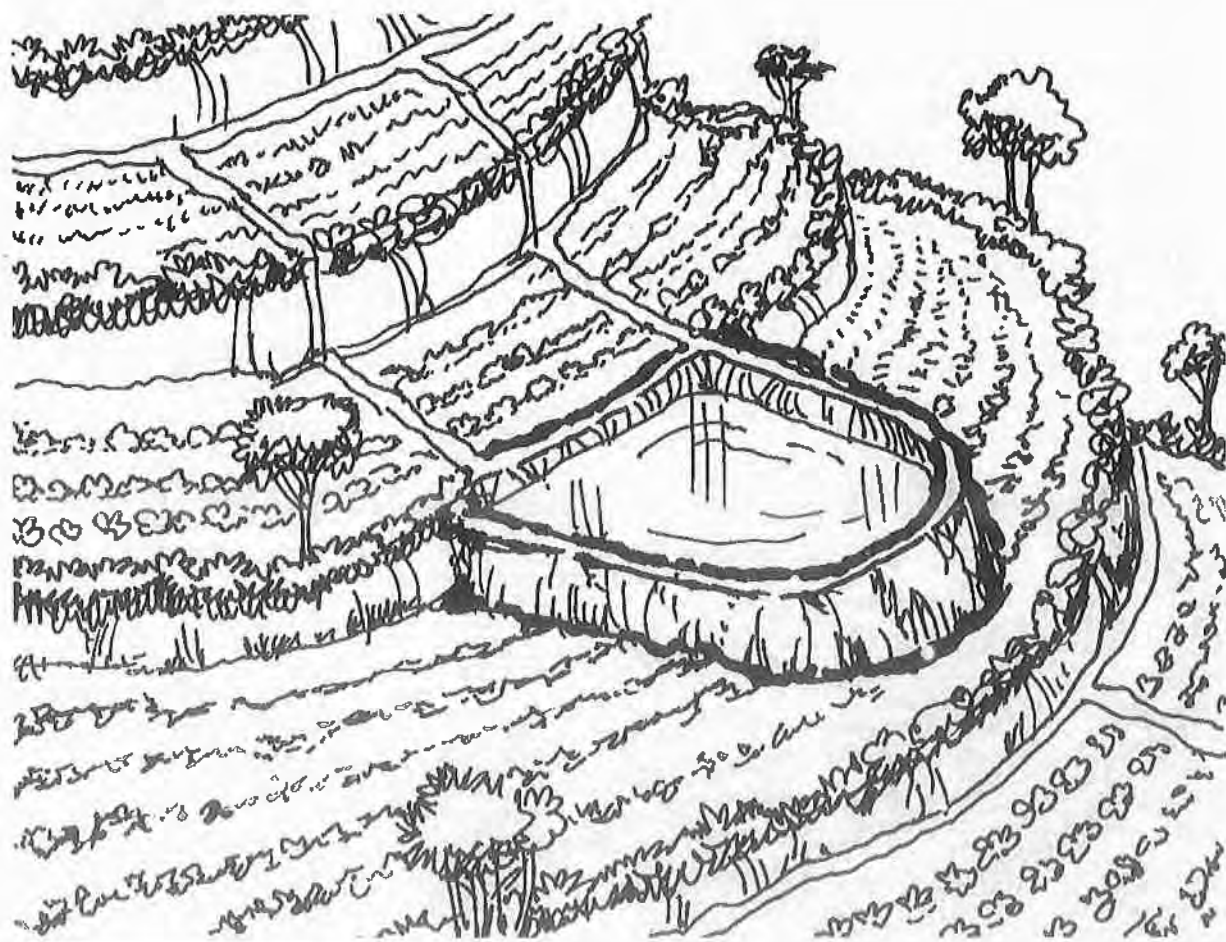
Gujarat

In Gujarat, the Aga Khan Rural Support Programme (AKRSP), which supports village institutions, has undertaken participatory planning and implementation of water harvesting and conservation projects with the local villagers. The main features of jointly identified appropriate technologies are:

- diversion drains;
- stone bunding;
- contour farming; and
- loose boulder checks.

Stone bunding, a traditional technology has been implemented on a watershed basis in a systematic manner since the inception of the AKRSP programme.

Stone bunds are found to be most suitable for this area because soil is shallow and stones are available within or near the fields. They are also more effective than earthen bunds in sloping fields.



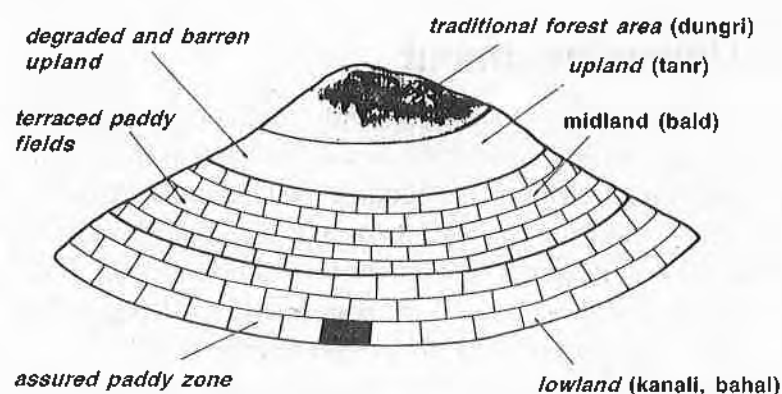
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Contributor: C. R. Shanmugham

Rainwater harvesting in the Chotanagpur region

The uplands of Chotanagpur are mostly alfisols in an advanced state of degradation, lacking humus and major plant nutrients, untterraced, unbunded and supporting low intensity cropping with low productivity, if not actually remaining fallow and barren. The midlands are mostly terraced ricefields with thin soil cover and poor moisture retention capacities. Mid season droughts occuring with unfailing regularity every 2-3 years ensure that traditional varieties of rice grown under rainfed conditions fail to field anything of significance. Lowlands, existing in small proportions, are the best in terms of productivity. Annual paddy is grown in these lands.

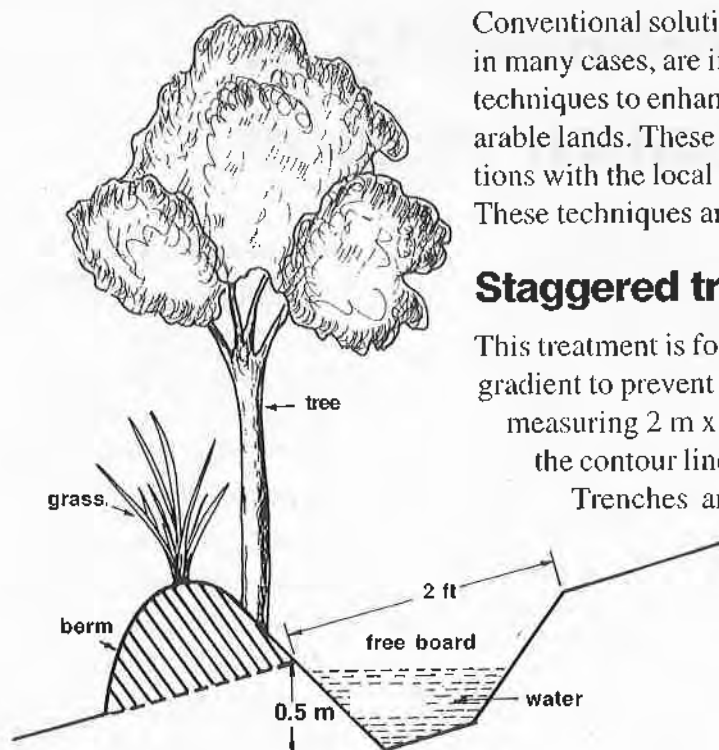
Land classification



The Chotanagpur plateau lies on the eastern extremities of the Deccan plateau in South Bihar, North Orissa, and the Southern part of West Bengals.

In the past, the forests of Chotanagpur were dense, supporting the practice of shifting cultivation and hunting. Arable land in this region can be classified into three groups based on its soil character. The classification determines what can be grown on it.

Topography	Soil	Crops
Upland (highland, <i>tanr</i> , <i>dungri</i>)	Red lateritic, shallow soils, low humus and nutrient content, mostly barren land	Pulses, oil seeds (sesame) and minor millets, vegetables like pumpkin, tomato, brinjal, cowpea are grown occasionally.
Medium land (midland, <i>bald</i>)	Sandy, murrummy, shallow soils; water retention better than uplands	Terraced paddy cultivation, under rainfed conditions, susceptible to mid-season droughts.
Lowland (<i>bahal</i> , <i>kanali</i>)	Sandy loam soils	Assured paddy zone.



Conventional solutions to these problems, having failed in many cases, are improved, appropriate and acceptable techniques to enhance the soil and moisture regime of the arable lands. These have been introduced after consultations with the local people and grassroot level NGOs. These techniques are presented below.

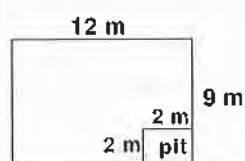
Staggered trenching

This treatment is for sloping land with more than 8% gradient to prevent runoff and erosion. Trenches measuring 2 m x 0.6 m x 0.5 m are excavated along the contour line with interspace between them.

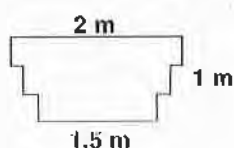
Trenches are staggered, trees and grasses are planted on the berm (the pile of soil excavated and kept on the side) and in the treated areas.

Upland treatment

Upland plot



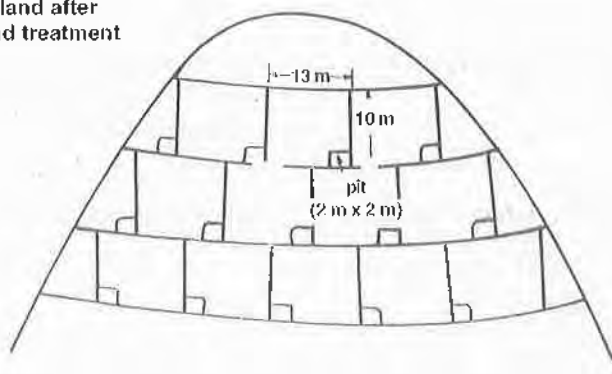
Section of pit



This treatment is for uplands with less than 8% slope. This arrests soil erosion and conserves rainwater *in situ*. The method is tie-ridges, i.e. bunding the land into rectangular plots measuring 9 m x 12 m. A pit is dug at the lowermost corner of the plot where rain water can be collected. Pits measuring 2 m x 2 m x 1 m are normally used, though this may vary according to farmer's preference and local conditions. This water then maintains a seepage line down the slope.

The excavated earth is used to prepare bunds of 0.3 m breadth and 0.2 m height along the plot. Runoff water is arrested and the bunds also act as substrate for biomass introduction, and a widespread recharging of soil profile. The bunds are stabilised by planting trees and grasses.

Upland after land treatment



Midland treatment

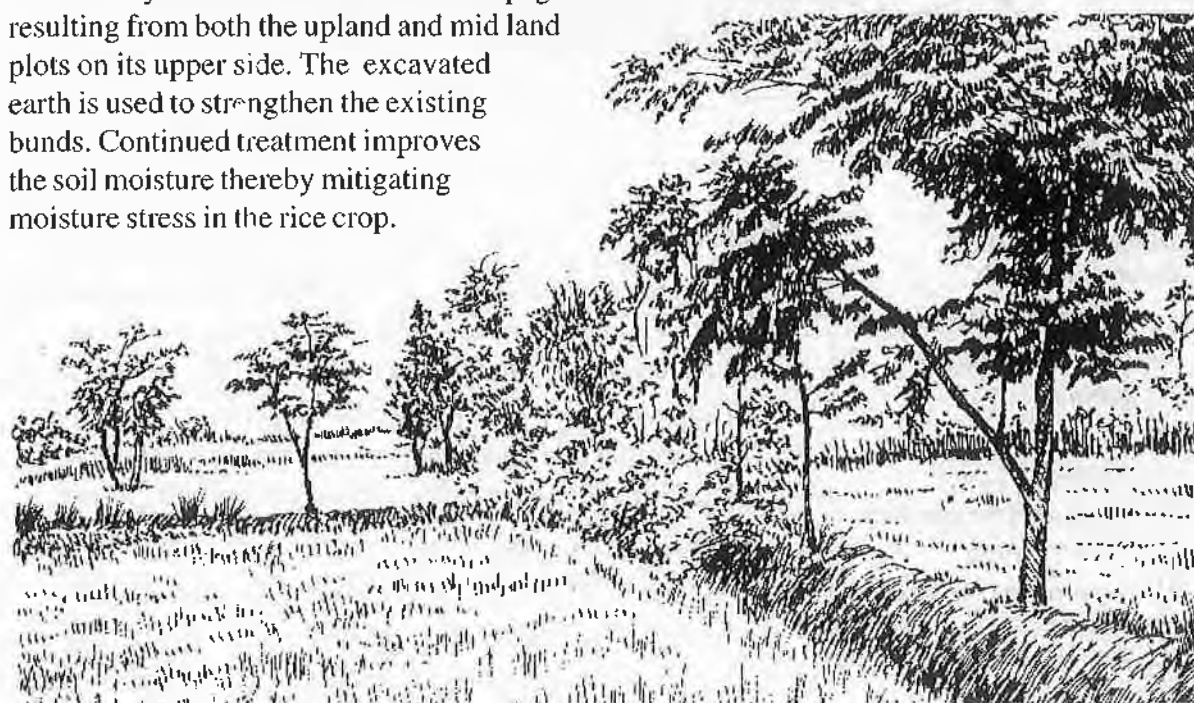
Seventy percent of the total agricultural land in the Chotanagpur region comes under upland or mid land, depending mostly on rainfall for any crop to be grown.

Though meteorological data reveal that the amount of rainfall received is not less than the minimum requirement, the fact is that in September, during the period of flowering and grain formation, the rainfall is mostly below the requirement. This inflicts great damage to the rice crop.

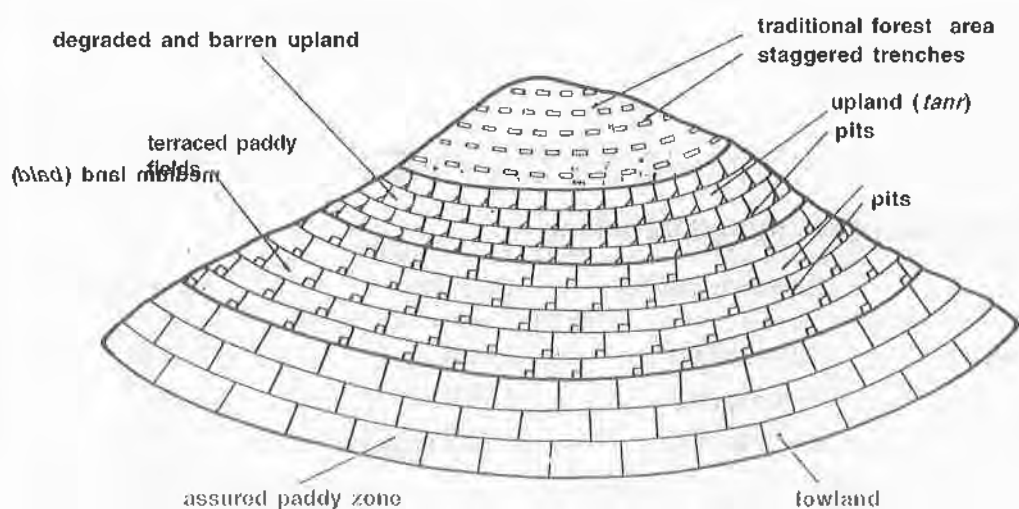
The land treatment technique described here excavates 5% of the area of each agricultural plot at its lowermost point to a depth of 1.1 m. Each pit harvests rainwater and additionally collects the sub-surface seepage resulting from both the upland and mid land plots on its upper side. The excavated earth is used to strengthen the existing bunds. Continued treatment improves the soil moisture thereby mitigating moisture stress in the rice crop.

Land treatment techniques	Area treated (ha)
Staggered trenching	19.50
Upland	433.20
Mid land	311.45

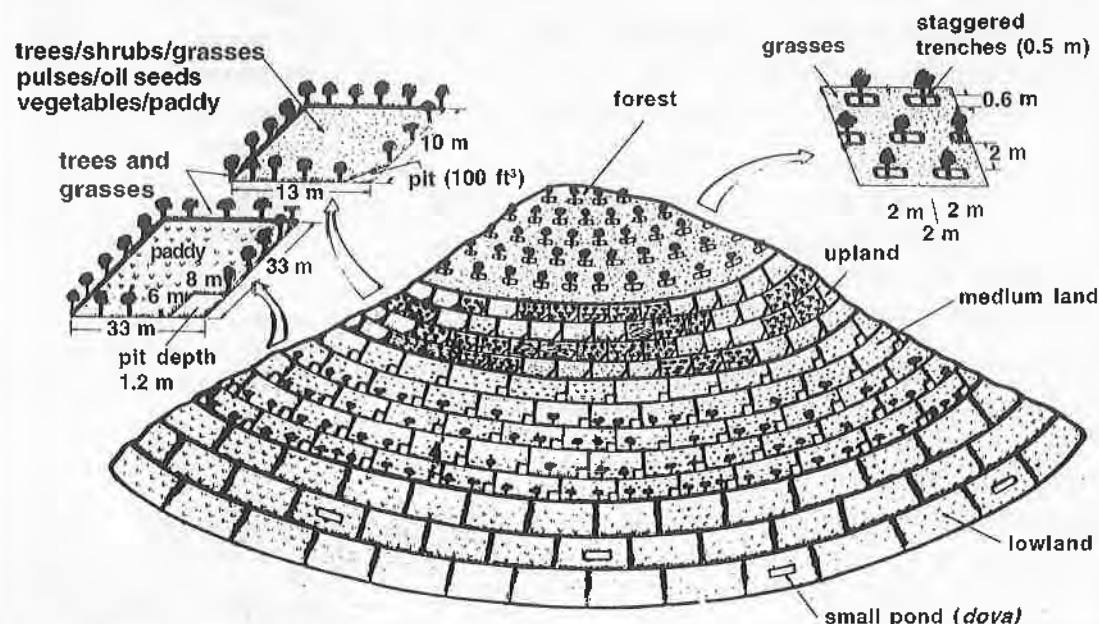
In total, 63 villages have been covered, benefitting 1,040 households (1992-96)



Microwatershed during early stage of treatment



Microwatershed after treatment and biomass introduction



Trees, grasses and shrubs favoured:

- Sisoo (*Dalbergia sisoo*)
- Gamhar (*Gmelina arborea*)
- Sabai (*Eulaliopsis binata*)
- Dinanath (*Penisetum pedicellatum*)
- Pigeonpea (*Cajanus cajan*)

Effects

Adopted technological measures yielded positive results and were widely acclaimed as an alternative to traditional soil and moisture conservation measures.

- Uplands lying barren and eroded (leading to formation of gullies that threatened land in the lower reaches) have been brought under cover of trees, shrubs and grasses.
- Subsistence needs for fuel, fodder, fibre and timber are being met from these barren lands.
- Excess is being sold and cash incomes are being earned.
- Prevents the outright loss of the rice crop and the distress conditions characteristic of mid lands.
- Due to the conservation of soil moisture, rice yield has improved.
- The pits in treated mid lands are being used for pisciculture for subsistence.

Costs

These cost figures might vary from area to area. The conversion rate is Rs 35 to \$1.00.

Cost per hectare of staggered trenching

Item	Quantum (per ha)	Rate (Rs.)	Total (Rs.)
Earthwork	202 mandays	25/day	5,050
Trees	1122 saplings	1.50/sapling	1,683
E. binata	1,17,730 slips	0.05/5 slips	1,177
Total			7,910

Stream of benefits from staggered trenching

Item	Rate (Rs.)	Returns/hectare (Rs.)				
		1st year	2nd year	3rd year	4th year	10th year
Trees	200/tree	-	-	-	-	179,520
E.binata	1/kg	-	-	23,546	23,546	23,546
Total	-	-	-	23,546	23,546	203,066

Cost per hectare of upland treatment

Item	Quantum (per ha)	Rate (Rs.)	Total (Rs.)
Earthwork	86 mandays	25/day	2,150
Trees	1,520 saplings	1.50/sapling	2,280
E. binata	9,600 slips	0.05/5 slips	96
C. cajan	720 plants	0.30	216
Total			4,742

Stream of benefits from upland treatment

Item	Rate (Rs.)	Returns/hectare (Rs.)				
		1st year	2nd year	3rd year	4th year	10th year
Trees	200/tree	-	-	-	-	243,200
E. binata	1/kg	-	-	1,920	1,920	1,920
C. cajan	10/kg	360	1,440	2,160	-	-
Total	-	360	1,440	4,080	1,920	245,120

Cost per hectare of mid land treatment

Item	Quantum (per ha)	Rate (Rs.)	Total (Rs.)
Earthwork	178 mandays	25	4,450.00
Trees	225 saplings	1.50	337.50
E. binata	6,750 slips	0.05/5 slips	67.50
C. cajan	225	0.30	67.50
Total			4,922.50

Stream of benefits from mid land treatment

Item	Rate (Rs.)	Returns/hectare (Rs.)				
		1st year	2nd year	3rd year	4th year	10th year
Rice	350/qtl.	875	875	875	875	875
Trees	200/tree	-	-	-	-	36,000
E. binata	1/kg	-	-	1,350	1,350	1,350
C. cajan	10/kg	112	450	675	-	-
Total	-	987	1,325	2,900	2,225	38,225

Comparison of costs and returns/ha for each technique

Technique	Cost/ha (Rs.)	Returns/hectare (Rs.)				
		1st year	2nd year	3rd year	4th year	10th year
Staggered trenching	7,910	-	-	23,546	23,546	203,066
Upland treatment	4,742	360	1,440	4,080	1,920	245,120
Mid land	4,922	987	1,325	2,900	2,225	38,225

Problems encountered

- Distance of the lands from the village habitation site, making protection difficult. People have to be specially assigned protection duty in order to protect browsable saplings.
- The overall risk in the rice crop in mid lands still remains high due to the probability of delayed or scanty rain in the previous stages (nursery and transplantation stages).
- Demand for labour because of any government programme or an unusually good crop season in neighbouring agricultural districts, etc. diminishes the utility of the land treatment programme for the beneficiary, causing them to abandon the latter. Sudden abandonment leads to the presence of untreated patches that hinder the overall efficacy of the techniques.

Each of these techniques is able to pay for itself within a few years. This is an indicator of sustainability from the economic point of view.



Information kit produced by
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Contributor: Arijit, Rajesh, Navin, Shouvik and R. P. Agarwal

Water harvesting: Improved

Conservation of rainwater so it stays in the soil profile for a longer period and is released slowly through the drainage line in that area becomes an important constituent of improved dryland farming. The average size of a land holding in India is only 2 ha ranging from 0.5 ha in Kerala to 4.7 ha in Rajasthan. In Tamil Nadu, it is about 1 ha and the holdings are fragmented. While 87.7% of the farmers are small and marginal, they hold only about 48.7% of the area under cultivation. These farmers are poor and come under the category of "weaker sections". This situation leads to complications in tackling dryland agriculture in the country (An economic appraisal, Tamil Nadu, 1989).

In the last two or three decades, considerable attention focused on improving rainfed agriculture. This has led to individual farmers to adopt moisture conservation measures, encouraging contour bunds and constructing check dams. The expenditure incurred was recovered from the farmers after deducting 25% to 33% as subsidy. Because the work was not done on a watershed basis, whatever improvements made were often nullified because runoff was not controlled in the upper areas. In the past, it was not realised that all development in drylands had to be tackled on a watershed basis. This has changed since and now the efforts are taken up on a watershed basis.

The following are some of the water harvesting practices to be undertaken in the watershed to conserve soil moisture and rainwater and utilise the excess water for increasing agricultural production. The treatment may be different in red and black soils and light and heavy rainfall areas. Based on soil type and rainfall, the watershed plan can be prepared and implemented with involvement of the farmers in the watershed.

- **In-situ moisture conservation practices**
- **Soil conservation techniques** — viz, contour bunding in low and medium rainfall areas; graded bunding in high rainfall areas in red soils; and broad-based structures or ridges with grass or vegetative barriers in black soils.
- **Construction of check dams and gully control structures**
- **Establishing farm ponds in individual farmer's fields**
- **Construction of percolation ponds**
- **Construction of irrigation tanks**
- **Conjunctive use of groundwater to supplement rainfall**

Improved water harvesting practices

Many of these practices have evolved from indigenous practices. The indigenous practices are, by and large, simple, and easily constructed with locally available tools and materials. Improvements to such practices became necessary, to make them more effective and durable, and so their maintainance would be relatively easy.

***In-situ* moisture conservation practices**

- Contour cultivation
- Formation of basins, furrows, random tie ridges, broad based ridges and furrows
- Cross ploughing in both red and black soils when rainfall is less than 750 mm
- Formation of drainage channel in black soil areas

In-situ moisture conservation is best adopted after the watershed is completely treated with soil conservation measures.

Appropriate *in-situ* moisture conservation methods in various rainfed areas and soil types

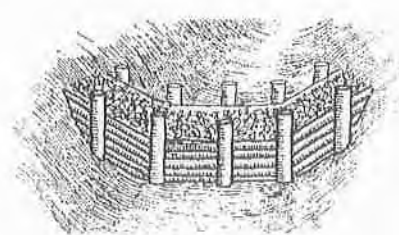
Type of soil	Rainfall	Water harvesting/ <i>in-situ</i> moisture conservation practices
Red soils	Low	Dead furrows at 3-6 m intervals
	Medium	Sowing in rows and ridging later
Black soils	High	Graded border strips
	Low	Contour cultivation
	Medium	Dead furrow at 3-6 m intervals
	High	Graded open furrows at 10 m intervals across the slope

Conjunctive use of groundwater to supplement rainfall

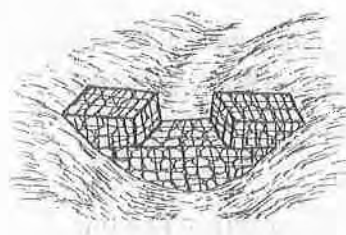
By implementing the water harvesting programme as described above, there is a good possibility of increasing the groundwater potential in the watershed. To prevent groundwater flow outside the area in the watershed, small sub-surface dams can be constructed in water-scarce areas.

In red soils, both biological and mechanical measures may often be required, in black soils, soil moisture can be augmented to a considerable extent by biological measures. No perfect erosion control structure has been evolved to conserve soil and water in black soil areas.

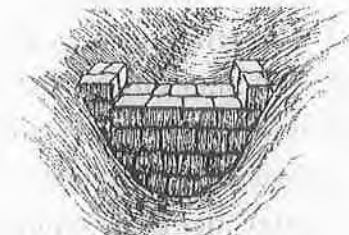
Examples of check dams



Brushwood



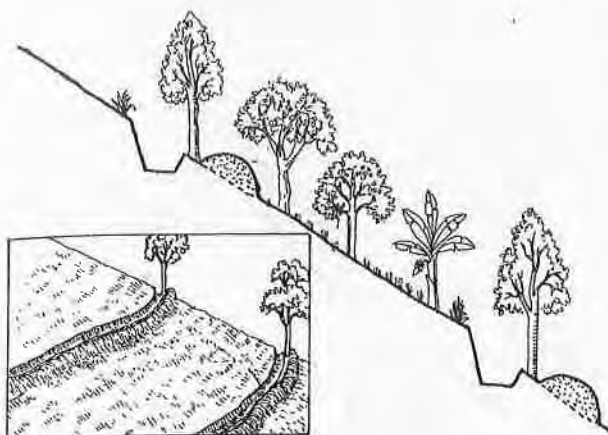
Gabion



Masonry

Moisture conservation measures

Contour trenches



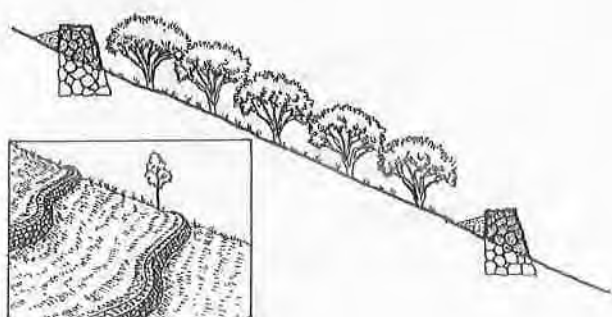
Conditions where contour trenches may be used:

- slopes of more than 33.3%; and
- any badly-eroded slope.

Uses

- for planting tea, coffee and other plantation crops; and
- to intercept runoff water from field sections between trenches for safe disposal.

Contour stone walls



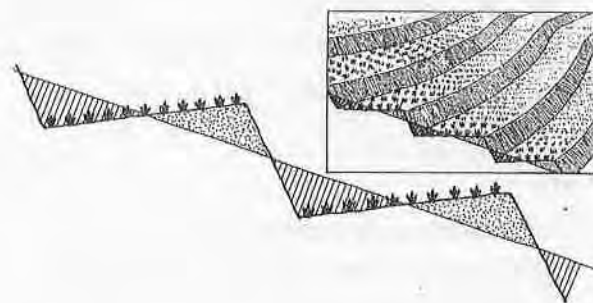
Condition where contour stone walls may be used:

- on any slope where stones and rocks are plentifully available.

Uses

- as an initial treatment for bench terraces; and
- to slow run-off and control erosion in plantation areas.

Bench terraces



Condition where bench terraces may be used:

- slopes between 16.7 and 33.3% and in areas having soil depth of more than 75cm

Use

- agricultural lands put to annual crops which permit soil erosion.

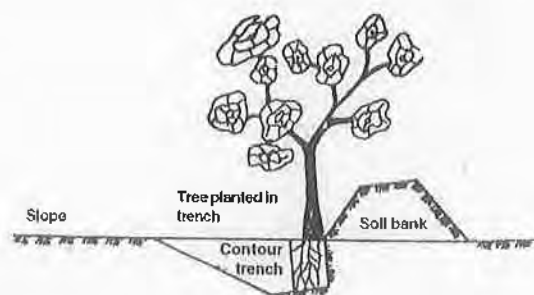
Graded trenches

Condition where graded trenches may be used:

- soil slopes ranging from 10 to 30% where soil depth is less than 75 cm and in areas with rainfall above 1000 mm.

Uses

- agricultural lands planted to annual crops that permit soil erosion; and
- as a waterway outlet to convey run-off to a point where it will be discharged without erosion damage.



Adapted from Gurmeh Singh, et al, 1990

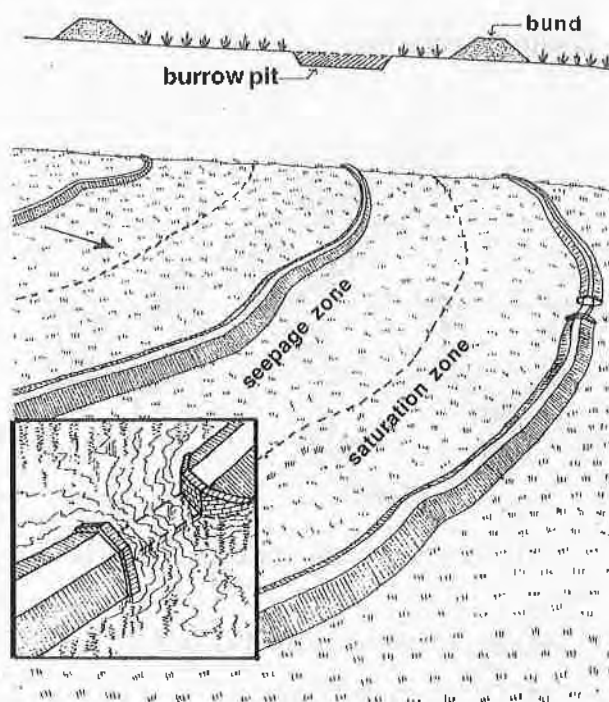
Contour bunds (level terraces)

Conditions where contour bunds may be used:

- soil slopes of between 1 and 10%; and
- areas of low rainfall (1000 mm or below).

Uses

- generally used in areas of suitable soils where outlets are a problem and run-off from the area must be kept to a minimum or entirely eliminated; and
- contour bunds with burrow pit could be used to retain water between the terraces. On steeper slopes burrow pits can also be used to decrease average slope of farmed areas, thus making land more farmable.



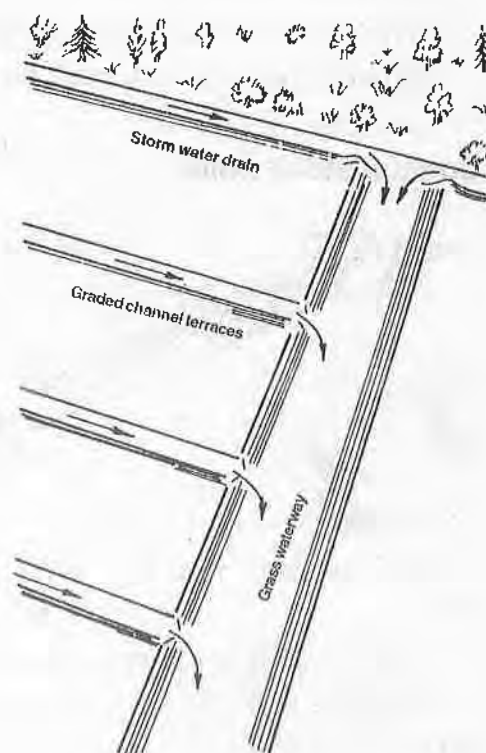
Graded bunds (graded terraces)

Conditions where graded bunds may be used:

- suitable for soil slopes of between 1 and 10%;
- particularly adapted to area of high rainfall (more than 1000 mm).

Use

- to store water temporarily and discharge through terrace outlets.



Adapted from Hudson, 1971

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Contributor: C. R. Shannugham

Water harvesting and recycling

Rainwater is an important component of dryland crop production. Low and uneven distribution of rainfall is the basic cause of drought. At present, widespread drought conditions all over the country have highlighted the immediate need to conserve precious rainwater. Despite concerted efforts, it is not possible to retain all rainwater in the soil. High intensity dryland rainfall causes nearly 25 to 30% of rainfall to be lost as surface run-off.

The need for managing water, the most essential input, thus calls for developing water harvesting technologies suitable to different rainfall, soil, and topographic situations.

Rainfall and run-off

Run-off from unfavourable large arid tracts can be harvested to augment crop production on suitable lands. Design of various kinds of water harvesting structures should consider the probable recurrence of storms of different intensities and duration so that stable structures can be constructed. The various factors affecting run-off are duration, intensity and distribution of rainfall, climate, topography, vegetation, soil characteristics and watershed factors like size, shape, orientation, etc.

Designing water harvesting structures

Harvesting surface run-off involves an estimate of the watershed area where water can be stored with minimum losses. Information required to arrive at a suitable pond size are catchment size, its run-off producing characteristics (including soil types), land use topography, conservation measures adopted and their effectiveness, storage losses from the pond and control measures adopted, period of storage required, area commanded by the pond and type of crops covered under protective irrigation. If other uses, like providing drinking water for livestock and domestic consumption are also involved, then these are also considered when deciding the total amount of water required to be stored. The size (capacity) of farm pond is also decided upon by the volume of run-off reaching the pond. The pond size is fixed to hold about 50% of the run-off so that the pond gets replenished even during years of low rainfall.

Water harvesting is defined as "the process of collection of natural precipitation from prepared watersheds for beneficial use".

Catchment and storage capacity

Small catchments may not be able to contribute sufficient water while very large catchments may lead to excessive silting of the pond and possibly damage the structure by overflow. The optimum area of catchment in red soil is 1 ha which can yield 250 m³ of water. A farm pond is ideal for the collection of this water.

Farm pond construction criteria

The following should be considered before making a decision on constructing a farm pond:

- detailed features of the catchment or watershed area;
- suitable site for the pond;
- possible utilisation of the stored water;
- cost-benefit analysis; and
- the total requirement of water for irrigation/livestock/domestic use.

Storage systems

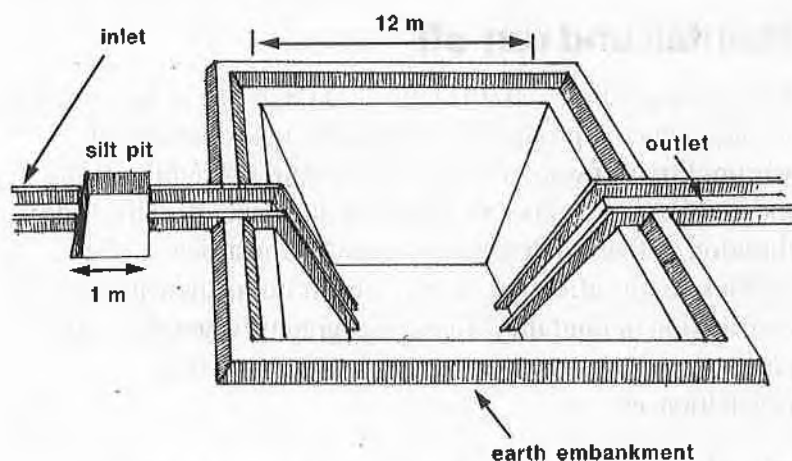
A complete runoff harvesting system includes consideration for suitable means to store the collected water. The basic storage systems currently in wide use are:

- excavated ponds;
- embankment type reservoirs;
- bags made of rubber; and
- tanks made of concrete materials or steel.

Excavated/dug-out farm pond

Excavated/dug-out farm ponds are usually constructed as square or rectangular ponds. A convenient depth is chosen for the pond, which usually varies between 3 and 5 m. Greater depths result in excavation costs disproportionate to the additional capacity provided. Greater depths increase seepage losses due to increased hydrostatic pressure. But greater depths do not increase evaporation losses. Seepage rates also become excessive due to increased hydrostatic pressure. Excavated ponds are provided with controlled inlets of the chute spillway type so that gulying does not occur at the inlet portion. Outlets are also provided in the ponds to discharge excess water.

Excavated/dugout farm pond



Dimensions

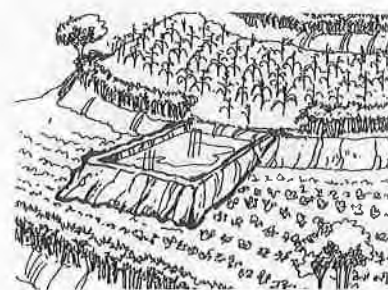
Bottom width:	6m x 6m	Silt pit depth:	0.5m
Top width:	12m x 12m	Inlet width:	2m
Depth:	3m	Capacity:	250 m ³
Side slope:	1:1	Catchment:	1 ha (approx)

Percolation tank

Percolation tanks are constructed when the terrain is sloping and annual rainfall is inadequate; or adequate but badly distributed over the season and where there is not enough time for the rain water to soak into the ground. It is also observed that nalas, in such tracts, get flooded for short durations during the monsoon and remain dry the rest of the year. It is, therefore, necessary to arrange for the rain water to soak into the ground which can help augment the water supply in the wells. This structure, and an earthen embankment across nalas, would be effective in a sloping terrain.

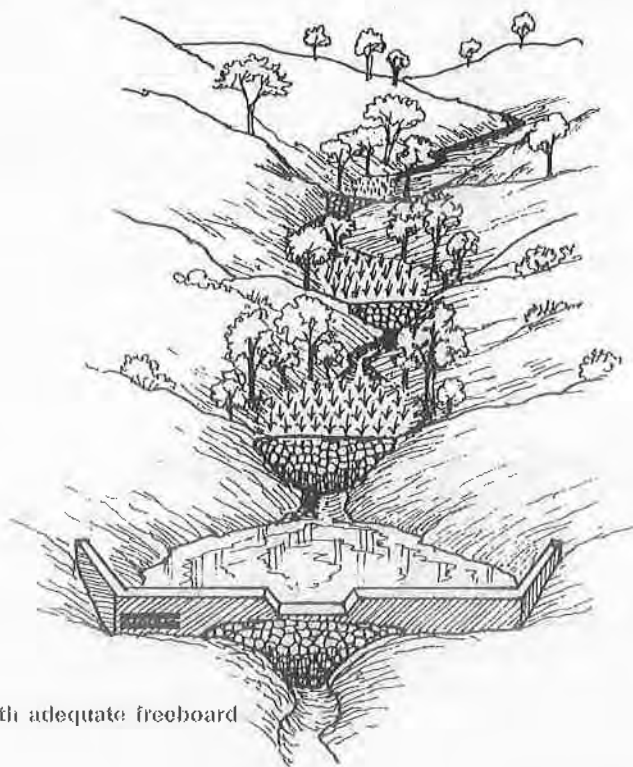
Embankment/surface pond

The embankment type ponds or reservoirs constructed by excavation of earth are the most common type of storage systems in use throughout India. In the embankment type of ponds, the total height of the embankment includes the design height for protection against overtopping and the concurrence of storms of higher frequency than the designed one. Another 5 - 10% extra height is considered for settlement due to consolidation of the earth work. A sufficient top width is provided to serve as a road connecting both the banks of the water courses. Upstream and downstream side slopes of embankment are usually kept as 3:1 and 2:1, respectively. In case of embankments with porous soils, a core wall of impervious soil is provided to cut down the excessive seepage losses and also to keep the phreatic line in check. A key trench is provided to secure the embankment with the foundation to overcome sliding action. Other appurtenances, like rock toe, are provided to check the grade of phreatic line.



Nala bund

Nala bunding work consists of constructing bunds or embankments of suitable dimensions across nalas or gullies to hold the maximum run-off water. This is done to create flooding of the upstream area for some time provided there are arrangements made for surpluses. The idea is to harness the nala in such a manner that it floods the lands on its banks and make it possible to bring the lands on the bed of the nala under cultivation. A nala bund is not a storage tank or a pond.



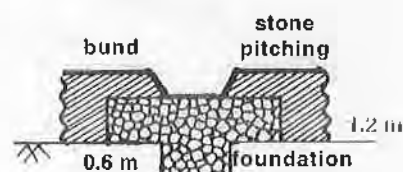
Bund with adequate freeboard



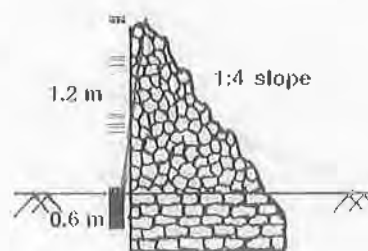
Note

Timely irrigation has always helped in increasing the yield of particular crops. Rates of increase range from 100 to 200%.

Cross section



Side elevation



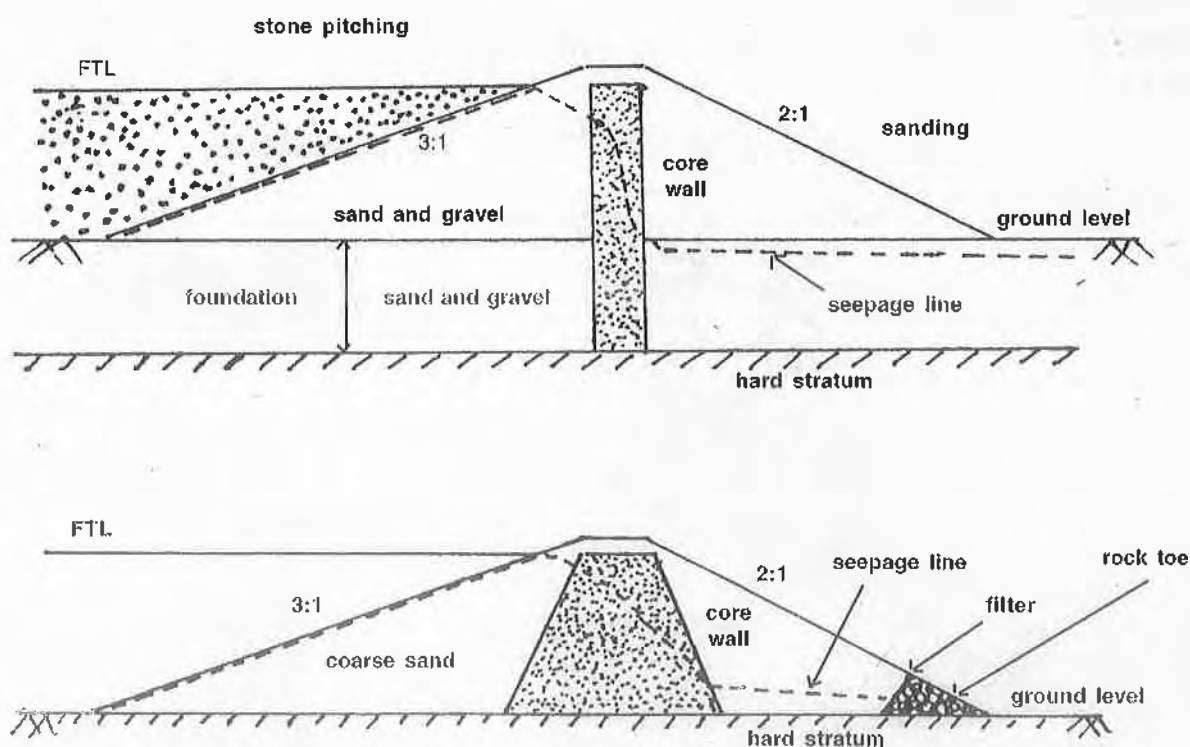
Low earthen dam

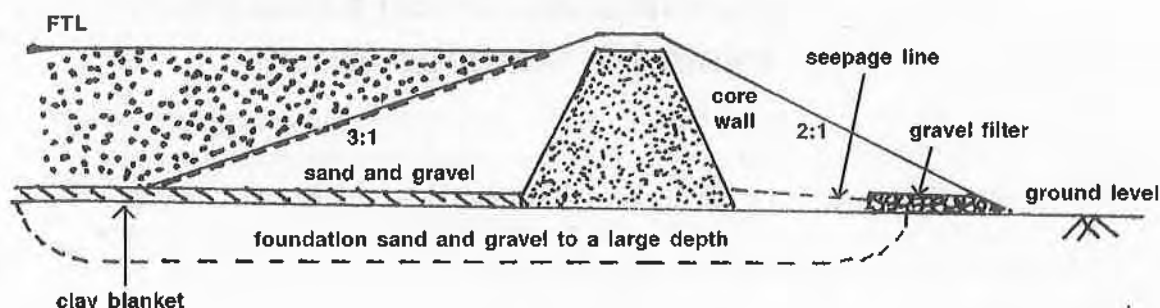
Low earthen dams/minor irrigation tanks are constructed across streams to create a water reservoir, providing irrigation to crops at critical periods during the year.

Criteria to be considered for selecting site and design of earthen dams:

- there should be no possibility of the dam being breached by flood water;
- the seepage line should be well within the toe at the downstream face;
- the upstream and downstream faces should be stable even under the worst conditions;
- the foundation sheer stress should be within safe limits;
- the free flow of water should be controlled;
- the dam and foundation should be safe against piping and underground mining; and
- the upstream face should be properly protected against possible wave action.

Cross sections of earthen dams with different types of materials and foundations





Storage losses and control

Storage losses due to evaporation, seepage and deep percolation should be considered at the time of site selection itself. Caution must be observed not to expose highly-permeable sub-surface materials in arid and semi-arid areas as this may lead to excessive seepage losses and unrestricted evaporation that can result in the loss of stored water.

Points of comparison

Structure	Access/ Beneficiary	Soil type	Slope	Uses
Dugout farm pond	Individual	Red and black	up to 4%	Protective irrigation for high value crops (vegetables, short duration field crops); fish rearing if water is stored for more than 8 months.
Percolation tank	Community	Red and black soil with high percolation at sub-soil	from 4% to 8%	Ground water recharge, additional water yield in wells below the structure.
Embankment/surface pond	Community/ Individual	Red and black soil	up to 4%	Community use, irrigation for nursery seedlings, fish rearing, ground water recharge.
Nala bund	Community	Red and black soil	up to 4%	Reclamation of gullied lands, recharge of groundwater, protective irrigation, minimise velocity of runoff.
Low earthen dam	Community	Red and black soil	from 4% to 8%	Community use, protective irrigation, fish rearing, ground water recharge.

Sealants and lining materials to minimize seepage losses

At different places in the country, various lining materials have been tried. Because all materials are not suitable for all situations due to one reason or another, selection has to be made according to specific local situation. The lining materials generally used for seepage control are:

- natural clay soil of low permeability;
- betonite alone or betonite soil mixture;
- bituminous materials: bitumen and cresol oil in the ratio of 4:1;
- soil cement mixture: Janata emulsion;
- stone or brick lining: liquid asphalt;
- cement concrete;
- cement plastering;
- chemical additives and sealants;
- asphalt compounds; and
- polyethylene, rubber, plastic etc.



Contributors: P. Ramanagowda, A.M. Krishnappa and Murukannappa

*Information kit produced by
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Tank rehabilitation

What is tank rehabilitation?

It is the process of restoring deteriorating tanks to their original design, standards and performance efficiency. A renovated tank raises the interest and enthusiasm of users to make the best use of the system. To sustain the benefits of a renovated tank in the long run, it is necessary that users are actively involved and committed, from planning through implementation and utilisation. An awareness of benefits and a recognition of responsibilities are essential in building a successful local management body.

Involving the local community

Steps for people's participation

- Take a grassroot approach in planning and mobilising people's contribution for the project.
- Discuss plans and options with leaders who have influence in the community.
- Appeal to people's individual or collective interests.
- Organise the users into a water users' association (WUA).
- Ensure active involvement by making beneficiaries contribute their time and money.
- Involve all stakeholders in the planning, implementing and management process.

People's participation is the way to gain public acceptance. People's involvement in planning is a good management practice.

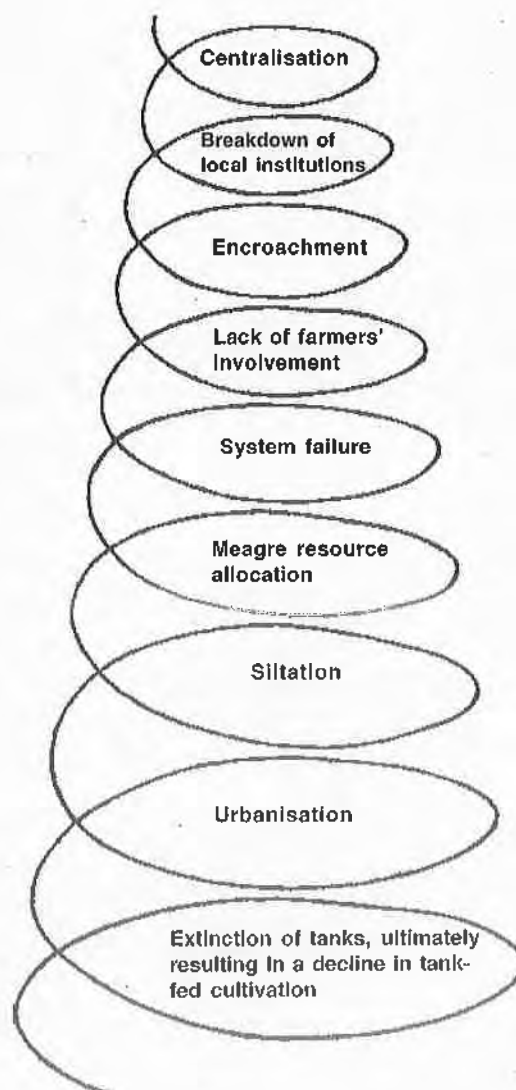
Benefits of a participatory approach

- Access to indigenous expertise or local knowledge.
- Taking into consideration the needs of different groups and individuals in the project proposal.
- Awareness of financial and/or other limitations to prepare a plan suitable to all.
- Identification of sensitive issues and ways to avoid their harmful effects.
- Overcoming conflicts to reach a consensus on project components.

Tanks are:

- village assets;
- traditional technologies;
- agricultural lifelines for the local community;
- lend themselves to self management; and
- an endangered resource.

Current situation:
downward spiral of tank
deterioration



Tank complex improvements

Desilting

- Inflow into the tank is increased by desilting the supply channel and tank waterspread.
- Excavated silt is used to strengthen the tank bund.
- Storage capacity is increased by removing silt.
- Reliability of water supply to the crops is improved.
- Fertility of surrounding lands is enhanced through application of silt.

Surplus weir crest conversion

Reshaping of the weir crest enables it to discharge excess water more efficiently.

Sluice outlet maintenance

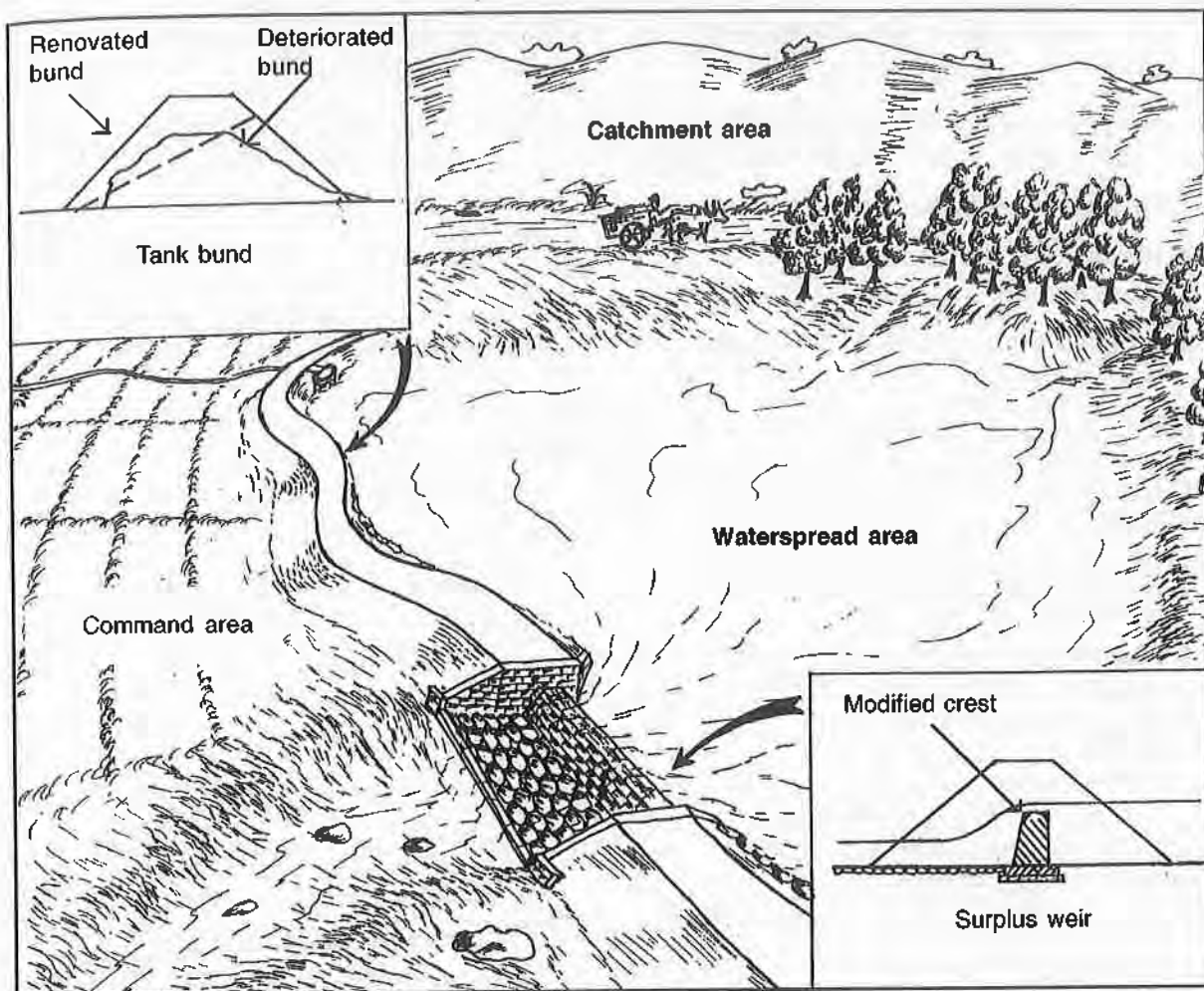
Periodical removal of silt from the sluice pipes, replacement of collapsed pipes with good quality, tested pipes and the construction of a masonry cistern restores the functional performance of sluice outlets.

Tree planting

Planting trees for fuel, fodder or timber in the foreshore of the tank bed provides an additional income to the people with a benefit to the local Panchayat. This income is useful for regular maintenance and management of the tank.

Conclusion

- All these rehabilitation measures are simple and easy to implement through rural artisans and the farming community.
- They are highly cost-effective requiring only about Rs 5000 per hectare of command area benefitted as against a sum of Rs 25000 per hectare, to create a similar water resource at current prices.
- They provide lasting benefits for small investments made.
- Through active participation in tank rehabilitation, the user group (WUA) gains experience and confidence to undertake maintenance and management of the rehabilitated tank system without depending on outside funds. This leads to self-reliance which is the ultimate objective of the project.



Revival of farmer management in tank-fed agriculture – PRADAN's approach

PRADAN's Approach

- Trust building
- Standardisation
- Integrated tank system development
- Self management of tank system

The PRADAN experience

Professional Assistance to Development Action (PRADAN) introduced people's participation in planning and implementing tank rehabilitation projects in Tamil Nadu. The project has been implemented in 50 villages in Madurai and Ramanathapuram districts adopting the following steps:

Operational steps

1. Participatory process of tank selection: Using tank hydrology criteria.
2. Commitment from farmers on their contribution, continued rehabilitation work, eviction of encroachers and long-term self management.
3. Farmer-based planning processes using various methods including Participatory Rural Appraisal (PRA).
4. Leadership identification and involvement.
5. Formation of Command Area Farmers' Associations (WUA).

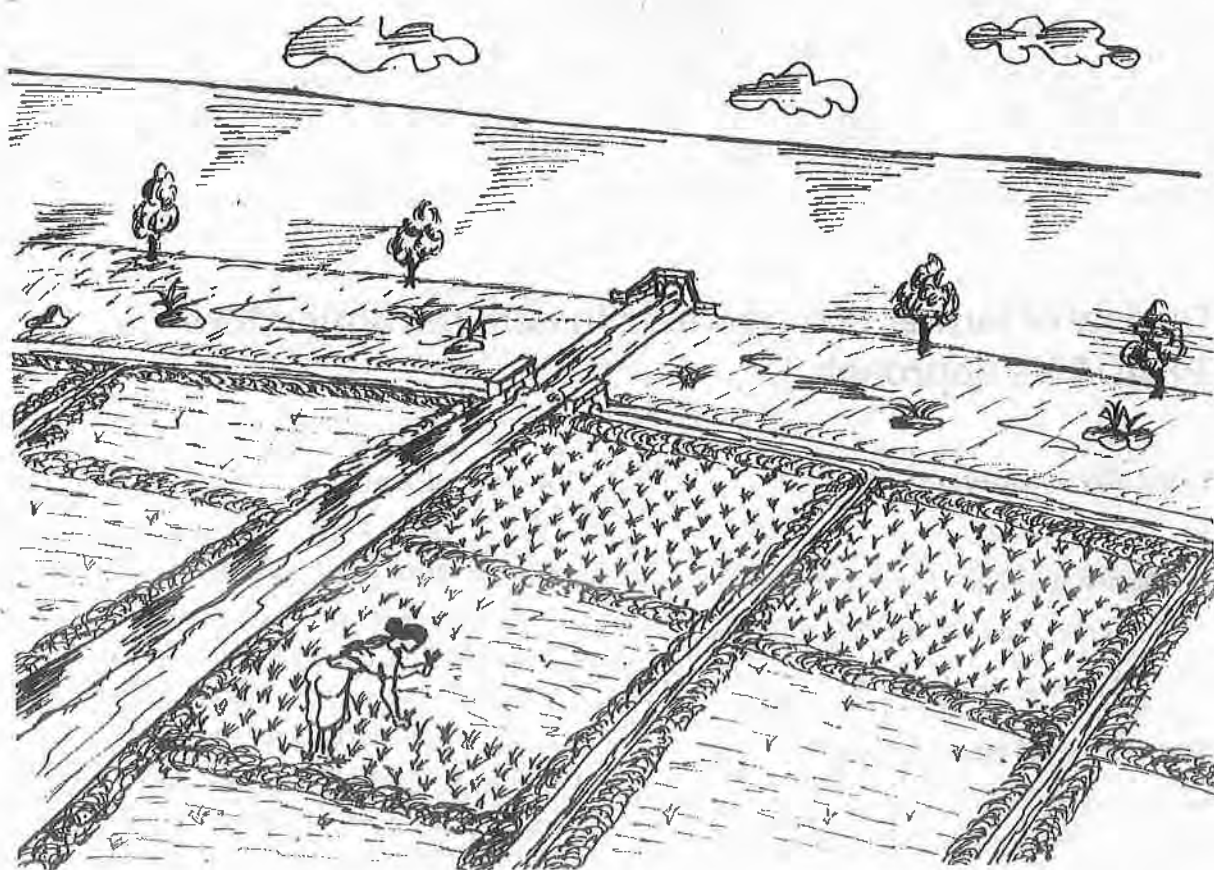
6. Submission of the rehabilitation proposal to a funding agency.
7. Memorandum of agreement between funding agency and WUA or/and NGO.
8. Farmers' implementation.
9. Formation of Catchment Area Farmers Associations.
10. Proposal for catchment treatment and community wells.
11. Crop production support to farmers.
12. Evolving efficient water management systems.
13. Creation of endowment fund and access for usufruct rights to WUA.
14. Formation of a federation of WUAs in a watershed for sharing and development.

- *15. Handling over of tanks to farmers for self- management.
- *16. Setting-up a periodical sharing mechanism between WUA, funding agency and other development institutions.

**These two activities need approval from the government and are yet to be implemented.*

Results

- Superior quality of work as compared to work done by contractors. .
- Equitable and economic water distribution.



Contributor: C.R. Shanmugham

*Information kit produced by
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Conservation and management of groundwater resources

The earth's finite land and water resources are currently being placed under great pressure due to expanding populations and economies. Although there is, in theory, sufficient fresh water to support a world population much greater than that which currently prevails, cross-country variations in factors such as rainfall, pollution and land degradation have served to raise the spectre of water scarcity within certain countries — one of which is India.

India's water resources

India receives about 400 million hectare metres (m ha m) of precipitation annually, of which 70 m ha m (17.5%) is lost in evaporation, 115 m ha m (28.75%) flows as surface run-off and the remaining 215 m ha m (54.75%) infiltrates into the soil.

Surface water

The total amount of surface water, which includes 20 m ha m carried in by streams/rivers from catchments lying outside the country as well as 45 m ha m regenerated flow from ground water, has been estimated at 180 m ha m. However, due to limitations imposed by topography, climate, soil conditions, etc., only about 67 m ha m (37%) of this estimate is considered to be available for actual use.

- At the end of the Seventh Plan (1992), roughly 36.5 m ha m of the surface water resource was being used, with agriculture accounting for approximately 95% of the total usage.
- Through the creation of optimum storages and transbasin diversions, it may be possible to increase the usable quantum of this surface water resource to 88 m ha m.

Soil moisture and ground water

- Out of the above mentioned 215 m ha m of precipitation which percolates into the soil, 165 m ha m is retained as soil moisture.
- The remaining 50 m ha m, along with an additional 5 m ha m from flood flows and 12 m ha m from irrigation systems, ultimately join the ground water reserves.

Global water resources

The total amount of water available on earth is approximately 1,400 million cubic kilometers. Of this, 97% is *saline* (ie. ocean water) while 2% is frozen in the form of ice-caps and glaciers. The remaining 1% is ground water with only minute proportions in fresh water lakes, rivers, soil moisture and biological systems. The water necessary for supporting life on the planet is found in the *hydrological cycle* within which the remaining 1% circulates.

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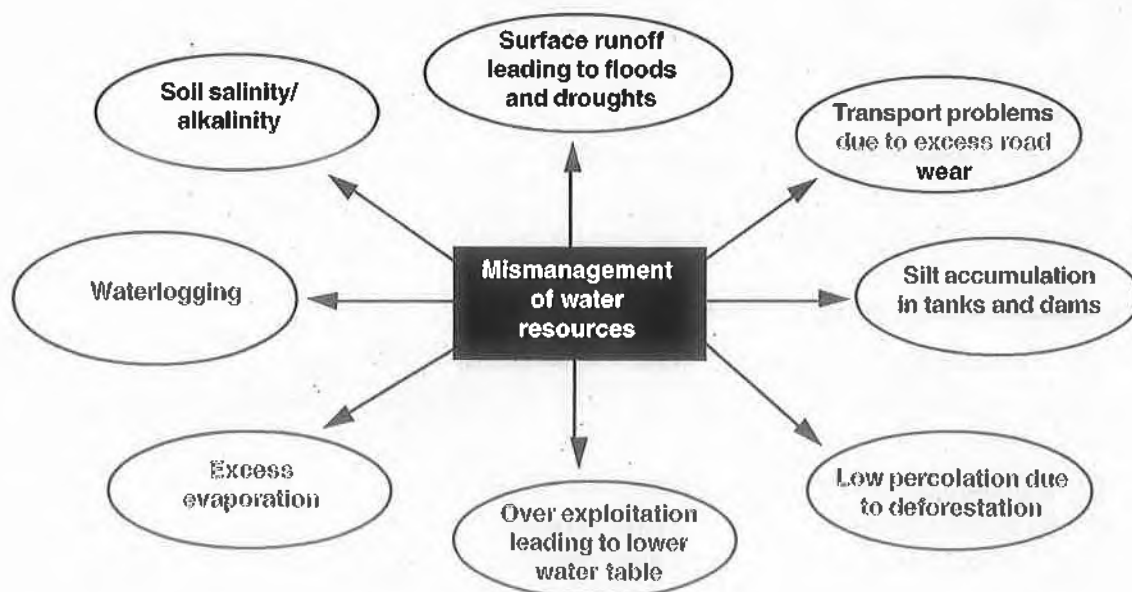
Over exploitation

- Over exploitation of ground water resources to meet growing needs and demands has resulted in a continuous decline of the water table in many parts of the country (e.g., Gujarat, Tamil Nadu, Andhra Pradesh, Maharashtra, Punjab, Rajasthan and Haryana).
- The net demand by the end of the Seventh Plan was placed at 9.994 m.ha.m/year, out of a total utilizable ground water supply of 42 m.ha.m/year. Meanwhile, not inclusive of rainfall, the total possible recharge is estimated at only 5.46 m.ha.m/year. The wedge between these two measures highlights the need to efficiently manage surface water.

- The bulk of this reserve is non-replenishable with only 42 m ha m or 63%, of it having been deemed potentially exploitable.
- Current utilization of this reserve stands at only 13.5 m ha m, 85% of which is directed towards irrigation purposes.

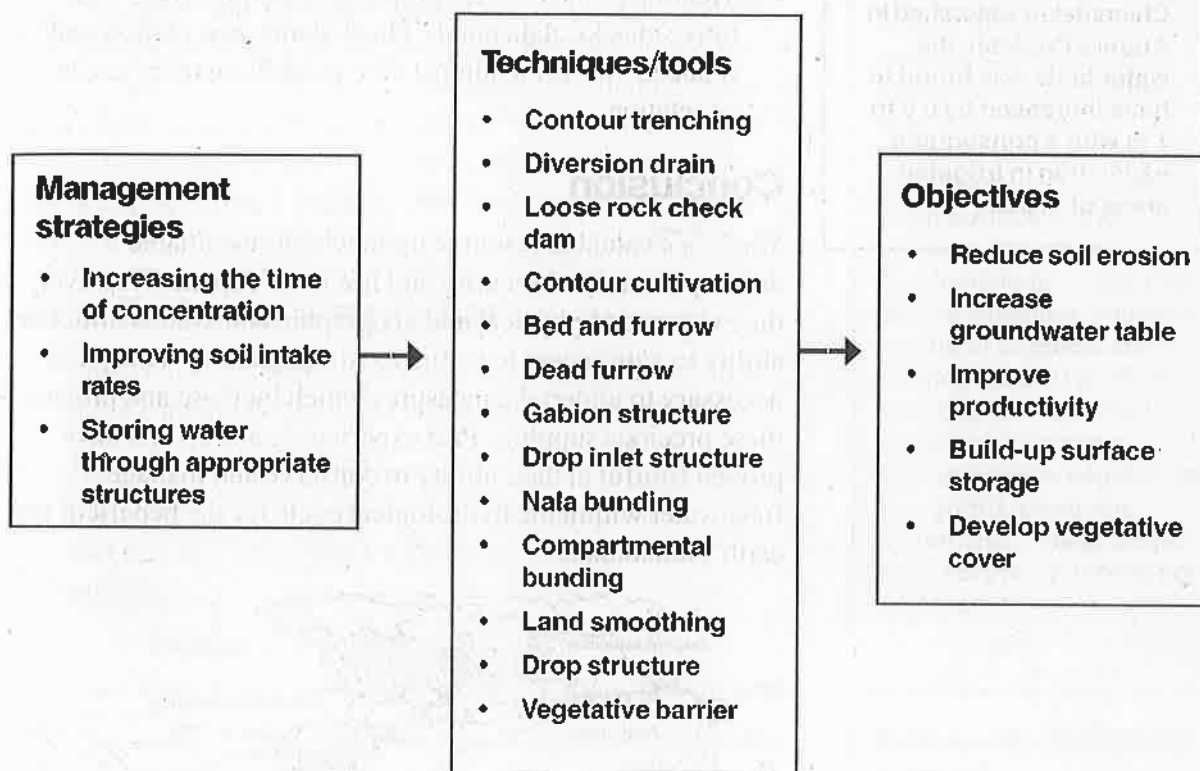
Consequences of mismanagement

- The largest demand for water comes from agriculture and, as a consequence, huge investments have been made in developing irrigation systems. Unfortunately, many such schemes are inefficient with loss rates ranging up to 60% of water supply.
- The resulting large amount of idle, excess water has led to increased incidence of salinity, alkalinity and water related diseases.
- Food production has become increasingly dependent upon access to water. Thus, mismanagement of these resources might weaken the implied link between national food security and water availability.
- It is estimated that 40 Mha of land in India is flood-prone. Due to mismanagement, an average of 9 Mha (of which, 3.8 Mha consists of cropland) is affected by flooding annually.
- These experiences suggest that improper management and use of fresh water resources are capable of posing a serious threat to sustainable development.



Groundwater management objectives

- It is possible to manage these scarce resources by such means as increasing time of concentration, improving penetration into the soil and storage through appropriate structures so as to reduce flood hazards and augment ground water recharge.
- When implementing any soil conservation measures, a general watershed management approach should be strictly adhered to. This means integrating and applying all measures minimizing run-off while simultaneously maximising production.



Experiences in recharging groundwater

Watershed management has been proven to be capable of conserving rainwater and improving groundwater recharge.

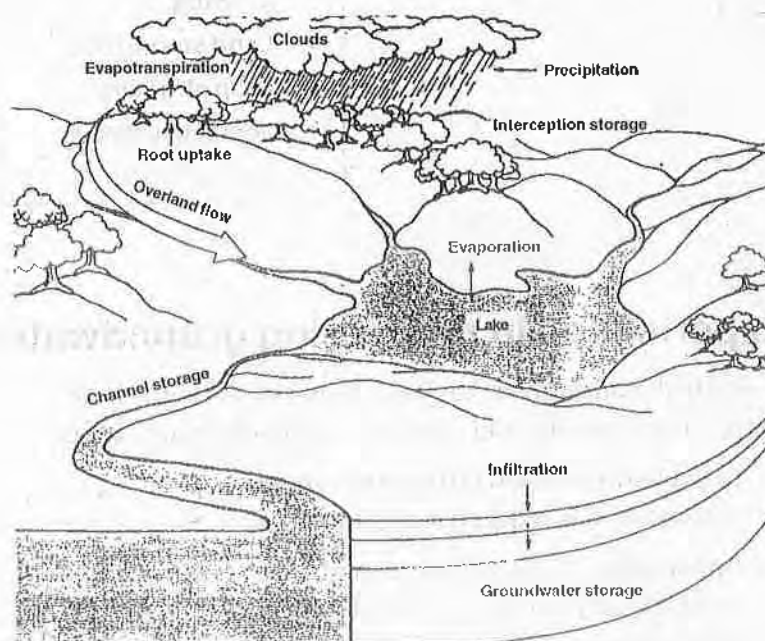
- In the north-western hill regions, simple contour cultivation has reduced run-off by 13%.
- Impounding types of mechanical measures (e.g., contour bunds, bench terraces) reduced the run-off by 80% in the hilly regions.
- Adopting conservation bench terraces in a 3:1 ratio reduced run-off by 80% in agricultural watersheds.

The Swadhyaya Association, under Ramakrishna Mission, helped to recharge 94,460 wells and 208 dry lakes in about 80,000 villages within the watershed where it operated. In the G.R.Halli watershed of Karnataka State, the groundwater table has registered an increase of 23.3% due to soil conservation measures. In a similar study at Chinnatekur watershed in Andhra Pradesh, the water table was found to have increased by 0.5 to 1 m with a consequent expansion in irrigated areas of 173%.

- Soil and water conservation measures have helped reduce the peak rate and run-off volume by 80% and 60%, respectively.
- In the southern hill regions, bench terracing reduced run-off from 4% to 1%.
- Adoption of soil conservation measures in tea gardens reduced run-off from 15% to 0.4%.
- In the plateau region, the recommended soil and water conservation measures have reduced run-off by 50%.
- In cases of non-arable lands, developing the areas with contour trenches having a capacity of 30% of annual rainfall reduced run-off to almost zero.
- Treating gullies with appropriate structures (i.e., vegetative checks, nala bunds, check dams, percolation tanks) reduced run-off to almost zero in addition to increasing vegetation.

Conclusion

Water is a valuable resource upon which sustainable development, food security and life itself depend. However, the existence of physical and geographic constraints limit our ability to gain access to its full existing quantity. Thus, it is necessary to undertake measures which increase and protect these precious supplies. Past experiences and efforts have proven fruitful in their ability to conserve and manage freshwater within the hydrological cycle for the benefit of the earth's inhabitants.



Adapted from Warshall, 1980

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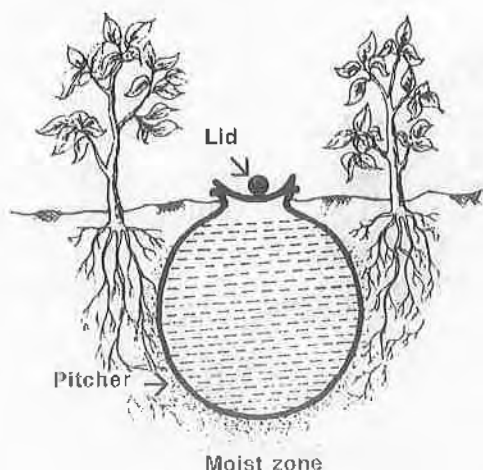
Contributors: M.S.Rama Mohan Rao, R.N.Adhikari, S.L.Patil and
M. Padmaiah

Use of scarce water resources in drylands through pitcher irrigation

Good quality ground water is very scarce in arid areas. Even where canal water has been introduced, proper methods of irrigation have not been used resulting in problems of soil salinity and waterlogging. So, in arid and semi-arid regions, every drop of water should be utilised in the best possible way. In the recent past, new methods like sprinkler and drip irrigation have been used successfully. But these methods involve heavy investments on installation and maintenance. Work done at research centres and universities in arid areas have shown that pitcher irrigation is effective in growing spreading type crops and saplings. It serves as the "poor man's drip irrigation system."

Installation of the pitcher

1. Dig a small pit with a spade or a hand-hoe; the depth of the pit should be the same as the height of the pitcher.
2. Place the pitcher in the pit.
3. Put powdered soil around the pitcher and press the soil so that it is in close contact with the outer wall of the pitcher.
4. Keep the neck of the pitcher above the soil surface.
5. Pour water into the pitcher and cover its mouth with a lid.
6. Sow seeds close to the outer wall of the pitcher when the area around it gets moistened in a day or two.
7. Refill the pitcher when three quarters of the water is used up.
8. Place a lid on the pitcher and close it firmly to reduce evaporation and prevent breeding of mosquitoes. This can be done by any indigenous method suitable to the local region.



Pitcher

The pitcher is a round, baked earthen container which is open at the top. This indigenous container is used by village women to fetch and store water. Water stored in pitchers maintains a cool temperature in summer as water evaporates from the outer surface of the pitcher. The same mechanism is applied for pitcher irrigation. Pitchers can be of different sizes ranging from 10 to 20 litres capacity. One pitcher is sufficient to irrigate spreading type vegetables like gourd, pumpkin, melon, etc. These crops need very few pitchers per unit area.

Environment-friendly method

- It does not require any electric or other form of energy. Once the pitcher is filled, it carries on irrigation work 24 hours a day.
- It minimises usage of fertilisers.



Note

- The soil around the pitcher should be powdered finely to ensure total moistening of the soil
- Seedlings and tree saplings should be planted in the moistened area only
- If salinity in the water is high, the site of the pitchers can be changed every three years to increase efficiency of the method.

Benefits of pitcher irrigation over other methods

- It saves water because there is minimal loss from seepage and evaporation.
- It reduces maintenance costs.
- It cuts down on weeding.
- It checks waterlogging.
- It minimises salt deposit accumulation in the soil.
- It enables application of soluble fertilisers in small quantities.
- It ensures optimum utilisation of water and fertilisers.
- It facilitates early growth of trees. In the case of the *Khejri* (*Prosopis cineraria*) from Rajasthan, the initial growth was faster, which otherwise is much slower.

Social benefits

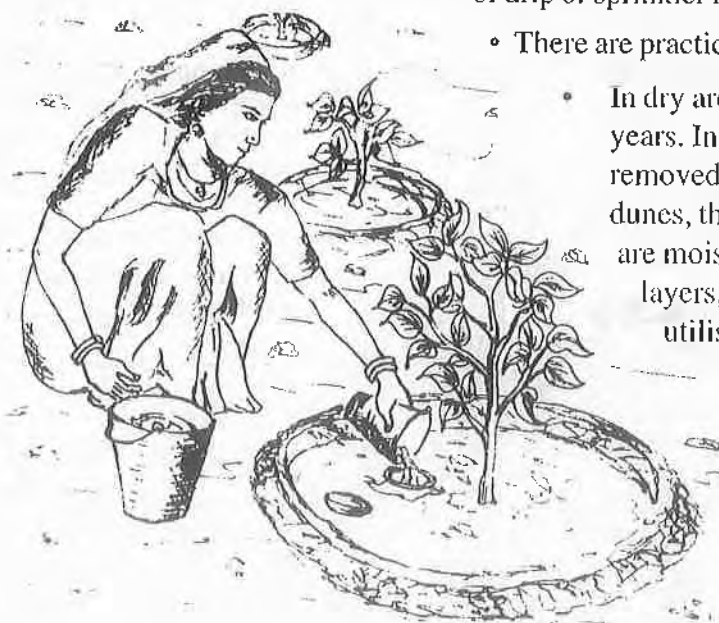
- Encourages a cottage industry by providing work to the potters who prepare these pitchers.
- Promotes the use of locally available materials.
- Provides more employment opportunities to landless labourers as the pitchers have to be repeatedly refilled.
- Allows easy handling by all family members.
- Poses no environmental hazard.

Economics of pitcher irrigation

- Each pitcher costs Rs 10-15 for a 10-15 litre capacity pitcher. The cost of installation of 1000 pitchers is around Rs 17,000 - which is less than the installation cost of drip or sprinkler irrigation.

- There are practically no maintenance costs.

- In dry areas, pitchers last for more than 3 years. In the case of trees, pitchers can be removed after one or two years. Even in sandy dunes, the soil layers at a depth of one metre are moist. Once the roots move to deeper layers, the pitchers can be removed and re-utilised elsewhere. The cost of growing crops and trees will be reduced considerably.

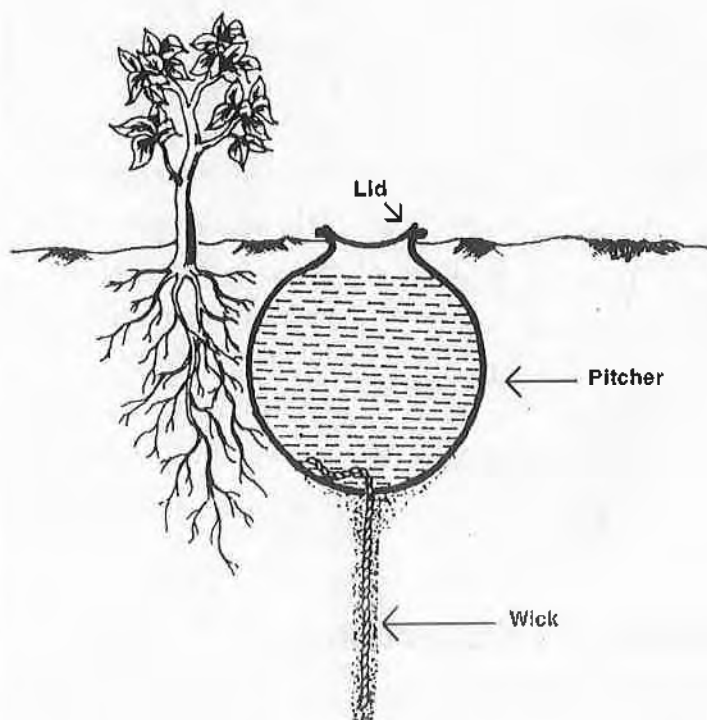


Pitcher irrigation as practised in Karnataka

Pitcher irrigation is a popular practice in the semi-arid and undulating areas of Karnataka. The method varies slightly from the one detailed earlier.

The steps are as follows:

1. Use a pitcher with an approximate capacity of 12 litres.
2. Make a small hole at the base of the pitcher.
3. Place a cotton wick in the hole.
4. Bury the pitcher in the soil close to the root of the plant ensuring that its neck is above the ground as shown in the illustration.
5. Pour water in the pitcher and keep it covered with a lid to prevent evaporation.



Courtesy: Mr. S.N. Doni and Mr. Ramachandrappa based on MYRADA's Kamasamudram Project.

Note

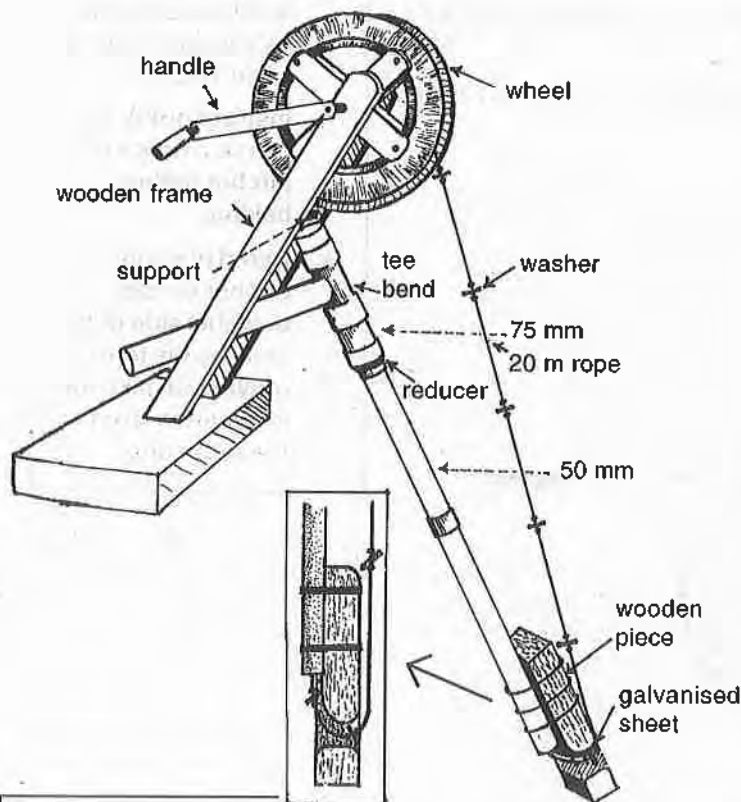
- Ensure that the wick is firmly fixed to prevent the plant roots from entering the pitcher.
- Position the pitcher in a way that no run off rainwater can enter because silt can block the pores of the pitcher.
- Instruct potter to pierce a hole in the pitcher before baking.
- Avoid placing pitcher on the downhill side of the plant as the force of gravity will take the water away from the root zone.

Contributor: K.K. Mehta

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Low-cost water pump for minor irrigation

The water pump for minor irrigation is very cost effective and easy to assemble. It can draw water from a depth of up to 7.6 m. Very practical to handle, this equipment is suitable for use on farm ponds, check dams, mini orchards, small intensive gardens and for livestock water needs. Usually, these operations are managed by women. Being easy to transport and assemble, women find it convenient to use.



Materials required

- ✓ 7 m of 50 mm (1.5") 6 kg PVC pipe
- ✓ 2 m of 75 mm (2.5") 4 kg PVC pipe
- ✓ one 2.5" x 1.5" PVC reducer
- ✓ one 75 mm (2.5") - 6 kg PVC tee connector
- ✓ 20 m nylon rope
- ✓ 35 nos. 1.25" washers made of tyre material (rubber)
- ✓ wooden frame
- ✓ tyre wheel with handle
- ✓ small piece aluminum sheet

Benefits

- Can be assembled quickly and easily.
- Can be operated manually.
- Can be operated safely by women, men or children.
- Maintenance cost is negligible.
- Light weight and easy to transport.
- Pump components are locally available.

Installation instructions

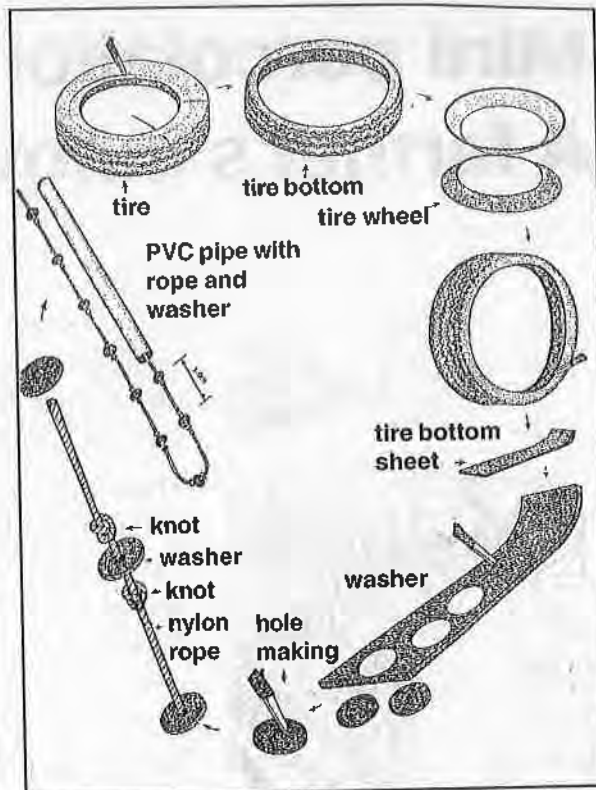
1. Fix the 50 mm pipe to the 75 mm pipe with a reducer.
2. Fix one side of the PVC Tee connector to the free end of the 75 mm pipe.
3. As a safety measure, fix the top of the pipe to a wooden plank to prevent constant shifting of the pipe.
4. Place the wheel on top of the pipe supported by a wooden frame on either side.
5. Fix 20 m nylon thread with washers (all of its length) with a distance of 50 mm (1.5") between every two washers. Make a knot on both sides of the washer to firmly hold it in place.

6. Insert downward one end of the thread through the top of the tee connector. The other end goes over the wheel, dropping down and connect to the first end at the bottom of the pipe.
7. To avoid wear of the washers and rope, attach a piece of wood to the bottom of the pipe. Then cut a hole in the wood, through this, attach a piece of galvanised sheet. This allows the rope and washers to run smoothly through the opening into the pipe.
8. Rip the wheel open, remove the metal rim and fix the wheel back with gum.



Important

If washers are not fixed firmly in place by the knots, the pump's effectiveness will be reduced.



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Contributor: Krisnan, with the help of NIE Mysore

Mini percolation tank: A farmer's innovation



This is a story of an innovative farmer. Mr. Bheem Rao Janakatti, who has a 3.23 ha of arable land, is a farmer who understands the importance of watershed development and subsequently, has shown great interest in it.

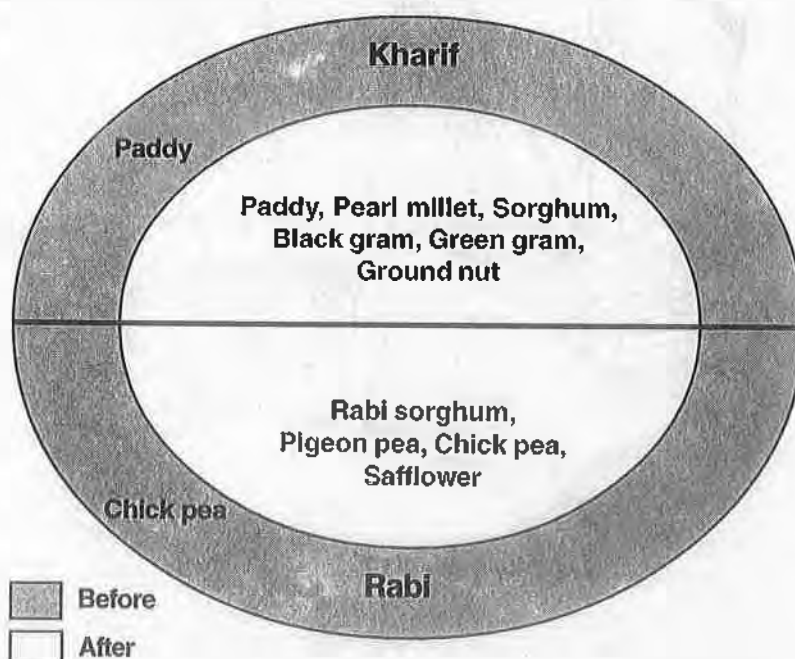
There was a 4 m wide *nala* with a catchment area of 20 ha falling abruptly in the middle of his land, carrying the fertile topsoil of his field away. When an integrated watershed project was undertaken in that area, Bheem Rao was advised to build up stone bunds across his land. These bunds checked the runoff and valuable silt started depositing in his field.

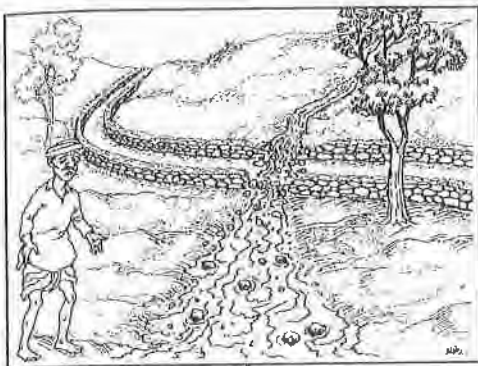
But Bheem Rao decided to do more and planned to dig a small 350 cm percolation tank ahead of the bund to hold rainwater. He and his family worked for almost a year to complete the tank. He now grows two crops on half an acre of his land with the stored water, while the rest of his land still lies fallow in the *rabi* (second) season. He did this with his own knowledge and skill using materials like stones and soil, etc. He is now using the deposited silt. He has planted a variety of trees like neem, *gliricidia*, etc. in the wide bund of the diversion channel. He is one of the millions of poor farmers in our country who is constantly innovating to ensure survival. To appreciate his effort, a local NGO has awarded him Rs.3,000, equivalent to 15 days of wage.

Impact

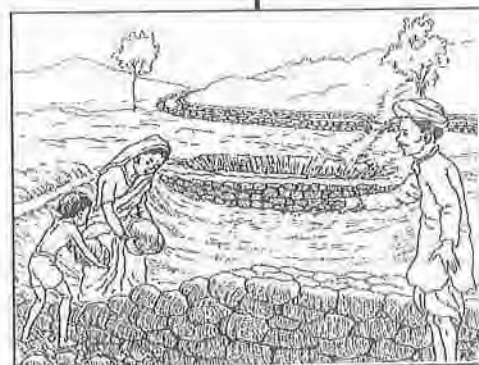
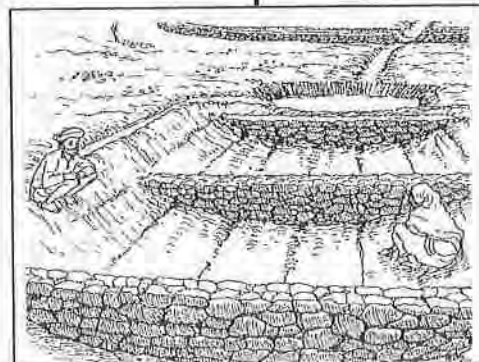
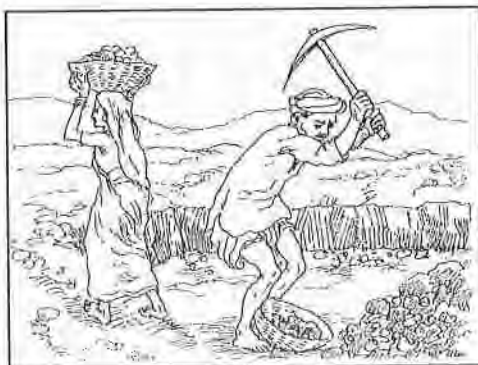
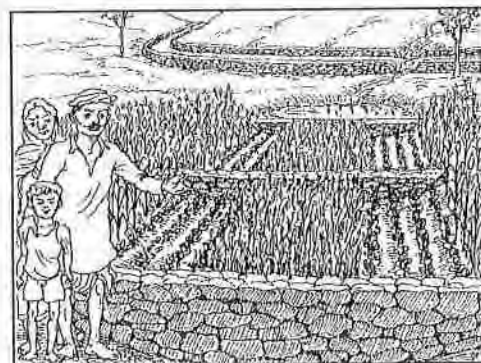
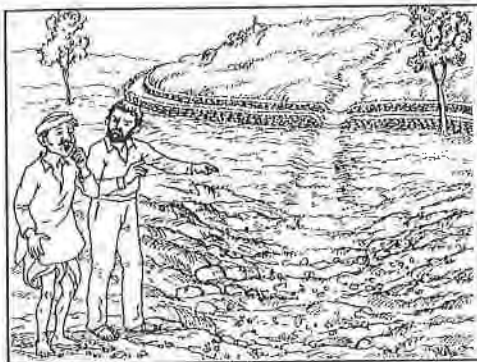
- Improvement in moisture regime.
- Controlled topsoil erosion.
- Increase in arable area
- Increase in cropping intensity
- Improved soil structure due to application of silt.
- Trees on the bund increase biomass production.
- Fields downstream growing crops due to percolation.

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Today, Bheem Rao's efforts have made a lasting impression on his peers; many farmers in his locality are now planning to replicate his model with the means and resources they have.



Contributor: L. Anand

3 Crop management

transmission of

3

Principles and concepts of cropping systems

What is a cropping system?

Cropping system is an important component of farming systems and represents cropping patterns practised on a farm. Cropping pattern refers to the proportion of area under various crops (at a point of time, in a unit area) or different crop sequences followed in a year.

Types of cropping systems

Cropping systems are classified based on the number, combination and spatial arrangements of crops grown at a given time or in succession during the year.

Monocropping

A single crop is grown on a piece of land and the same crop is grown every year.

Multiple cropping

Two or more crops are grown on the same piece of land in one calendar year.

Types of multiple cropping

Intercropping

Two or more crops are grown at a given time in spatial arrangement.

Mixed cropping

Two or more crops are randomly grown at a given time without any distinct arrangement.

Sequential cropping

Two or more crops are grown in succession one after another. **Relay cropping** is also a type of sequential cropping in which there is an overlap of a few days between the harvesting of the preceding crop and seeding of the succeeding crop.

Traditional practices

Intercropping and mixed cropping are the most common cropping systems practised for centuries by farmers in rainfed drylands of Asia.

Predominant monocrops in drylands

- groundnut
- sorghum (*jowar*)
- finger millet (*ragi*)

Examples of predominant multiple cropping systems in drylands

- Intercropping — sorghum/pigeon pea in red soils
- Mixed cropping — sorghum, pigeon pea, and sesame in black soils; *ragi* and lablab in red soils
- Sequential cropping — sorghum-safflower and maize-chickpea in deep black soils
- Relay cropping — *ragi* and horse gram in red soils

Advantages of multiple cropping

- Avoids risk of total crop failure due to erratic rainfall or pests and diseases and ensures food security.
- Increases the annual net yield per unit area.
- Optimum utilisation of natural resources such as land, water, sunlight and nutrients.

Factors influencing choice of cropping system

Farm resources

Choice of cropping system depends on land, labour, water, capital and infrastructure. In drylands, water availability is the most important constraint for crop production. Amount of rainfall as well as soil type and water-holding capacity influence the type of cropping system based on the length of the crop-growing season.

Potential cropping systems in relation to rainfall and soil type

Rainfall (mm)	Soil type	Water availability period (weeks)	Potential cropping systems
350-600	Red soils and shallow black soils	20	Single <i>kharif</i> crop
350-600	Sandy soils	20	Single <i>kharif</i> or <i>rabi</i> crop
350-600	Deep black soils	20	Single <i>rabi</i> crop
600-750	Red soils, black soils, sandy soils	20-30	Intercropping
750-900	Sandy soils, deep black soils, red soils	>30	Sequential cropping — double cropping
>900	Sandy soils, deep black soils, red soils	>30	Sequential cropping — double cropping (assured)

Farm enterprises

Enterprise at the farm level leads to a cropping system having specific crops; e.g., fodder crops in dairy and grain crops in poultry.

Farm technology

Improved technologies alter the cropping systems. In deep black soils with annual rainfall >750 mm, dry seeding yields both *kharif* and *rabi* crops instead of only one *rabi* crop in the post rainy season.

Crop interaction

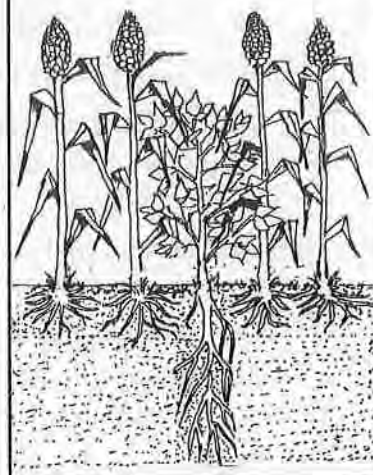
Intercropping

- The interaction between the component crops may be competitive, non-competitive or complementary.
- Competition for growth factors such as sunlight, water and nutrients must be avoided.
- A combination of tall and short crop (e.g., millet/groundnut) or short- and long-duration crop (e.g., groundnut/pigeonpea) reduces competition for sunlight.
- Water is used more efficiently by crops that extract water from different soil depths due to different rooting depths (e.g., sorghum/pigeonpea); or produce more canopy, thus, reducing evaporation from soil surface (e.g., cotton/green gram).
- A combination of cereal and legume crops reduces input of nitrogen (N).

Sequential cropping

- The interaction is non-competitive.
- Some preceding crops have an allelopathic effect on the succeeding crop (e.g., sunflower).
- Soil fertility is reduced by the preceding crop.
- Residual effect of farm-yard manure (FYM) or phosphorus (P) fertilizer can be seen on the succeeding crop.

Root depth of component crops



Soil fertility

Sorghum and millet reduce the N availability in the soil; therefore, N application to the succeeding crop is essential.

Sorghum/pigeonpea intercrop



Crop management

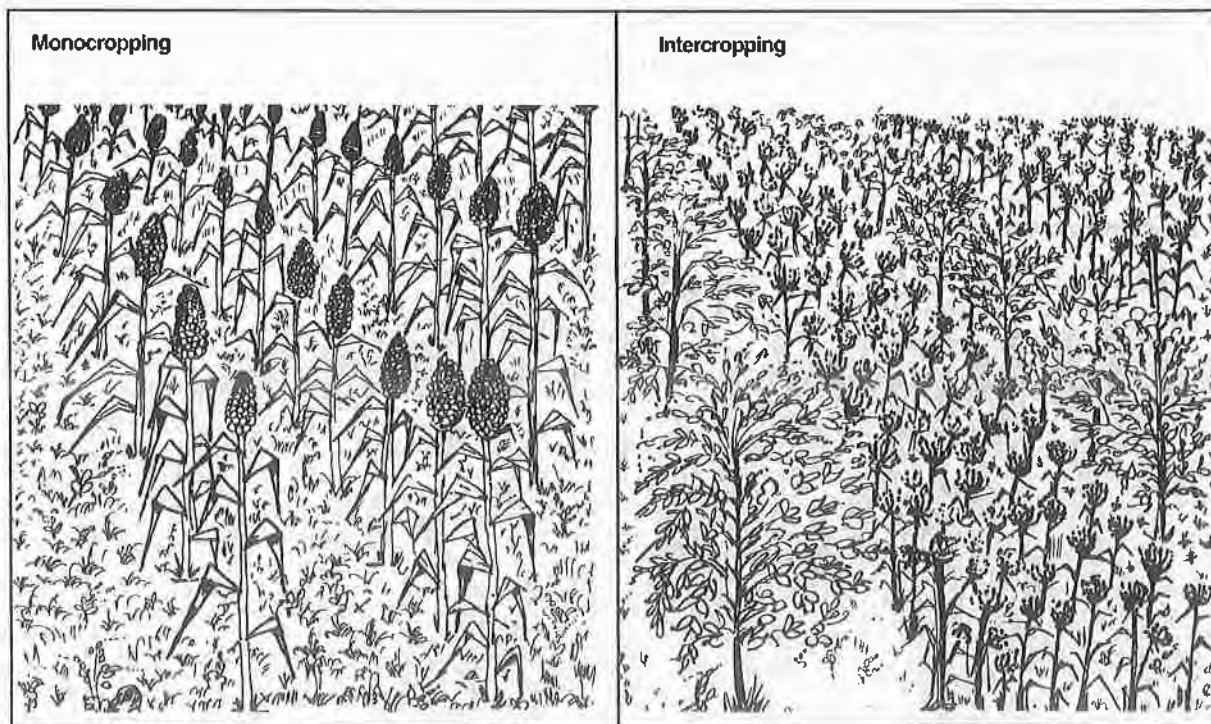
Intercropping

- Prepare seedbed as per the base crop.
- Use less competitive varieties.
- Adjust time of sowing; e.g., staggered planting in aggressive and non-aggressive crop combinations.
- Adequate nutrient application essential as per the requirement of component crops.
- Weed control — less weed infestation compared to monocrops; but chemical control is difficult.
- Pest and disease control — less pests and diseases due to crop diversity.

Sequential cropping

Crop management is easier than in intercropping because the crops are treated separately.

- Use short-duration and photo-insensitive varieties.
- Harvest the first crop at physiological maturity to avoid terminal drought of second crop.
- Overcome allelopathic effect of the preceding crop on the succeeding crop.
- Add additional amounts of N if the preceding crop is sorghum or millet (their roots have wide C:N ratio).
- Reduce 10 to 15 kg N per ha if the preceding crop was a grain legume, e.g., pigeonpea.
- If FYM or P fertilisers are applied to the preceding crop, reduce the input of N and P to the succeeding crop.



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Contributor: T. J. Rego

Cropping systems and sustainable agriculture

- Cropping systems represent crop cultivation in different patterns.
- Traditionally, farmers cultivate different crops in various crop combinations to meet the requirements of the family.
- Cropping system can be classified into two major types: monocropping and multiple cropping.
- With the introduction of high-yielding varieties and cash crops, some farmers shifted towards monocropping.
- The plant characteristics that influence cropping systems are plant height, crop canopy, nutrient and water requirements, root structure and plant products.
- Farm sustainability depends on the efficient use of natural resources (soil, water, energy and plant diversity) depending on the requirements of the farmers.
- A sustainable system aims to optimise production rather than maximising it.

Major cropping systems

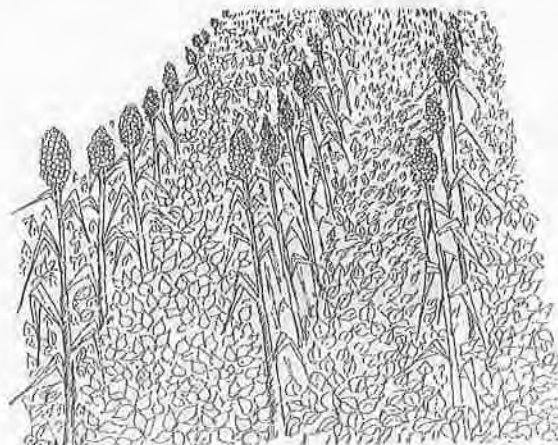
- **Monocropping** — a single crop is cultivated on the same plot of land every year, e.g., rice, groundnut, finger millet (*ragi*).
- **Multiple cropping** — two or more crops are cultivated on the same plot of land at the same or different times during the year.

Examples of multiple cropping systems in India

- **Intercropping** — in dryland areas of Tamil Nadu and Karnataka, intercrops of pigeonpea with groundnut, green gram, black gram, cowpea, or lablab; and sorghum with cowpea and soybean are common.
- **Mixed cropping** — commonly used by farmers in rainfed and in hilly areas. A combination of three to four cereals and pulses, sometimes oilseeds, are grown in the same field.
- **Sequential cropping** — more common in irrigated areas. In dryland areas of Tamil Nadu, groundnut is cultivated sequentially depending on the rainfall.



Monocropping



Intercropping

Criteria for ecologically-sustainable cropping systems

Ideal system 

An **ideal** cropping system includes crop combinations meeting these criteria:

- soil and water conservation;
- efficient use of water and energy;
- increase and maintenance of soil fertility;
- maintenance of crop yield level; and
- farm (including crop) diversity.

Criteria for farmers' choice of crops

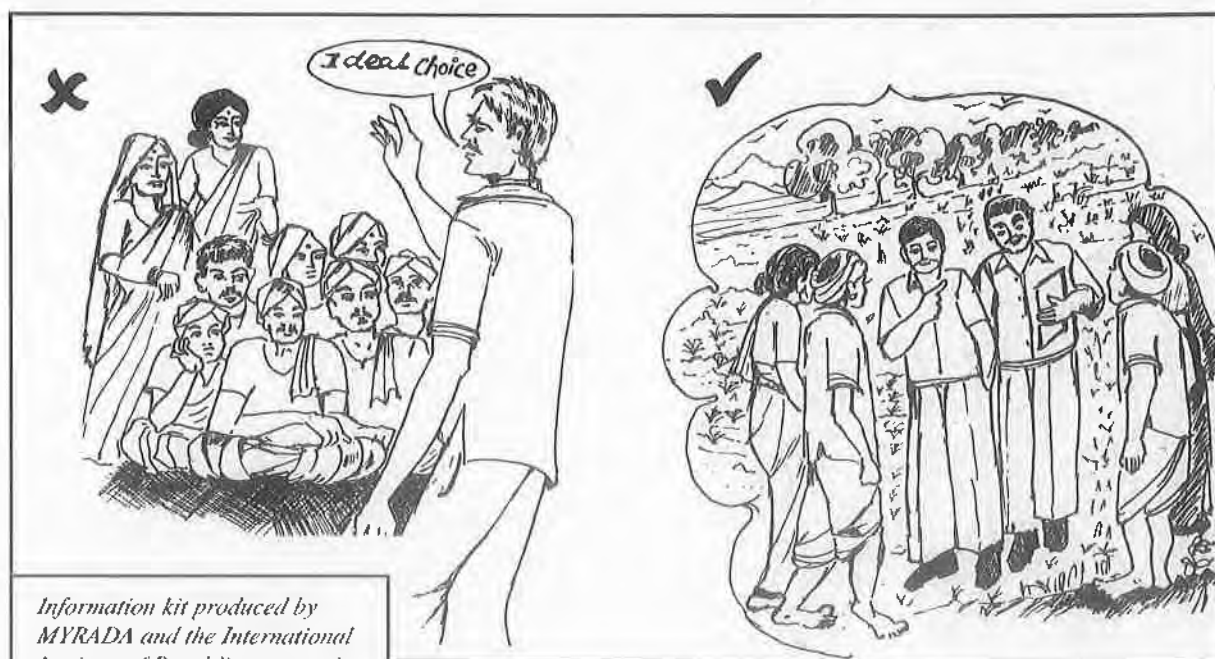
Actual system 

An **actual** cropping system includes crop combinations that meet these criteria:

- availability of resources (water, soil type, seed);
- availability of labour;
- family requirements (food, fodder, fuel, manure);
- farm income; and
- market access.

Cropping systems for sustainability

- Researchers and extensionists must have a dialogue with farmers to arrive at a realistic choice by farmers.
- A realistic choice of cropping pattern is a combination of the criteria for the farmers' choice of crops as well as for idealistic crop combinations. Such a cropping system contributes to sustainability.



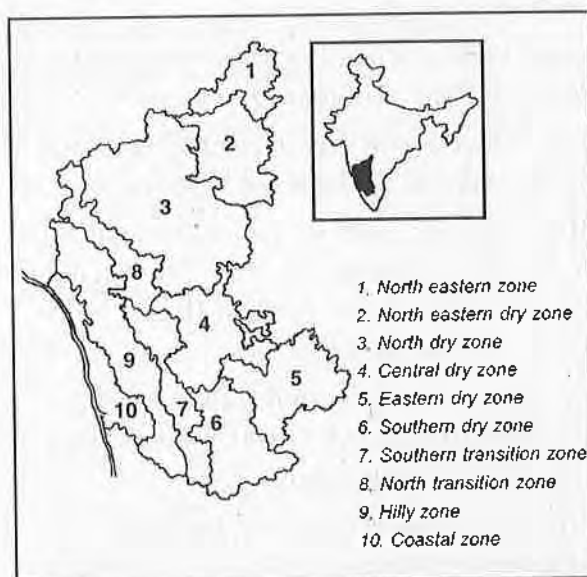
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Contributor: V. Gandhimathi

Cropping systems of different agro-climatic zones of Karnataka

Some research recommendations

The efficiency of a particular crop or cropping system is decided upon on the basis of its relative yield and spread indices. The performance of crops and cropping systems under a given set of recommended practices depend mainly on land capability, rainfall and its distribution. The major factors affecting the capability of land are its inherent characteristics (depth, available water holding capacity), landscape factors and climate. These, in turn, influence the length of the growing period.



North Eastern Transition Zone

Bidar and parts of Gulbarga District

Characteristics

Average annual rainfall: 870 mm

Coefficient of variation in the rainfall: 20%

Rainfall distribution: 790 mm from June to October

Cumulative reference crop evapotranspiration: 327.7 mm from June to November

Soil type: Deep red lateritic and medium to deep black soils

Water holding capacity (per metre depth): 17 to 22 cm in lateritic soils and 20-25 cm in medium to deep black soils

Length of growing period: 90 to 120 days for lateritic soils, 125 to 150 days for medium to deep black soils

Moisture stress on crops: Relatively low

Crops and cropping systems

Black and lateritic soils (Kharif season)

Sequential cropping systems

Sunflower --- chickpea/rabi sorghum

Sesamum — rabi sorghum/sunflower

Inter cropping systems

Hybrid sorghum + pigeonpea (2:1)

Black gram/green gram + pigeonpea (4:2)

Groundnut + pigeonpea (4:2)

Sesamum + pigeonpea (4:2)

Black soils (Rabi season)

Wheat, rabi sorghum

North Eastern Dry Zone

Raichur and Gulbarga districts

Characteristics

Average annual rainfall: 736.50 mm

Coefficient of variation in the rainfall: 29%

Rainfall distribution: Major portion of the annual rainfall (626.7 mm) is received from June to October

Cumulative reference crop evapotranspiration: 350 mm from June to November

Soil type: Deep to very deep black soils and sandy clay loam to light red sandy soils

Water holding capacity (per metre depth): 18 to 20 cm for deep black soils, 25 to 27 cm for very deep black soils and 8 to 10 cm for sandy clay loamy soils

Length of growing period: 125 to 135 days for black soils and 90 to 100 days for sandy to sandy clay loamy soils

Moisture stress on crops: Higher due to more evapotranspiration and higher coefficient of variation in rainfall

Crops and cropping systems

Red soil and medium deep black soils (Kharif season)

Hybrid sorghum + pigeonpea (2:1)

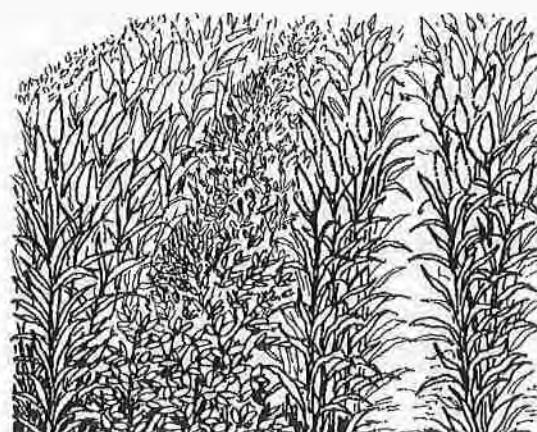
Sunflower + pigeonpea (2:1)

Pearlmillet + pigeonpea (2:1)

Deep black soil

Chickpea + safflower (4:2)

Rabi sorghum



Pearl millet + pigeonpea

Central Dry Zone

Entire Chitradurga district, parts of Tumkur, Chickmagalur and Hassan districts

Characteristics

Average annual rainfall: 606.8 mm

Coefficient of variation in rainfall: 25.6%

Rainfall distribution: 80% of the annual rainfall is received from May to October

Cumulative reference crop evapotranspiration: 284.20 mm

Soil type: Sandy loamy soil characterised with lesser depth

Water holding capacity (per metre depth): 10 to 15 cm

Length of growing period: 90 to 100 days

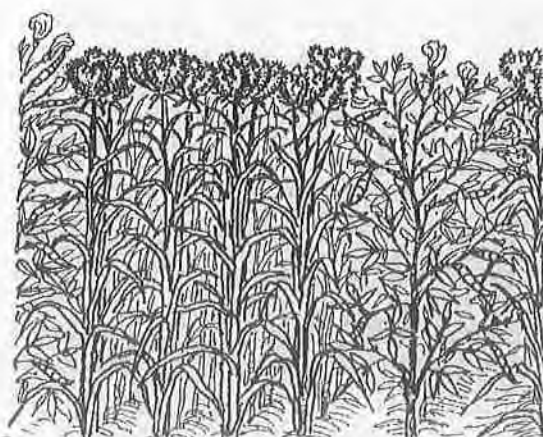
Moisture stress on crops: Severely stressed

Crops and cropping systems

Hybrid sorghum + pigeonpea (3:1)

Fingermillet + pigeonpea (4:1)

Groundnut + pigeonpea (8:2)



Fingermillet + pigeonpea

North Eastern Dry Zone

Raichur and Gulbarga districts

Characteristics

Average annual rainfall: 736.50 mm

Coefficient of variation in the rainfall: 29%

Rainfall distribution: Major portion of the annual rainfall (626.7 mm) is received from June to October

Cumulative reference crop evapotranspiration: 350 mm from June to November

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Water holding capacity (per metre depth): 18 to 20 cm for deep black soils, 25 to 27 cm for very deep black soils and 8 to 10 cm for sandy clay loamy soils

Length of growing period: 125 to 135 days for black soils and 90 to 100 days for sandy to sandy clay loamy soils

Moisture stress on crops: Higher due to more evapotranspiration and higher coefficient of variation in rainfall

Crops and cropping systems

Red soil and medium deep black soils (Kharif season)

Hybrid sorghum + pigeonpea (2:1)

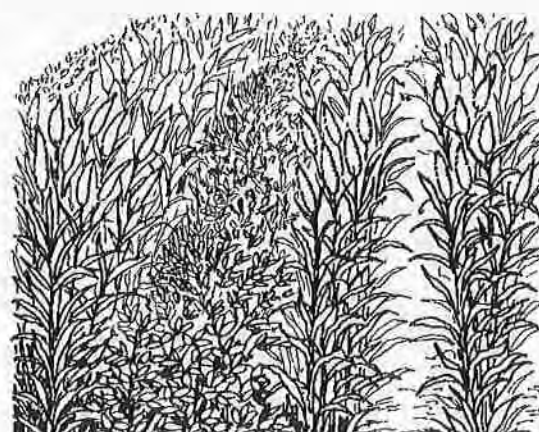
Sunflower + pigeonpea (2:1)

Pearlmillet + pigeonpea (2:1)

Deep black soil

Chickpea + safflower (4:2)

Rabi sorghum



Pearl millet + pigeonpea

Central Dry Zone

Entire Chitradurga district, parts of Tumkur, Chickmagalur and Hassan districts

Characteristics

Average annual rainfall: 606.8 mm

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Rainfall distribution: 80% of the annual rainfall is received from May to October

Cumulative reference crop evapotranspiration: 284.20 mm

Soil type: Sandy loamy soil characterised with lesser depth

Water holding capacity (per metre depth): 10 to 15 cm

Length of growing period: 90 to 100 days

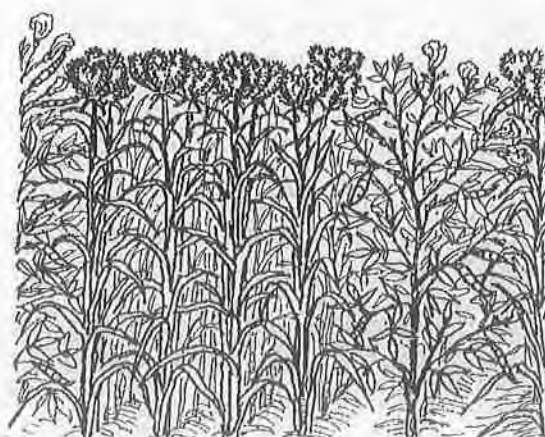
Moisture stress on crops: Severely stressed

Crops and cropping systems

Hybrid sorghum + pigeonpea (3:1)

Fingermillet + pigeonpea (4:1)

Groundnut + pigeonpea (8:2)



Fingermillet + pigeonpea

Northern Dry Zone

Entire Bijapur and Bellary districts and parts of Belgaum, Dharwad and Raichur districts

Characteristics

Average annual rainfall: Very low average rainfall — 583 mm

Coefficient of variation in rainfall: 30.8% with high desiccating wind velocity.

Rainfall distribution: 128 mm from June to August and 455 mm from September to November

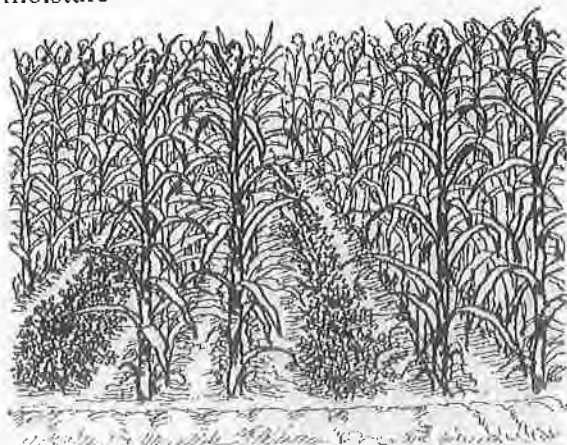
Cumulative reference crop evapo-transpiration: Higher than rainfall from May to August and almost equal to rainfall from September to November

Soil type: Shallow (30 cm), medium (30 to 60 cm) and deep black (> 60 cm) soils constitute 80% of the zone. Red loamy and sandy soils constitute 20% of the zone

Water holding capacity (per metre depth): 20 cm for deep black soils, 10 cm for medium deep, 7 cm for shallow black and 6 cm for red soils

Length of growing period: 90 to 120 days for medium to deep black soil, 75 to 80 days for shallow black to red loamy soils and 55 to 60 days for sandy to sandy loam soils

Moisture stress on crops: Crops experience severe moisture stress due to very low rainfall with higher coefficient of variation, desiccating wind velocity, higher potential evapotranspiration and less stored soil moisture



Rabi sorghum + chickpea

Crops and cropping systems

Shallow black soils (Kharif season)

Pearlmillet + pigeonpea (2:1)

Seteria + pigeonpea (4:2)

Medium deep and red loamy soils

Pearlmillet + pigeonpea (2:1)

Spreading groundnut + pigeonpea (4:2)

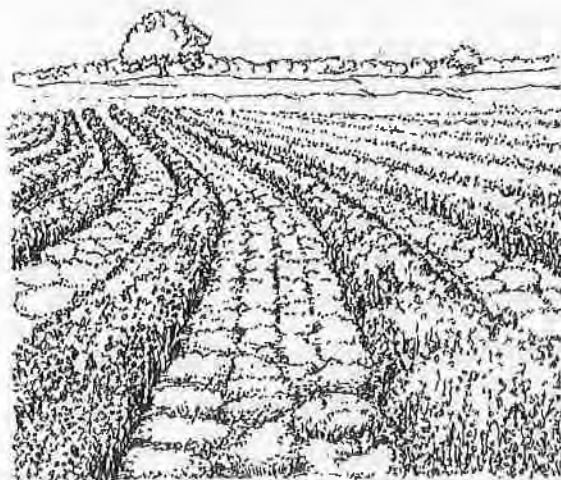
Bunch groundnut + pearl millet (4:2)

Deep black soils

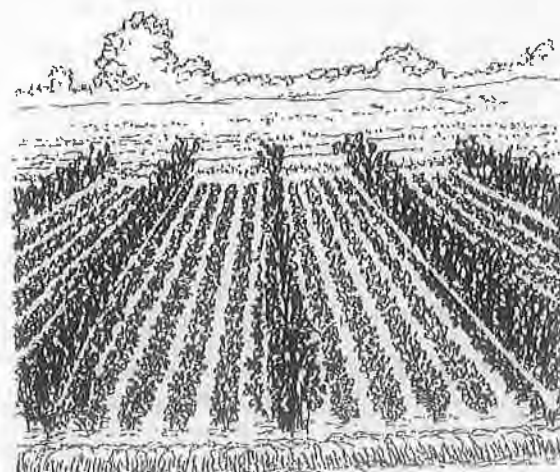
Rabi sorghum + chickpea (2:1)

Chickpea + safflower (4:2)

Coriander + safflower (4:2)



Safflower + chickpea



Sunflower + groundnut

Eastern Dry Zone

Entire Kolar and Bangalore districts

Characteristics

Average annual rainfall: 768.2 mm is received in two peaks, one in May and the other from September to October

Coefficient of variation in rainfall: 25.6 %

Rainfall distribution: Nearly 82% of the annual rainfall (628.8 mm) is received from May to October

Cumulative reference crop evapo-transpiration: 339.4 mm

Soil type: Red loamy soils in major areas and few areas with lateritic soils

Water holding capacity (per metre depth): These soils are shallow with low available water holding capacity of 14 to 20 cm

Length of growing period: 90 to 120 days

Moisture stress on crops: Higher degree of moisture stress is observed

Crops and cropping systems

Sequential cropping systems

Sesamum — Fingermillet/horsegram

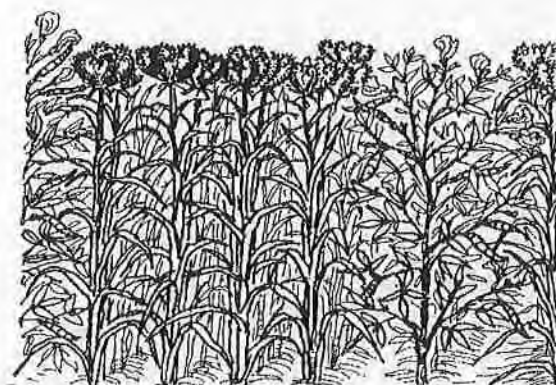
Hybrid maize — Transplanted fingermillet

Intercropping systems

Fingermillet + pigeonpea (4:1)

Groundnut + pigeonpea (8:2)

Maize + pigeonpea (1:1)



Fingermillet + pigeonpea

Southern Dry Zone

Entire Mandya district and parts of Hassan, Mysore and Tumkur districts

Characteristics

Average annual rainfall: 730.7 mm

Coefficient of variation in rainfall: 25.6%

Rainfall distribution: More than 70% (573.8 mm) is received from May to October

Cumulative reference crop evapo-transpiration: 308 mm

Soil type: Red sandy loamy and black soils

Water holding capacity (per metre depth): 8 to 10 cm for red soils and 10 to 15 cm for black soils

Length of growing period: 85 to 90 days for red soils and 100 to 125 days for black soils

Moisture stress on crops: It is observed during July – August

Crops and cropping systems

Red and black soils (Kharif)

Sunflower and mulberry

Intercropping systems

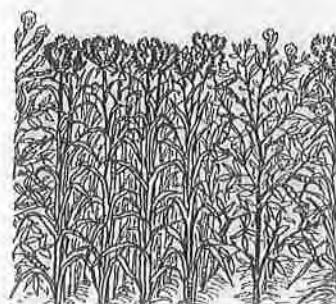
Hybrid sorghum + pigeonpea (3:1)

Fingermillet + pigeonpea (4:1)

Groundnut + pigeonpea (8:2)

Black soils (Rabi season)

Chickpea and Rabi sorghum



Fingermillet + pigeonpea

Southern Transition Zone

Shimoga, Chikmagalur and parts of the Hassan and Mysore districts

Characteristics

Average annual rainfall: 875 mm

Coefficient of variation in rainfall: 18%

Rainfall distribution: Fairly well distributed, nearly 50% of the normal rainfall is received from May to August and over 35% from September to December

Cumulative reference crop evapotranspiration: low

Soil type: Major soils are lateritic and red sandy loam

Water holding capacity (per metre depth): 18 to 23 cm

Length of growing period: 90 to 150 days

Moisture stress on crops: Due to well distributed rainfall with lower coefficient of variation and lower reference crop evapotranspiration these areas are seldom subjected to moisture stress

Crops and cropping systems

Sequential cropping systems

Potato — Fingermillet/castor

Sunflower — Horsegram

Fingermillet — Bengalgram

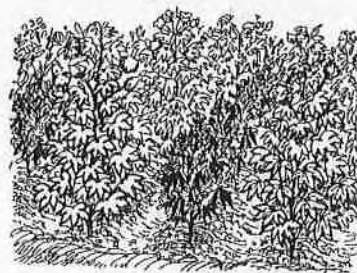
Hybrid maize — Horsegram

Intercropping systems

Fingermillet + pigeonpea (8:2)

Fingermillet + dolichos (4:2)

Chili + hybrid cotton (1:1)



Chili + cotton

Northern Transition Zone

Parts of Dharwad and Belgaum districts

Characteristics

Average annual rainfall: 749 mm with maximum of 1037 mm in Belgaum taluk and 838 to 623 mm in other talukas

Coefficient of variation in rainfall: 18% in Belgaum taluk and 23% in the other talukas

Rainfall distribution: More than 50% is received from May to August and over 35% from September to December

Soil type: Medium to deep black soils (40 to 45%) (> 90 cm) and red soils in the remaining area

Water holding capacity (per metre depth): 25 to 27 cm for deep to very deep, black soils, 18 to 23 cm for medium deep, and 5 to 6 cm for shallow red soil

Length of growing period: 125 to 150 days for black and lateritic soils, 90 to 100 days for red loamy soils and 75 to 80 days for clayey red soils

Moisture stress on crops: Stress during July and August

Crops and cropping systems

Medium deep black soils

Sequential cropping systems

Potato — Wheat/Rabi sorghum

Groundnut — Rabi sorghum/wheat

Sunflower — Chickpea

Deep black soils

Intercropping systems

Cotton + groundnut (1:2)

Maize + pigeonpea (2:1)

Chili + cotton + onion (½:½:2)

Chickpea + safflower (4:2)

Alfisols and medium deep black soils

Intercropping systems

Groundnut + pigeonpea (4:2)

Sunflower + pigeonpea (2:1)

Finger millet + pigeonpea (3:1)

Chili + cotton (1:1)

Tobacco as a pure crop

Hilly Zone

Kodagu, Uttar Kannada and parts of Shimoga, Chickmangalur, Belgaum, Dharwad and Hassan districts of Western Ghat and Malnad regions

Characteristics

Average annual rainfall: 1000 to 3700 mm

Coefficient of variation in rainfall: Low

Rainfall distribution: Quite uniform. Safe disposal of runoff water assumes importance

Soil type: Deep red clayey, gravelly, lateritic and brown forest soils

Water holding capacity (per metre depth): 18 to 20 cm.

Length of growing period: More than 210 days.

Crops and cropping systems

Sequential cropping systems

Rice — Chickpea

Hybrid maize — Chickpea

Intercropping systems of plantation crops

Arecanut + pepper + banana

Cardamum + cocoa



Coconut + pepper + banana

Coastal Zone

Uttar Kannada and Dakshina Kannada districts which include the coastal area of Karnataka

Characteristics

Average annual rainfall: Varies from 3,000-3,700 mm

Soil type: Lateritic, red clayey, nongravelly and alluvial soils are the major soil types

Crops and cropping systems

Sequential cropping systems

Rice — Groundnut

Rice — Sesamum

Inter cropping systems

Coconut + banana

Coconut + pepper + banana

Arecanut + banana

Cardamom + cocoa



Arecanut + pepper + banana

Contributors: M. B. Guled, M. I. Belgaumi,
B. S. Nadagoudar and V. S. Surkod

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Planning for aberrant weather conditions: Production and management strategies

Rainfall is the main and the most variable source of water for dryland crops. Its variability (between and within a year) plays a dominant role in influencing crop growth and yield. The cropping pattern in a region is usually planned on the basis of prevailing rainfall behaviour. Any significant deviation in such a behaviour is termed "aberrant". The most important aberrant weather situations in dryland regions are: low seasonal rainfall; and maldistribution of seasonal rainfall. These call for management practices to mitigate its effects. Invariably, these practices include the selection of drought-tolerant crops/varieties, combined with a choice of technologies for moisture conservation.

Production and management strategies for low rainfall tracts

When a low rainfall season is forecasted, the contingency measures described below are helpful in conserving the meager soil moisture.

Tillage

- Till black soil deep (up to 25-30 cm) immediately after harvest of the previous season's crop to increase the effective soil depth and control perennial weeds.
- Undertake shallow tillage (up to 10 cm depth) in red soils immediately after harvest of the previous season's crop to improve infiltration.

Graded furrows

- Open furrows with a grade of 0.2 to 0.4% and maintain them by deepening once or twice.

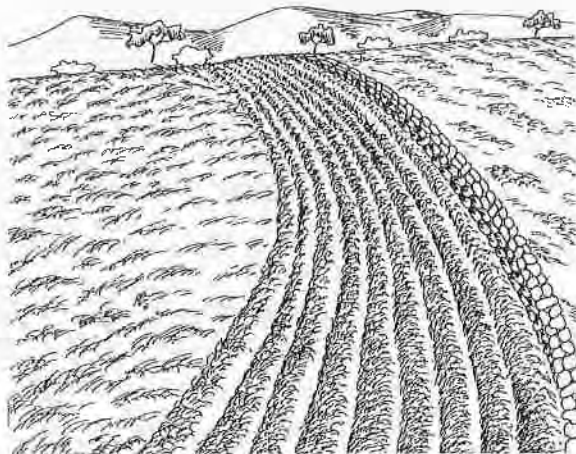
Important climatological inputs in crop planning

- Seasonal rainfall totals
- Probable period of assured rainfall distribution
- Long-range forecast
- Medium-range forecast

The India Meteorological Department (IMD) has successfully forecast the monsoon seasonal rainfall over India with an accuracy of more than 90% during the last decade.

Contour cultivation

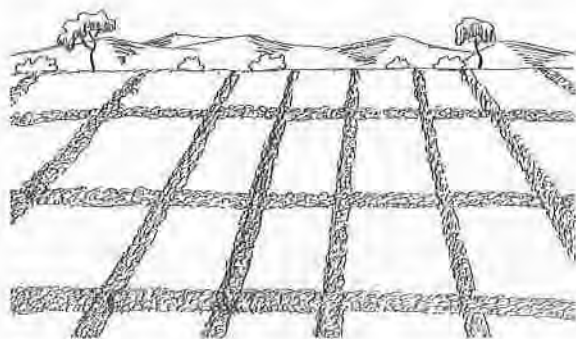
- Conduct all field activities like ploughing, tilling, seeding, etc. along the contour or across the slope. This increases the yield e.g., in *Setaria* by 35% and in sorghum by 22%.



Contour cultivation

Compartmental bunding

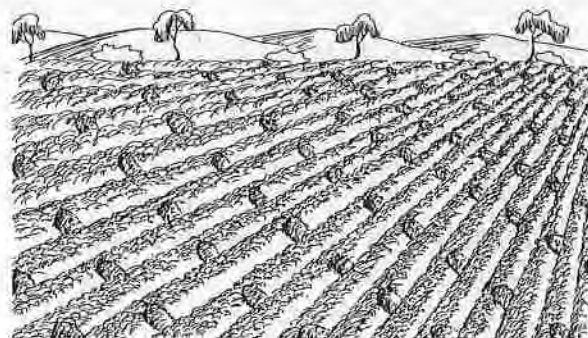
- Keep the lands with medium and deep black soils fallowed during the *kharif* season.
- Immediately after the rains in *kharif*, complete primary tillage first, followed by two harrowings.
- Construct compartmental bunds of 4.5 x 4.5 m and 3 x 3 m during the second fortnight of July on lands having slopes of 2% and 3%, respectively.



Compartmental bunding

Tied ridges and furrows

- Open the furrows 60 to 70 cm apart across the slope in medium to deep black soils, after completion of primary tillage, during the second fortnight of July. Tie at regular intervals along their length. This technique increases sorghum yield by 50%.



Tied ridges and furrows

Broad furrows and ridges

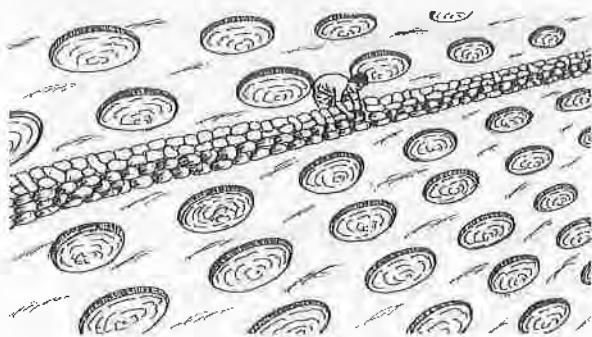
- Lay out the land into broad furrows and ridges across the slope in medium to deep black soils of 2% slope to conserve rainwater effectively and increase grain yield.



Broad furrows and ridges

Scooping

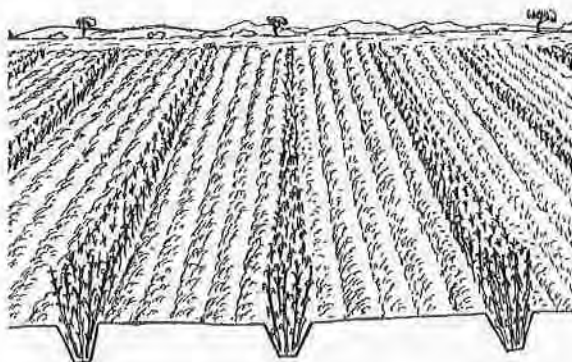
- Form scoops during the second fortnight of July across the slope or along the contour to increase the infiltration rate and to reduce erosion of medium and deep black soils which have poor infiltration characteristics. It is important to revive the scoops after each rain to facilitate better infiltration.



Scooping

Mulching

- **Vertical mulching:** The procedure involves opening trenches of 30 cm depth and 15 cm width across the slope at vertical intervals of 30 cm, and stuffing *jowar* stubbles vertically in these trenches so that they protrude 10 cm above ground. These vertical mulches of *jowar* act as intake points and guide runoff water to subsoil layers. Adoption of this technique in medium to deep stiff and clayey soils increases the grain yield of *jowar* by 26 to 54%.



- **Surface mulching:** Open ridges and furrows, 120 cm apart, 45 days prior to planting.
- Perform sowing in two lines in a furrow and break the ridges during the first interculturing, thereby creating adequate dust mulch.
- Alternatively, apply crop residues between the crop rows to reduce (soil) evaporation and improve water intake.

Wider row spacing, optimum plant population and seed rate

Row spacing

Rabi sorghum, safflower, sunflower	60 cm
Spreading groundnut and cotton	60 cm
Redgram	90 cm

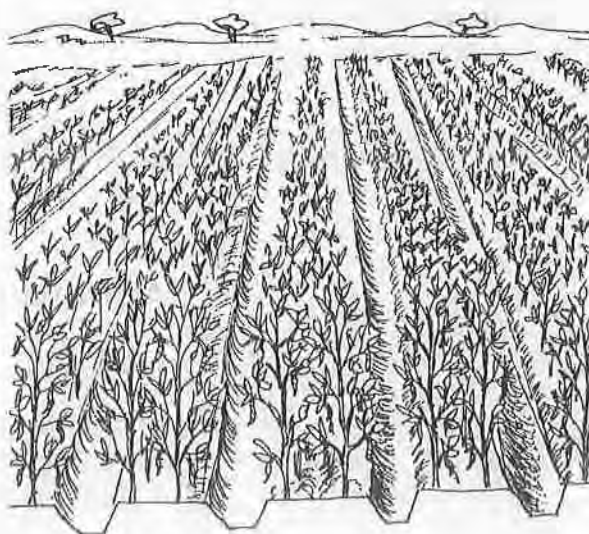
Seed rate and plant population (per hectare)

Rabi sorghum (7.5 kg/ha)	90,000
Safflower (7 kg/ha)	56,000
Redgram (15 kg/ha) and cotton (5 kg/ha)	56,000
Sunflower (5 kg/ha)	65,000

Figures in parentheses indicate the seed rate.

Border planting method

- The procedure involves skipping one row after every two rows of sowing of safflower/sunflower/redgram or three rows of bengal gram/groundnut. A furrow should be opened along the skipped row and tied after germination has taken place.



Seed hardening

Seed hardening refers to the technique of subjecting seeds to 2-3 cycles of soaking with appropriate chemical solutions and drying. This results in remobilisation of nutrients in the embryo and thickening of protoplasm within the body of the seedling, after germination, to impart drought tolerance.

Dry seeding

Dry seeding is the technique of placing the hardened seeds in a dry soil. The seeds are placed at a depth of 5 to 7.5 cm so they germinate at the onset of monsoon and not with the pre-monsoon drizzles. In the cases of red gram and castor, the seeds are placed in the centre of the furrow and covered with finely-powdered farmyard manure. In the cases of sorghum, pearl millet, bengal gram, sunflower, safflower, etc., the seeds are placed in the soil using a seed drill. Dry seeding is practised when delayed rain is forecasted.

Frequent deep intercultivation

- Frequent deep intercultivation operations break the soil, help in closing the cracks, create dust mulch and control weeds.

Seed hardening and dry seeding

- Treat *rabi* sorghum, bengal gram and safflower seeds with 0.2% calcium chloride for eight hours and subsequently shade-dry till it attains less than 10% moisture content for seed hardening. Practise dry seeding.

Management practices for early season drought

In certain years, the monsoon is forecasted to be sluggish to begin with, but improves later. If the sowing is delayed based on the forecast, it could result in reduced crop yields. For such a situation, the management practices described below are suggested.

Sluggish period

Land configurations

- Formation of tied ridges at an amplitude of 90 cm for redgram and 60 cm for pearl millet, castor and sunflower during the first week of June.
- Formation of broad furrows and ridges at an amplitude of 1.2 m for sesamum, 1.8 m for *Setaria*, sunflower + sesamum and spreading groundnut during the first week of June.

Crop management

- Practise seed hardening and dry seeding. Redgram and pearl millet respond well to these. Dry seeding practiced alone is sufficient for castor. Even a rainfall of 5 mm is sufficient for germination of these crops and also for their revival when congenial moisture conditions are attained.

Active period

Black soils

- Spread groundnut to the erect type. Sow in broad furrows and ridges in such a way that four rows are accommodated in each furrow (45 cm row spacing).
- Intercrop sunflower + sesamum in such a way that 4 rows of sesamum and 2 rows of sunflower are accommodated in each furrow.

- Sow sunflower in the centre of tied ridges opened at an amplitude of 60 cm.

Red soils

Select recommended crops and varieties for the red soil zones.

Transplanting

- Raise community nurseries of *ragi* at locations where water is available during July (for long duration varieties) and August (for short duration varieties) and transplant during August (long duration varieties) and September (short duration varieties).

Resowing

- If a dry spell is forecasted after sowing operations, with the inherent possibility of poor germination, plan for resowing of crop rather than maintaining the poorly established plant stand so that higher yields are obtained.

Management of biotic stress

In addition to the abiotic stress caused by deficient rainfall or dry spells at unanticipated stages, aberrant weather conditions may also cause biotic stress in the form of multiplication of insect pests or development of crop diseases, which should be combated with a combination of chemical, biological and cultural measures.

Ratooning

Ratooning is a technique of rejuvenating stumps after harvesting the main crop, either for green fodder or for grain purposes.

Additional management practices for mid-season droughts

Mid-season droughts are the results of breaks in the south-west monsoon. If a prolonged dry spell is forecasted or experienced during the vegetative phase of crop growth, before the reproductive stage of, say, pearl millet, undertake ratooning of the crop. In the case of *kharif* sorghum, ratooning may be deferred until its reproductive phase. Sometimes, it is necessary to invigorate the drought-affected plants during their revival. For this purpose, top dressing (for *ragi*) and foliar spray of urea at 2% (for castor and pigeonpea) are suggested.

Mid-season drought situations are critical for *rabi* sorghum if it coincides with the flower primordia initiation [45-50 days after sowing (DAS)] or flag leaf (65-70 DAS) stages. In such events, reduce the leaf area index by removing every alternate or third row of crop at flower primordia initiation stage, and four basal leaves at flag leaf stage. Close the soil cracks by repeated deep interculturing. This further helps in retention of moisture.

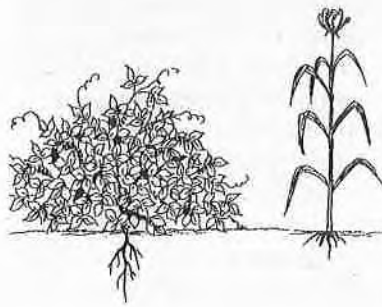
Additional management practices for late season droughts

When a crop encounters moisture stress during the reproductive stage, it may lead to forced maturity. Moisture stress during grain filling stage causes considerable yield loss in both *ragi* and *rabi* sorghum. The corrective measures are supplemental irrigation and use of surface mulches of straw or farm waste wherever possible. Avoid cracks by forming thin soil mulch using a blade hoe.

Contributors: M.B. Guled, H. Venkatesh, M.I. Belgaumi, B.S. Nadagoudar and G.D. Radder

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Indigenous intercropping practices in drylands



Intercropping means growing two or more crops in the same field at the same time.

Plants usually grow on soil and their proper growth is generally governed by the following factors:

- adequate root room;
- adequate nutrient supply;
- adequate water;
- adequate air;
- proper temperature and light; and
- absence of toxins.

The practice of intercropping generally considers the above factors in the way fields are planted.

Intercropping

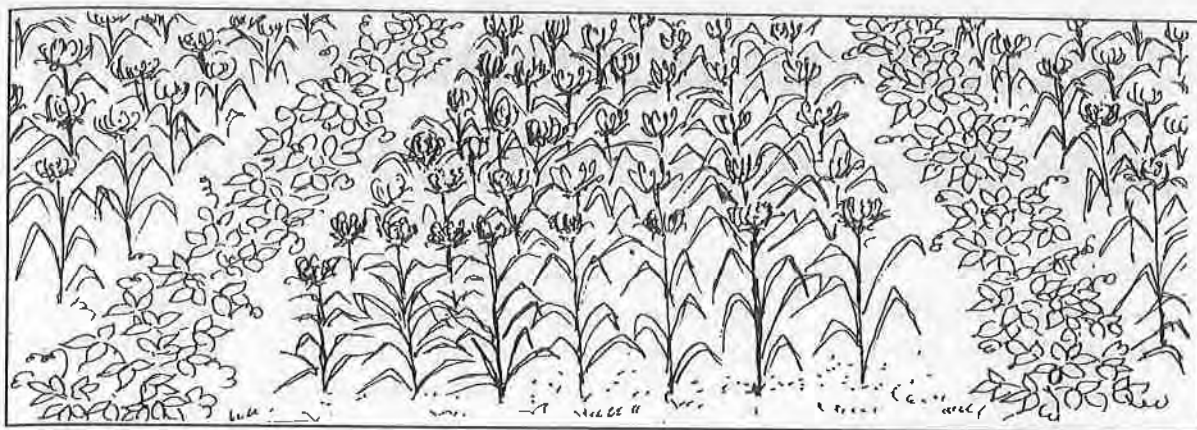
Intercropping is an ancient agricultural tradition that continues to be practised up to this day.

There are many advantages to it, particularly in dryland farming where resource constraints are many and majority of the farmers earn low incomes aside from being concerned with household food security needs.

The most popular indigenous crop combinations include several rows planted with millet/coarse cereals followed by one row planted with pulses/legumes.

The practice of planting *Ragi* (*Eleusine coracana*, finger millet, a coarse cereal) as the main crop with *Lab lab* (a pulse of the *Leguminaceae* family or *Purpureus* var *typicus/lignosus*) as the intercrop is widely prevalent in the drylands of southern India and amply illustrates the advantages of intercropping:

- *Ragi* has an adventitious root system while *Lab lab* has a tap root system. Their roots draw sustenance from different zones of the soil, thereby optimising the use of soil nutrients with minimal competition between the two plant types.
- *Ragi* is taller than *Lab lab* and grows straight while *Lab lab* is bush-like and spreads out at a lower level. This reduces the competition for sunlight between the two plant types.



- The combination of *Ragi*'s adventitious root system and *Lab lab*'s bush-like spread on the soil surface has a mulch-like effect and helps in both soil and moisture conservation.
- *Lab lab* is a nitrogen fixer, the benefit of which is derived by the *Ragi* crop.
- Intercrops are generally more tolerant of aberrant weather conditions. *Lab lab* is no exception and in drought periods, it lives longer than *Ragi* and ensures at least some income.
- Under normal weather conditions, both crops fetch an almost equal income even though planting ration is 5 rows of *Ragi* to one row of *Lab lab*.
- While both crops are planted at the same time, *Ragi* is harvested first and *Lab lab* a little later. This helps distribute the income of the farming family over a longer period.
- Both crops and crop residues have several alternative uses (food, fodder, fuel).

Note

While *Ragi* and *Lab lab* have been used as an example to illustrate the practical advantages of a popular indigenous intercrop combination, there are other equally-popular intercrop combinations that perform similar functions (including cash and food crop combinations).

Management tips

- Intercrops can be competitive, non-competitive, or complementary. The choice should be made with forethought and care. It is best to choose plant combinations that do not compete with one another for nutrients, water and sunlight.
- Some intercrops (e.g., marigold planted as an intercrop with onions/tomatoes) also act as trap crops against pests attacking the main crops.
- Leguminous intercrops can help reduce expenditure on nitrogen application.
- Under unpredictable weather conditions, intercrops give poor farmers with a last chance.

Contributor: P. Pachappa

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Farmer-managed participatory research for varietal selection

Inefficient varietal promotion of rice

About 525 varieties have been released in India. Of these, only the top 10 varieties account for 60% and the bottom 57 varieties for 1% of production.

Participatory varietal selection (PVS) is a farmer-participatory approach for identifying improved crop cultivars or varieties. It is a rapid and cost-effective process of identifying farmer-preferred cultivars.

Key assumptions

- Cultivars are not adopted by farmers because of inefficient varietal promotion.
- Poor adoption is not due to lack of willingness to adopt; or lack of a good choice of materials.

Varietal promotion and adoption

- Choice of cultivars should be provided to farmers.
- Farmers should identify suitable cultivars from a basket of choices.
- Number of cultivars adopted would increase.
- Speed of adoption would also increase.

Reasons for the approach

- To avoid unacceptable varieties.
- To select elite varieties.
- To test in farmers' and farmer-managed fields.
- To consider farmer-relevant crop traits.
- To provide a basket of choices.
- For rapid and easy adoption.

Phases of a successful PVS program

1. Identification of farmers' needs in a cultivar.
2. Search for suitable material to test among farmers.
3. Experimentation on its acceptability in farmers' fields.
4. Wider dissemination of farmer-preferred cultivars.

Search process for seed identification

- Farmers' needs by participatory rapid rural appraisals (PRAs) focused on crops.
- Breeders' advanced lines.
- Cultivars in advanced stage of testing, including failed entries.
- Private sector releases.
- State releases.
- National releases.

Alternative to farmer's variety

While conducting a search for crop yields and farmers' needs, consider farmers' preferences and varietal parameters (traits) learned from the PRAs.



Trial assessment through farm walk

Farmer-managed experimentation

The extent of farmers' participation varies in the different testing and evaluation systems. Many on-farm trials are conducted by researchers on farmers' fields with little or no involvement of farmers. In contrast to this method, farmers can be given a range of cultivars to grow with minimal intervention from outsiders such as scientists and development workers.

Participatory assessment

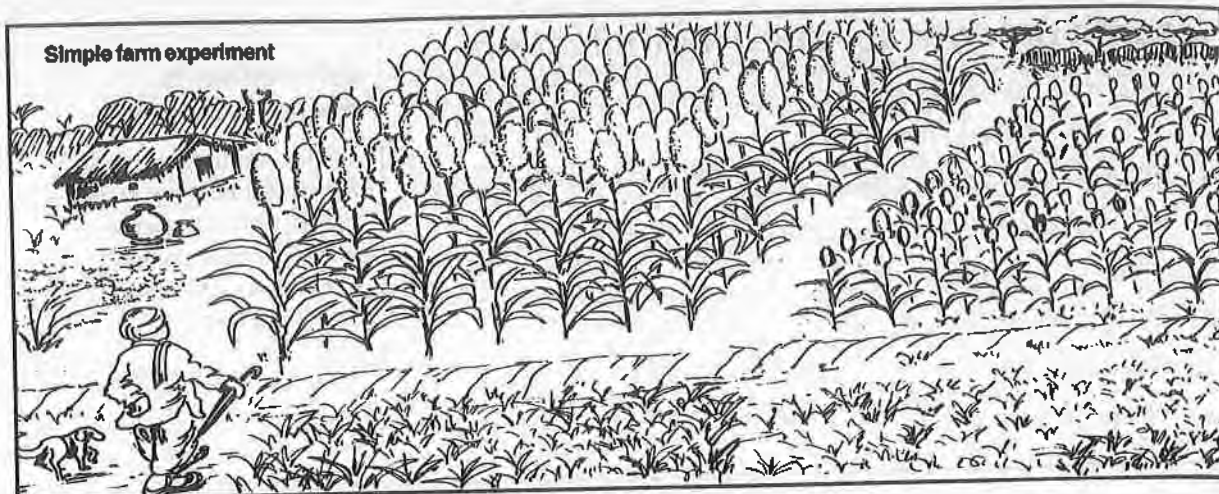
Farm trials can be evaluated for their performance using various participatory tools, such as:

- farm walks;
- pre- and post-harvest focused group discussions; and
- household level questionnaires.

Tips

Outside intervention can be minimised by simple methods.

- Only one cultivar per farmer.
- Comparison of new and local cultivars.
- Management practices and inputs used by the farmer.



Methods of varietal selection with varying degrees of farmer participation

Method	Evaluation of data	Institution
Researcher-managed and evaluated on-station trials	Yield	Research
Researcher-managed on-farm trials (replicated design)	Yield	Research
Farmer-managed, scientist-supervised, on-farm trials (several entries per farmer)	Yield, farmers' perceptions	Research
Farmer-managed, on-farm trials (unreplicated design with one cultivar per farmer; replicated across farmers)	Yield, farmers' perceptions	NGO, research, extension
Farmer-managed, on-farm trials (unreplicated design with one cultivar per farmer; replicated across farmers)	Farmers' perceptions only	NGO, extension, research
Farmer-managed trials (no formal design)	Informal, anecdotal	NGO, extension, research

Focused PRAs conducted by Krishak Bharati Cooperative Limited (KRIBHCO) in 1992-96

Crop	Farmer-preferred traits	Farmer-preferred varieties
Rice	Extra-early (70 days) to early (85 days) maturing types; tall, non-lodging types; upland, direct-drilling types; coarse to medium grain types with varied husk colour (red, black, and straw); sticky (on cooking) types	Pathariya, Dhibri, Dabda, Kolam, Rati Hal, Nani Hal
Maize	Extra-early (75 days) to early (95 days) maturing types; white, flint grain types	Telni, Nani gangri, Dudhmogar
Black gram	Early, spreading type with bold, shiny grains; early, dull, black-seeded types	Teliya, Kuvestiya

A case study

In 1993-96, the KRIBHCO conducted farm trials in 15 clusters of villages in the districts of Panchmahals (Gujarat), Banswara (Rajasthan), and Jhabua (Madhya Pradesh). Three crop varieties have been highly preferred by farmers. These are Kalinga III (upland, direct-drilled rice), Shweta (early, white, composite maize) and TPU-4 (black-seeded black gram).

Contributors: Arun Joshi and J. R. Witcombe

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Participatory plant breeding: Concepts and examples



The centralised plant breeding of the green revolution has yielded results in the more favourable agricultural environments. Most low-resource farmers in marginal areas, however, have not benefitted from these varieties. As an alternative for these areas, farmer participatory approaches are being adopted in selecting and breeding better adoption varieties.

Types

The approach depends on crop and availability of resources.

Consultative

Farmers are consulted at every stage to set the breeding objectives and in choosing the appropriate parent.

Collaborative

Farmers grow the early variable generations and select the best plants among them from their own fields.

Krishak Bharati Cooperative Limited (KRIBHCO) implemented a participatory natural resource management project in the districts of Panchmahals (Gujarat), Jhabua (MP) and Banswara (Raj.). This paper presents the results of the programme and collaborative research using a participatory plant breeding with Gujarat Agriculture University.

Key assumptions

- Farmers are interested.
- Farmers and scientists collaborate.
- It will not fail because:
 - locally adopted parental material are used;
 - local environment is selected; and
 - selected by farmers themselves.

When to use?

- when no suitable cultivars are identified.
- when participatory varietal selection does not produce results.

How to use?

- local landrace x high yielding varieties
or
- participatory varietal selection cultivar x high yielding varieties
or
- local landrace x participatory varietal selection cultivar

Methods

There are many participatory plant breeding methods that have varying degree of farmer participation.

Methods	Site specificity	Examples
All generations are grown by the plant breeders. Farmers involved at the pre-release stage or even after release.	Wide adaptation targeted. Early generations may all be in single location followed by multi-location testing.	CGIAR NARS DC programmes
Early generation (F_2) in farmers' fields. All other generations and procedures with plant breeder on station.	Single location testing site for F_2	R.Thakur (1995)
Best advanced lines at F_7 or F_8 given to farmers for testing. Closest method to participatory varietal selection, because farmers were given nearly finished product.	Easy to test the best advanced lines across locations.	Recommended by Galt (1989)
From F_3 or F_4 onwards, farmers and plant breeders select and identify together the best material on farm. Farmers select, plant breeders facilitate. Breeder prepares release proposal.	Possible to run selection procedures on early generations in more than one location.	Sthapit <i>et al.</i> (1996) Nepal
Breeder gives F_3 or F_4 material to farmers. All selections left to farmers. At F_7 to F_8 or later, breeders identify best material in farmers' fields to enter in conventional trials.	Extremely easy to run selection schemes in many locations.	Salazar (1992)
Trained expert farmers make crosses and select without assistance from breeders. Breeders place best material in conventional traits.	Specific to farmers' requirements.	None yet. Second generation technology

Advantages of participatory over conventional breeding methods

- At least one parent in any cross is well adapted to the local environment.
- Genotype x environment/location (GxE) / (GxL) interactions are more positive because breeding is done in target environment.
- The impact of genotype x year interaction is probably reduced because the local parental materials adaptable to year to year variations are likely to be encountered.
- Few crosses are made, large F_2 and F_3 populations can be grown to the increase possibility of desirable F_4 and F_5 progeny.

Steps for participatory plant breeding

1. Set the breeding objectives.
 - Crop-focused PRAs
 - Analyse results of participatory varietal selection
2. Identify the parent material.
 - From landrace
 - From participatory varietal selection
 - From cultivar database for elite/high yielding varieties
3. Decide (consultative/collaborative) model.
 - On the basis of available resources
 - On the basis of farmers' participation
4. Crosses to be made. Facilitate selection as per either of the above two approaches.
5. Monitor the progress, follow the participatory varietal selection approach of new lines identified from participatory plant breeding.
6. Facilitate entry of participatory plant breeding lines in formal trial system.
7. Prepare trial system proposal, if success is achieved.

Examples

1. Sthapit (1996) in Nepal tried participatory plant breeding (PPB) with rice farmers. Farmer participation began at F_5 stage and progress was followed for two seasons in villages.

The most preferred material, Machhapuchhre-3 — a new rice bred in high altitude, formally released in Nepal — has performed very well in the formal trial system.

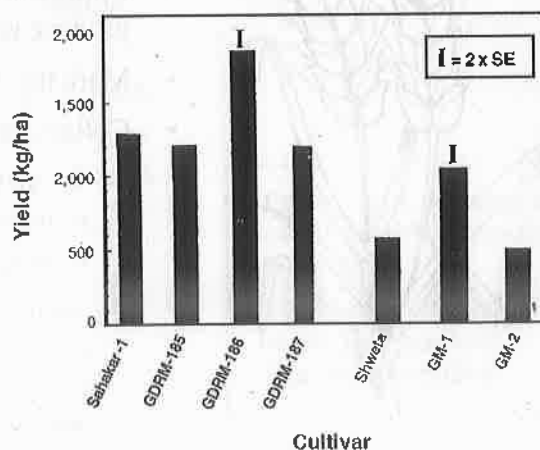
2. Maurya (1988) tried segregating populations on farmers' field and developed further along farmer-preferred lines.

3. Thakur screened F_2 material in farmers' fields but subsequent generations were grown by researchers.
4. Joshi and Witcombe, in collaboration with Dr. S.N. Goyal of Gujarat Agricultural University, have started PPB in maize.

Note

For the Joshi and Witcombe example, the farmers were involved in the selection of parents. Out of six parents, three are locally adopted and developed from local land races while three others are released from elite. Composites were tried in participatory varietal selection in the year 1993-94 in several villages. After the fourth random mating, three experimental lines were isolated, selection is in progress on farmers' field in a number of villages and in stations. These lines would enter into formal final system in the coming season.

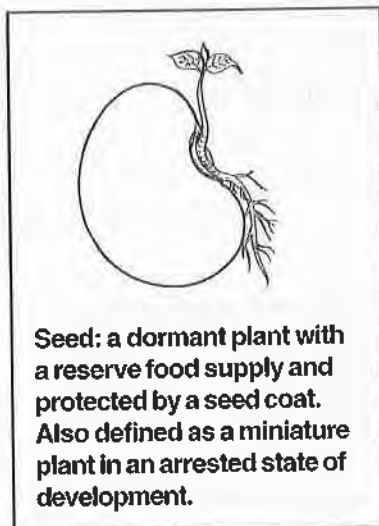
Decentralised plant breeding in maize



Contributors: Arun Joshi and John Witcombe

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Seed management



Modern cultivation methods eroded the indigenous plant genetic resources. Farmers all over the world have produced, stored and used their own seeds and continue to do so even today.

Seeds that have been engineered to produce higher yields (hybrid seeds and high-yielding varieties) are not only more expensive to grow. They are more prone to pest and disease attack and often show a decline in productivity when harvested directly from the fields for seed purposes. Such hybrid seeds are better purchased fresh from seed markets each year. Indigenous or locally-adapted seed varieties have demonstrated greater resilience against many types of stress (moisture stress, pests and diseases) and are less expensive to cultivate. Their yields may be lower, but their cultivation operations can be controlled and managed entirely by the farmer. This also includes seed production.

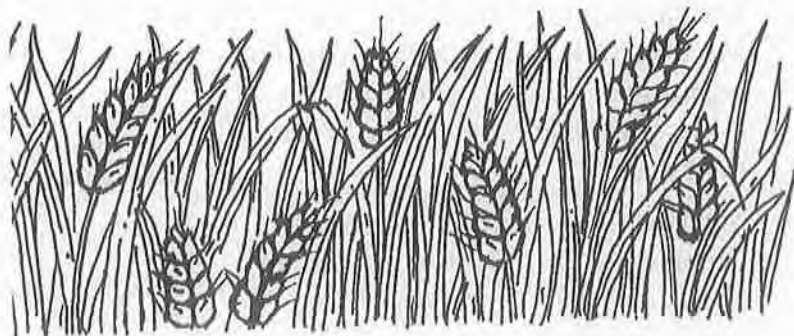
There are many factors that influence a farmer's choice of seed. When an indigenous variety is chosen, a few simple activities can improve seed harvest, processing and viability.

Seed collection for sowing in the next season

- Choose healthy plants just prior to harvest, where the produce appears to be of good size, shape and colour.
- Mark these plants so they are not accidentally harvested.
- Collect seeds when the produce is fully matured.
 - where the seed is in the pulp of the produce (e.g., tomatoes, *brinjal*), pick the fruit when ripe and turning soft.
 - where the seed is synonymous with the produce (e.g., cereals, pulses and oilseeds), dry first on the plant itself (except groundnut), but expose them to rains and/or predators and pick them when fully mature.



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- Collect the seeds on a bright day, after 10:00 am when dew has evaporated.
- Clean the seeds immediately after collection.



- wash seeds that have juice or flesh adhering to them with cold water.
- rub seeds surrounded with mucilage gently using coarse sand and then wash off using a sieve.
- winnow the seeds of dry plant wastes.



- Dry the seeds before storing for future use. Natural drying or sun drying is sufficient in most cases.

- do not dry seeds rapidly under intense sunlight (11:00 am to 2:00 pm) as this will lower germination.
- spread seeds in a thin layer and turn occasionally for uniform drying.
- do not let seeds to come in contact with soil when drying.

- Treat the seeds to protect them from plant diseases, seedrot, seedling blights, storage insects and soil insects using organic or chemical additives. As far as possible, use organic additives over chemical additives.

- The seed is a living organism. Store seeds in a place safe from pests, rodents, mould and microorganisms. Various means of storage are in practice, but the important things to remember are:

- that the container is air tight;
- that the container is moisture proof;
- that the container is rodent- and termite-proof; and
- that the container is in a cool and dark place.

- Wherever possible, label the stored seeds with the plant name, variety name, place of collection, date of collection and the collector's name.



Note

Seeds have dried well when they snap or crack easily when broken.

For every 1% decrease in seed moisture, longevity is doubled.

For every 5% decrease in storage temperature, longevity is doubled.



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Testing seeds for viability before planting

Seeds are of no use unless they germinate well.

Sometimes, seeds are carefully collected, cleaned, dried and stored but when they are sown in the fields, they do not germinate. To avoid losses and resowing after planting, test seed samples for their viability. There are several ways to do this and one of the methods is described below:

Method

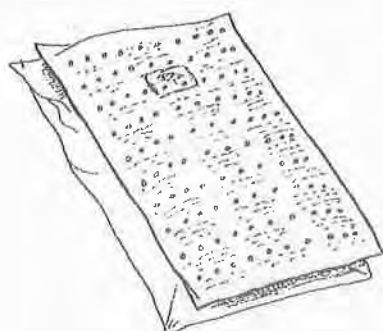
1. Take a sheet of blotting paper or newspaper of a blotting nature.



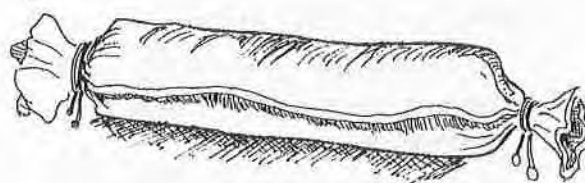
2. Soak the blotting paper in water.
3. Squeeze out the water.



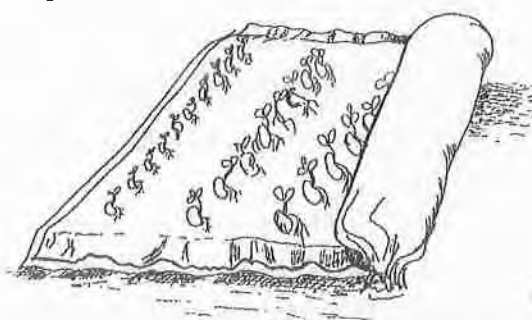
4. Spread the sheet on a polythene sheet of the same size.
5. Count exactly 100 seeds from the batch which viability is being tested.
6. Place these seeds on the wet newspaper in 10 evenly spaced rows, with 10 seeds in each row.



7. Roll or fold the newspaper along with the plastic sheet in such a way that the seeds placed on them maintain the distance between one another.
8. Tie the ends of the folded/rolled newspaper and leave for five days.



9. Unroll the newspaper and count the number of seeds that have germinated.
10. If 80 or more seeds have germinated, then the batch from which the seed sample was taken can be safely sown.
11. If less than 80 seeds have germinated it is better to go for another batch of seeds. If no other seed is available, then retain the batch, but sow more than the normal quantity.



In most field crops, germination takes about five days for every viable seed, including the slowest.

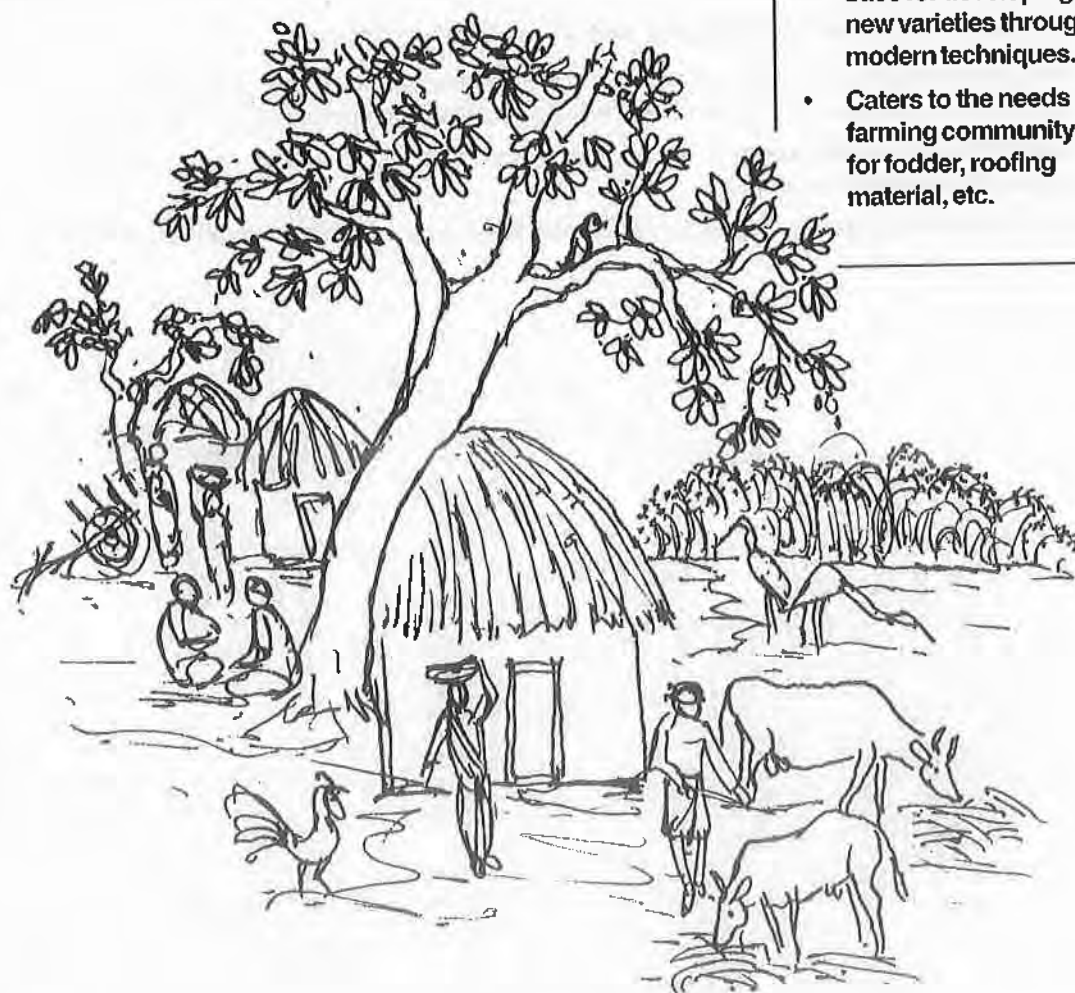
Contributors: Ramachandrappa, Doni and Neelkanth

Role of indigenous seeds in addressing household food security

While high yielding crop varieties have immense importance in ensuring food security, resource-poor farmers, especially those living in marginal lands, find it difficult to cultivate these varieties because of high energy inputs and complex management practices involved in raising such crops. For these farmers, the traditional varieties ensure better food security at household level owing to the hardy nature of these varieties. It is believed that the country is losing biodiversity at a faster rate today than before, owing to the emphasis laid on "yield", to the disadvantage of several other desirable factors. A systematic understanding of the varietal diversity, development, use, storage, treatment and exchange of indigenous/local seeds is, therefore, essential to develop dryland agriculture in general and household food security of resource-poor farmers in particular.

Benefits of conserving indigenous seeds

- Provides resilience against crop failure due to biotic and abiotic stresses.
- Adapts easily to local environment.
- Meets the community preferences for taste, colour, cooking quality, cultural/religious needs, etc.
- Provides the resource base for developing new varieties through modern techniques.
- Caters to the needs of a farming community for fodder, roofing material, etc.



Local practices in seed selection, treatment and preservation

- To separate and select heavy paddy seeds from light ones, farmers follow a local technique called *batlu turudu*, a method similar to casting a net against the wind.
- An innovative farmer in Byrapur village in Northern Karnataka, soaks sunflower seeds in sour butter milk for better germination.
- A farmer in South Kanara district of Karnataka dips cucumber and bean seeds in kerosene before sowing to keep ants away from the seeds.
- In Malanad region (Karnataka), farmers apply ash or "vibhuti" to cardamom seeds to keep ants away.
- Seeds can be preserved in coconut shells after removing the kernel (Coastal districts of Karnataka and Kerala).
- Vegetable seeds are preserved in dried cow dung cakes to enhance viability (Coastal Karnataka).
- Vegetable seeds are preserved in air tight pots/boxes or in cloth bags exposed to kitchen smoke to protect them from insect and pest attacks.
- Pulse crop seeds that are sun-dried for four to five days and kept in gunny bags covered with paddy straw after being mixed with shell pieces of cashew nut (*Anacardium occidentale*) repel storage pests.
- Seeds can be protected from insects and pests using neem leaves, neem oil, leaves of *Vitex negundo* (*Lukky soppu*), barks of *Cinnamon* and *Eucalyptus* as well as dried pepper stalk.

Traditional practice of exchanging seeds and information

- Social gatherings like marriages, festivals and village fairs provide opportunities for exchange of information and experiencing the joy of quality foods prepared with local varieties.
- The bride brings the local seeds to the bridegroom's house after marriage. These seeds are grown in the fields of the couple.
- The Siddhi tribals exchange seeds during *Beemana amavasye* (a local festival) every year.



A bride carrying seeds to the bridegroom's house

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A bride carrying seeds to the bridegroom's house

Traditional methods of seed preservation

The methods of preserving varieties are closely linked to the local customs, religious beliefs, "cultural hobby" and ingenuity of the farmer. For example, a paddy variety *Hallublu* is specially used in Karnataka for housewarming feast. Hundreds of paddy varieties are preserved by devotees to offer worship to Lord Jagannatha in Orissa. Similarly, rural women and tribal communities are known to have preserved, for centuries, hundreds of crop varieties. An innovative farmer in a coastal district of Karnataka has developed and preserved a unique brinjal variety "quintal brinjal", bearing nearly 100 kg of fruits per plant.

Considering the importance of local seeds in conserving biodiversity and in the households' food security of resource poor farmers, a systematic approach should be undertaken for their preservation.

How to protect the intellectual property rights of the farming community?

In the new global climate of patenting and intellectual property rights, the rights of the farming community should be protected and benefits passed on to them for preserving biodiversity. The following measures are suggested:

- Record and systematically document information on indigenous varieties/crops and the farmers who preserve them.
- Maintain community registers for record and documentation at the village level, involving village institutions, students, teachers, *mahila mandals*, youth associations and the like.
- Do "defence patenting" on behalf of indigenous communities by NGOs or governmental organizations to ensure benefits to the entire community.
- Promote networking and access to legal support systems to protect the rights and interests of the farming community.

Suggested conservation measures

- *In situ* conservation, supported by *ex situ* conservation in seed banks.
- Documentation and publication of information and awards to deserving farmers.
- Governmental support.
- Involvement of women in decision-making.
- Participatory breeding involving scientists.

Contributors: Tejaswini and T. N. Prakash

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Home gardening in drylands

Limited to a few short periods of rain, home gardening is an age-old food production system practised by villagers/tribals in their backyards — be it in the plains or in hilly tracts. Home gardens provide a steady, round-the-year supply of fresh fruits, vegetables and herbs. The rich diversity of traditional vegetables and herbs varieties (which is fast disappearing) can be conserved through home gardening. Home gardens ensure food and nutrition security for the family.

Characteristics of a home garden

- **Located near or around home**

Advantages

- Less losses from theft.
- Use of wastewater (not soapy water), kitchen waste, animal manure is maximised.

Disadvantage

- Threat from domestic animals/pets etc.

- **Mainly for own use and based on local inputs**

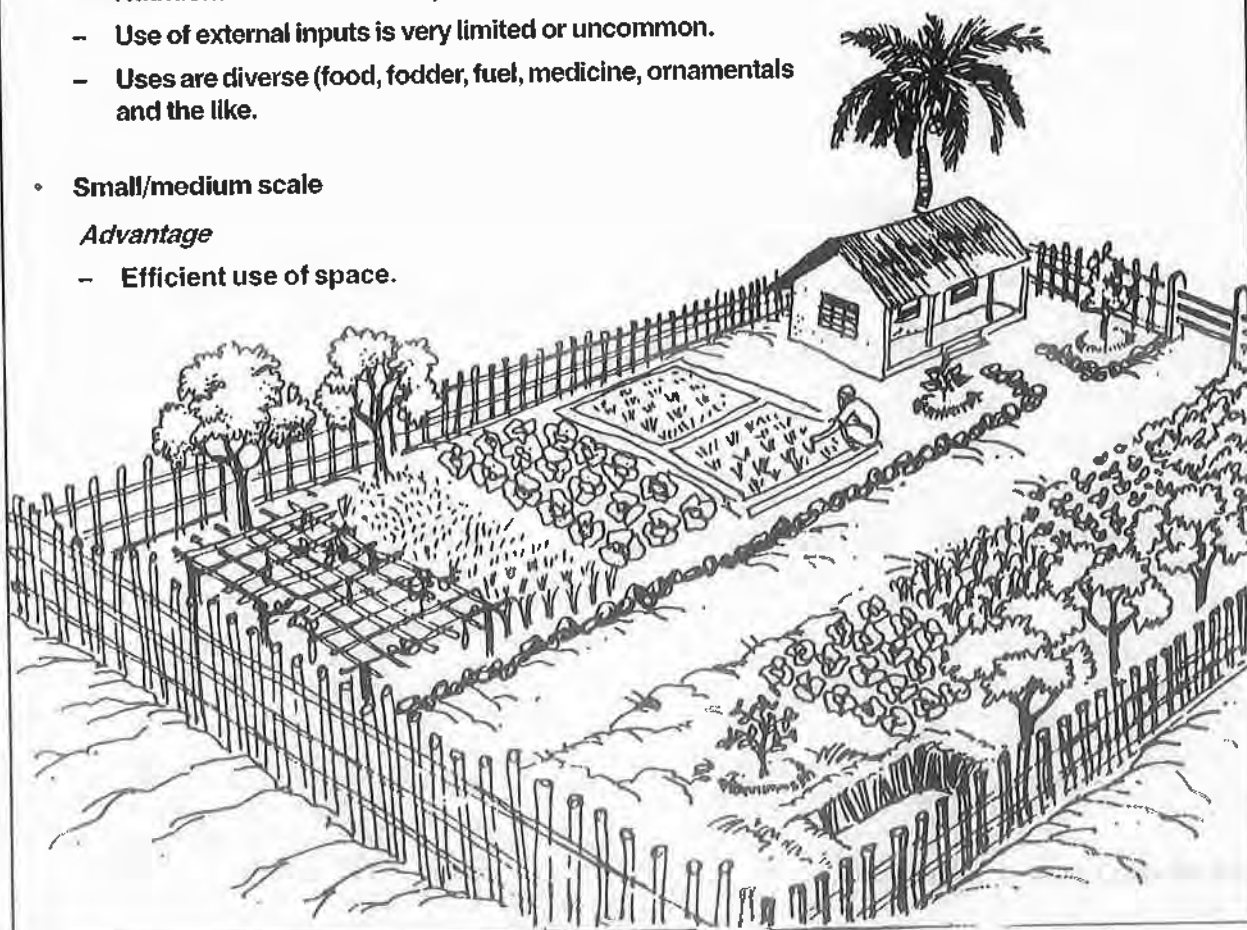
Advantages

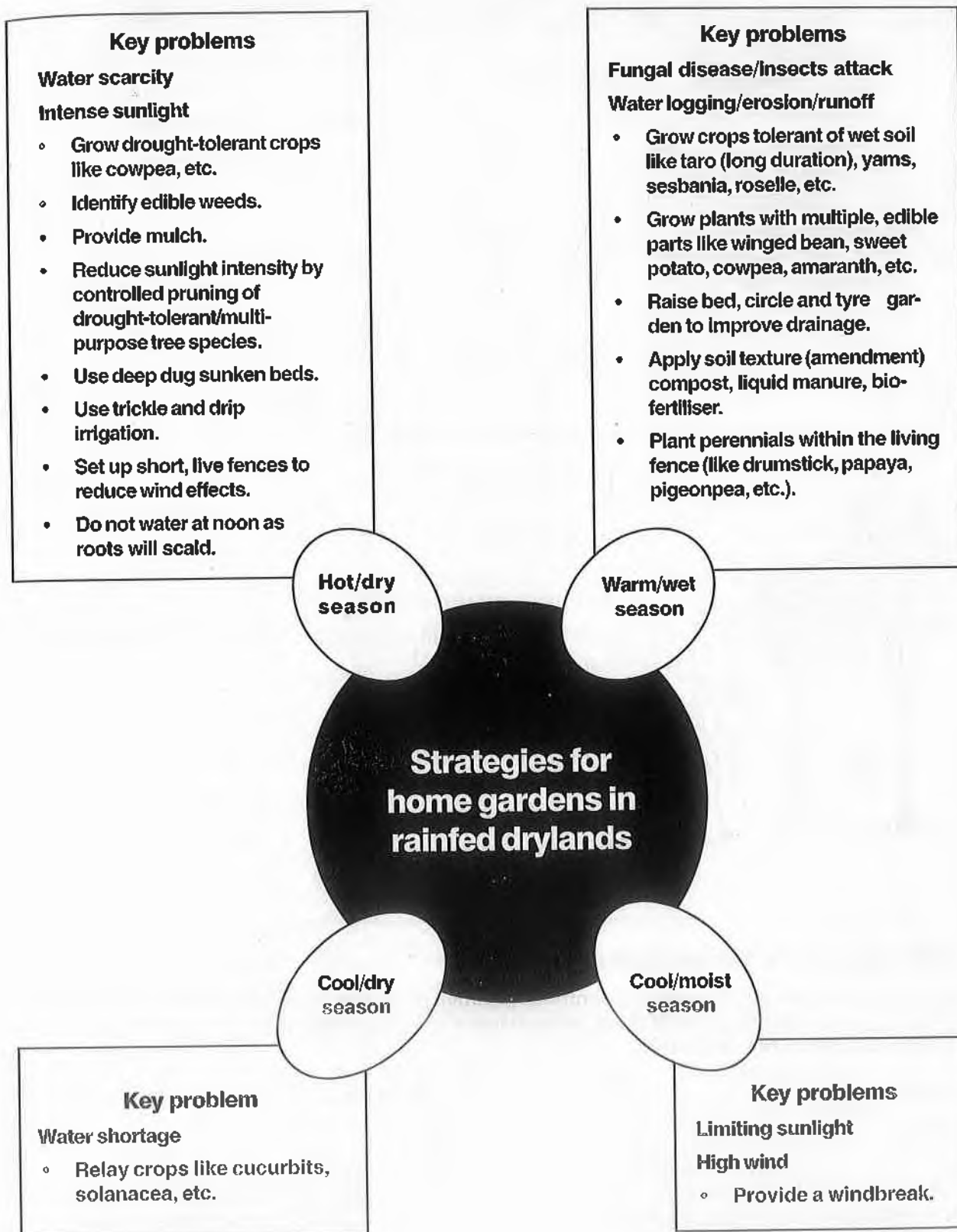
- Nutritional value is more important than market price.
- Use of external inputs is very limited or uncommon.
- Uses are diverse (food, fodder, fuel, medicine, ornamentals and the like).

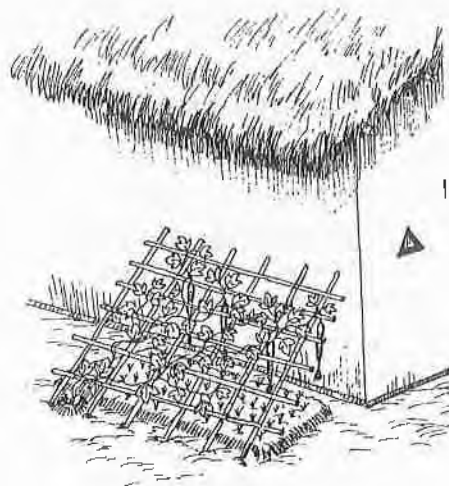
- **Small/medium scale**

Advantage

- Efficient use of space.







Trellis

Trellis are used to use space vertically.

On the trellis

Climbing legumes viz. winged bean, lima bean, etc.

Climbing fruit vegetable viz. gourd, cucumber, etc.

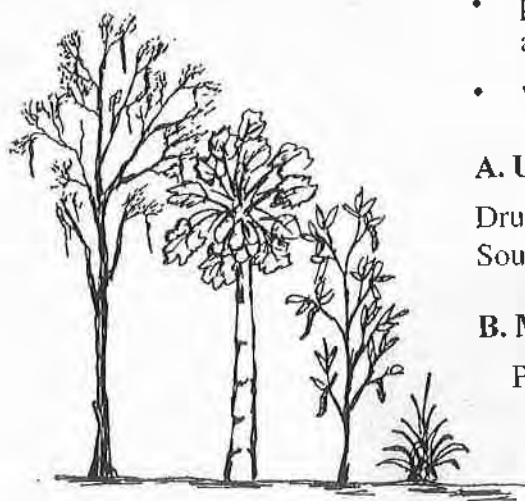
Under the trellis

Sweet potato, tumeric, ginger, amaranth

Live fence

Live fence are for:

- creation of micro climate;
- protection against stray animals;
- windbreak;
- green manure;
- food;
- fuelwood; and
- fodder.



A. Upper canopy species

Drumstick, *Sesbania grandiflora*, *Gliricidia sepium*, Guava, Soursop, Custard apple, etc.

B. Mid canopy species

Papaya, Winged bean, Greater yam, etc.

C. Lower canopy species

Cassava, Pigeonpea, Chili, etc.

Safe homemade bio pesticides

Some safe ingredients are useful in controlling garden pests. The "sprays" described below can all be applied using bunches of grass or small twigs to splash and paint the mixtures on plants. Below are two examples.

Chili extract

Recipe

Grind whole hot (spicy) chili peppers, including the seeds. Seeds contain a concentrated source of capsaicin, the fiery-hot active ingredient in chili sprays. Leave to soak overnight in water the grounded chilis. Soap can also be added to this mixture. Care should be taken as this spray can burn the skin and eyes.

Reported to control: aphids, caterpillars, beetles and other insect pests.

Source: Food from Dryland Gardens, UNICEF and Center for People, Food and Environment.

Garlic extract

Recipe

Crush or grate 100 g garlic and soak for 24 hours in two teaspoons of mustard oil. Add 0.5 litre of water and 10 g of soap. When ready to use, add about 20 litres of water to the mixture.

Reported to control: aphids and some caterpillars and beetles.

Preservation of garden produce is commonly practised in drylands. It is undertaken to meet the lean season requirements. Drying is one of the easiest and most effective ways to preserve garden produce.

Produce	Preparation and drying methods
Leaves: amaranth, other greens, etc.	Whole. Dry on a flat ventilated surface or hang in bunches.
Onions, peppers, tomatoes, okra, eggplants, chillies	Sliced. Dry on a flat ventilated surface (no blanching).
Root crops	Sliced. Dry on a flat ventilated surface (blanch for three minutes).
Cucurbits	Sliced. Dry on a flat ventilated surface or hang in strips (blanch for two minutes).
Dates, grapes, figs	Figs and dates whole or split. Dry on a flat ventilated surface or string; grapes in bunches or singly (no blanching).
Moist fruits: mangoes, bananas, papaya, etc.	Sliced. Dry on a flat well-ventilated surface; turn regularly (no blanching).

Note

Returning migrant labourers bring new varieties of seeds and saplings. They try these out in their home gardens. This is a form of varietal testing which takes place in gardens rather than on the farm itself.

Herbs

Herbs can be grown in the garden (preferably in the fence) to take care of primary health needs.

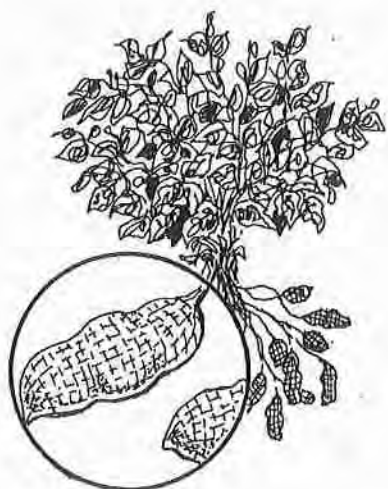
Common name (Botanical name)	Part used	Used for
Neem (<i>Azadirachta indica</i>)	Seed and leaf paste	Skin care
Basak (<i>Adhatoda vasaka</i>)	Leaf extract	Cough and cold
Satamuli (<i>Asparagus racemosus</i>)	Leaf	Stomach problem
Pipal (<i>Piper longum</i>)	Leaf	Cough and cold, common fever
Ghrita Kumari (<i>Aloe vera</i>)	Leaf paste	Cuts and burns
Sajina (<i>Moringa oleifera</i>)	Leaf paste	Cuts and wounds
Pineapple (<i>Ananas comosus</i>)	Leaf extract	Worms

Backyard gardens are the best curators of vegetable and herb germplasm.

Information kit produced by
MYRADA and the International
Institute of Rural Reconstruction

Contributors: Subrata Rana, Rajashakar and Praveen Mehta

Guidelines for groundnut cultivation on red soils in Southern India



Groundnut is the most prevalent cash crop in semi-arid areas of Southern India. It is cultivated by big and small farmers alike because of its income potential. Like any other crop, raising groundnut has its share of problems and therefore, it is necessary to have an overall understanding of the factors that are at play. It is important to consider the socio-economic and ecological dimensions of groundnut production, when any alternative package of practices is considered.

Under rainfed conditions, erratic rainfall and poor soil water retention capacity are the limiting factors. It clearly indicates that appropriate corrective steps are necessary to improve water management and soil organic matter content. On the other hand, under irrigated conditions, poor yields can be improved by introducing proper nutrient, pest and disease management packages.

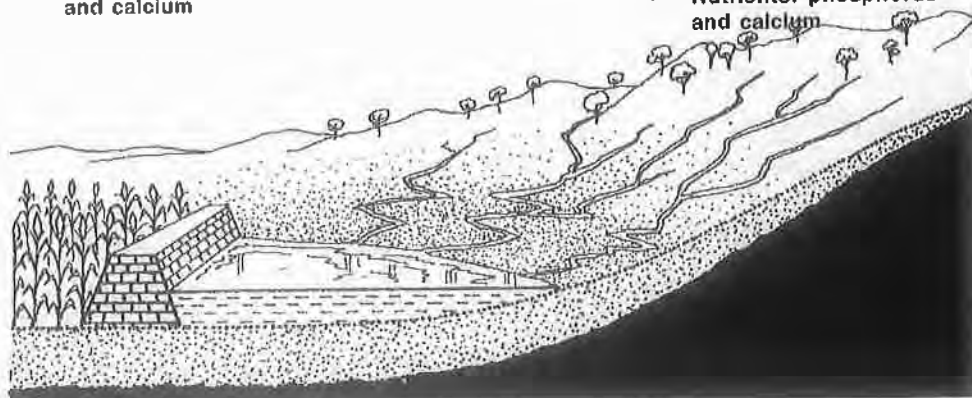
Groundnut cultivation on red soils in Southern India

Soil characteristics

<i>Soil type</i>	Silt loam to clay	Sandy loam to silt loam	Sandy to sandy loam
<i>Depth</i>	>60 cm	>60 cm	30-60 cm
<i>Water holding</i>	15 to 36 days of growth	18 to 30 days of growth	4-18 days of growth

Groundnut production

<i>Yield level</i>	15-20 bags/acre	8-12 bags/acre	3-8 bags/acre
<i>Limiting factors</i>	◦ Jul - Jan: tikka spot ◦ Jan - Jun: Spodoptera ◦ Soil fertility: potassium, micronutrients and calcium	◦ White grub ◦ Tikka spot ◦ Nutrients: phosphorus and calcium	◦ Water availability ◦ Organic matter content ◦ White grub ◦ Tikka spot ◦ Nutrients: phosphorus and calcium



To plant one acre for groundnuts, 40-50 kg of seed is required:

- A well inoculated crop can fix up to 80 kg of nitrogen per acre from day 30 after planting until day 110. Thus, about 1 kg of nitrogen per acre per day is needed.
- A harvest of 1 kg of pods will yield about 1 kg of crop residues (leaves, etc.).
- Groundnut roots develop up to a depth of 60 cm but can reach 120 cm deep.
- For every 900 grams of pods, groundnut will require 1,000 litres of water.
- 1 mm of effective rain means about 4,000 litres of water for an acre.
- Effective rainfall is about 30% of the total rain that falls in the upper reaches of a watershed; in the middle reaches it is about 50% and in the lower reaches it is estimated at 70%.
- In Southern India, rainfall is about 800 mm per season.

Rainfall and risk

1 in 3 years — complete failure (*Cause: uneven rainfall distribution efficiency and poor water retention capacity*)

1 in 4 years — good yield
the other years — average yield

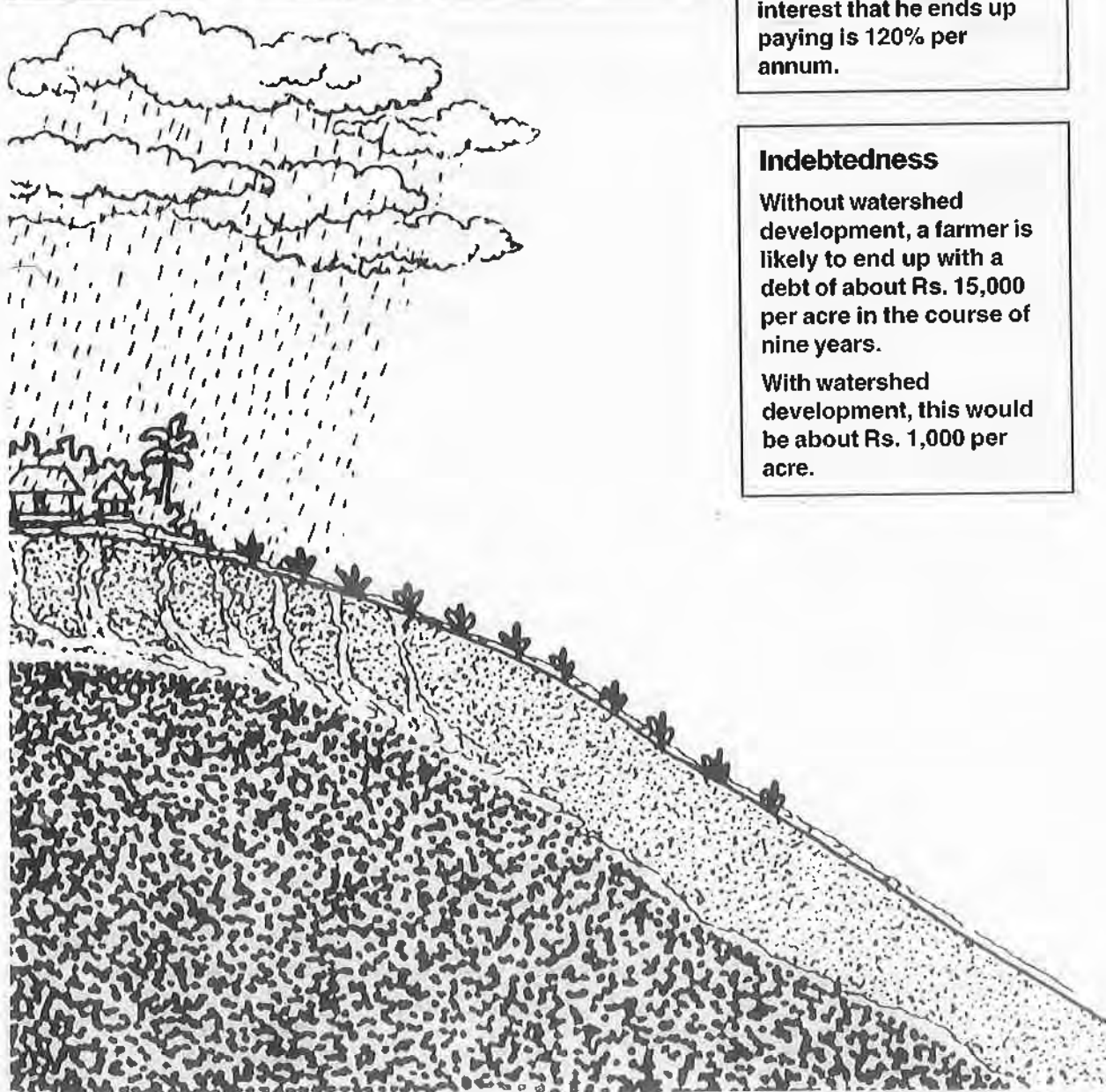
Money-lender's grip

A farmer borrows seeds from money-lenders on the condition that he pays back his dues by selling the produce through the money-lender. The interest that he ends up paying is 120% per annum.

Indebtedness

Without watershed development, a farmer is likely to end up with a debt of about Rs. 15,000 per acre in the course of nine years.

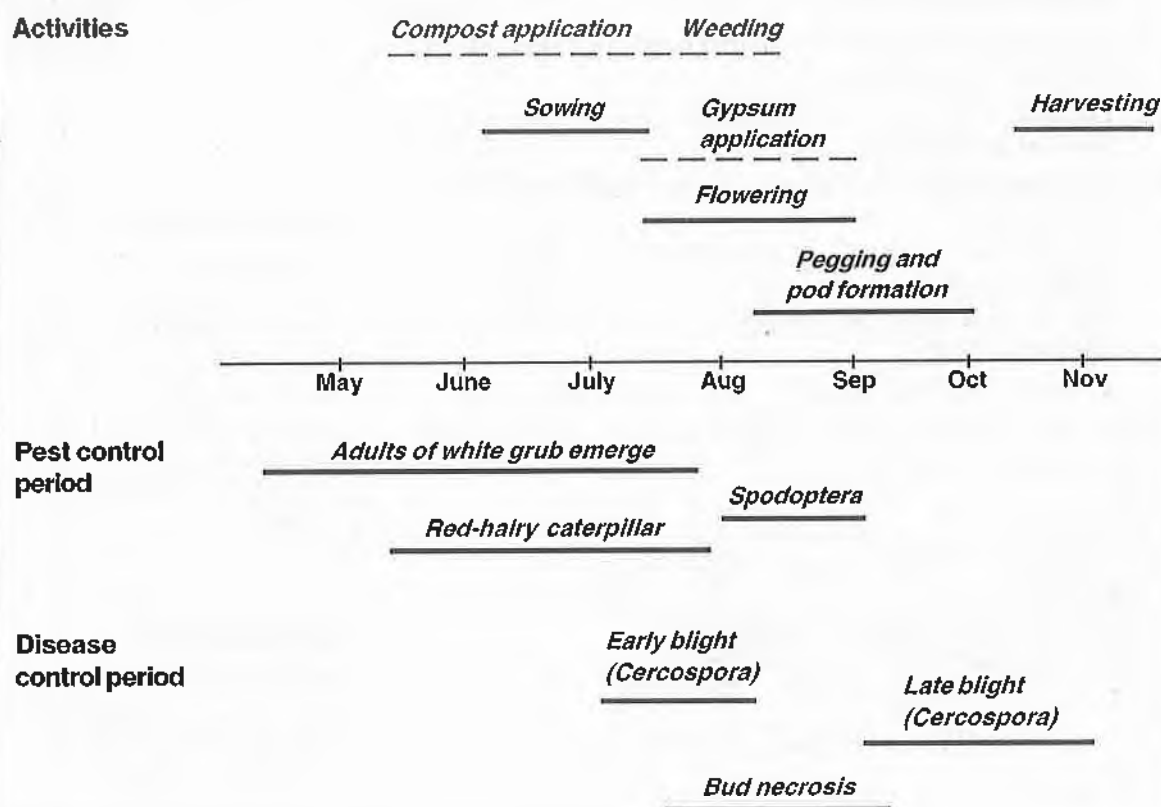
With watershed development, this would be about Rs. 1,000 per acre.



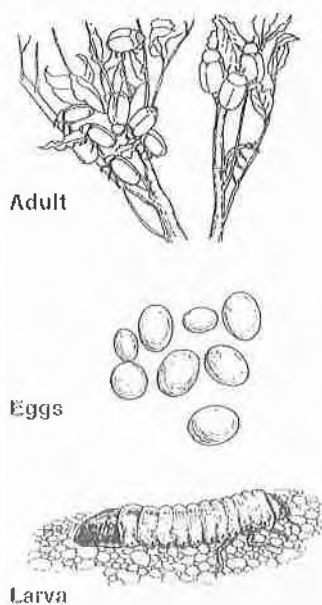
Steps for crop management

The steps farmers have to take in cultivating groundnut are described below.

Timeline of groundnut production



White grub (*Lachnosterna consanguinea*)



Control of white grub

- At the onset of the monsoon, collect branches of neem or any *acacia* species and place them randomly in the field.
- Adult moths emerge in the evening between 7:00 and 10:00 p.m. to feed. Collect the branches and burn them. This method can control white grubs to some extent.
- Also, shake the host trees in and around the field, collect the insects and destroy.
- Repeat this process daily for the first three weeks then reduce it gradually.
- Continue until mid July.
- Alternatively, treat the seeds against white grub by soaking the seed in Chloropyrriphos - 0.6 litres per 100 kg of seeds for 2 acres.



Caution

Methods incompatible with organic pest control methods may kill *Rhizobium* and *Trichoderma*.

Basal dressing

Application of organic matter

- Apply a minimum of two tons FYM (Farmyard Manure) per acre, i.e., 5-6 cartloads of organic matter per acre for each crop.
- If compost is applied, four cartloads would be adequate.
- If vermicompost is used, two cartloads would be sufficient. However, this may be a costly choice.

Nutrient management

- Apply mussoorie phosphate at the rate of 100 kg per acre.
- Mix the mussoorie phosphate with compost or FYM before use.
- Phospho bacteria and VAM (Vesicular Arbuscular Mycorrhizae) are bio-fertilisers needed to mobilise soil phosphorus. These can also be mixed with compost and applied.
- It is recommended to apply about 1 kg of Rhizobium/ Phospho-bacteria mix per acre.
- Apply magnesium along with compost. Magnetite rock from Salem might be a future source of this material; analysis is presently being done by the Agriculture Man Ecology (AME) and field test results will be available in 1998.

All these, i.e. application of compost, mussoorie phosphate, phospho bacteria, VAM, and magnetite form the basal dressing. The compost mixture should be ploughed in **immediately** after application.

Fertility maintenance

For one bag of groundnut pods (40 kg) produced, the total crop will remove some amount of nutrients from the soil if all the leaves are also removed from the field (*see extent of nutrient depletion box*).

After an initial correction of the soil fertility according to what is recommended under basal dressing, replace only the nutrients removed. Thus, the yield of the previous crop determines the quantities to be applied. For each bag of groundnut pods produced, apply 200 kg FYM (about 0.5 cartload), 3 kg mussoorie phosphate and 2 kg gypsum. These would replace the nutrients removed by the crop.

Extent of nutrient depletion

(for one bag of groundnut pods — 40 kg)

N	2.50 kg
P ₂ O ₅	0.55 kg
K ₂ O	1.60 kg
MgO	0.66 kg
CaO	0.40 kg
S	0.06 kg
Zn	0.06 kg
Fe	0.30 kg



Caution

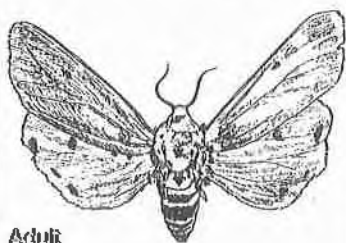
The application rates recommended for gypsum and mussoorie phosphate are difficult to spread over one acre. The cost of mussoorie phosphate is about Rs 2.5 per kg and for gypsum Rs 1.0 per kg. It is recommended to increase the dosage for easier handling and this will not harm the crop.

Note

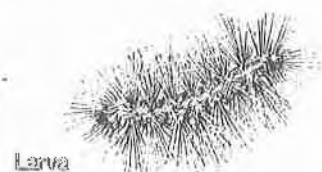
If adequate water and nutrients are available, a crop can have full leaf cover and produce about 80 kg of plant materials (seed + leaves, etc.) per acre per day. So a groundnut variety that can grow for 125 days instead of 95 days could give a higher yield: $30 \times 80 = 2,400$ kg consisting of 1,200 kg pods and 1,200 kg leaves. In reality, it will not be as high as this, because other factors limit growth. But the principle will hold if growth conditions are favourable.

Suggestion: Use longer duration varieties under reliable irrigated conditions, and shorter duration varieties in the upper reaches of the watershed, that probably has shallow and sandy soils.

Red hairy caterpillar
(*Amsacta albistriga*)



Adult



Larva

Crop establishment: July

Seed selection

Use varieties resistant to leaf spot (Tikka or Cercospora) and rust, e.g., ICGV 86325, ICGV 87123, ICGV 87128, 87141. Preferably, the seeds should also have tolerance to *Spodoptera litura*, bud necrosis and stem rot.

Treatment

- Treat the seeds with Rhizobium (for nitrogen fixation) and Trichoderma (to control fungi like stemrot).
- Use at the rate of 250 g of Rhizobium for every 12.5 kg of seed for $\frac{1}{4}$ acre, i.e., 1 kg Rhizobium for 50 kg of seed per acre.
- Use 1 kg of Trichoderma per acre.

Making the mix

(for 50 kg seed or per acre)

- Boil 200 g of jaggery in two litres of water for 10 minutes. Cool at room temperature.
- Add four packets of Rhizobium and 1 kg of Trichoderma to the jaggery solution. Mix well.
- Roll the seeds carefully in the mix.
- Dry in shade for 24 hours and use for planting immediately.

Suggestion: Improved mixture can be tried by adding 10 tablespoonsful of mussoorie phosphate.

Planting

- Plant the seed not deeper than 4-6 cm. Deeper planting can reduce the yield by about 40%.
- Try to establish as close to 1,20,000 plants per acre as possible. Check by counting the number of plants per square meter. This should be close to 30.

Mid-May to Mid-July

Control of red hairy caterpillar

- Control of adults is very important.
- Period of control is between the third week of May and mid July.
- Set up light traps to attract the insects; place basins of water with kerosene beneath the light to collect the insects that get attracted. (Source: Red Hairy Caterpillar ASW & Oxfam [India] Trust, 1993.)

Install 40 W tubelights or 160 W mercury lamps on 4 ft high poles to attract the adults. These fall on the water with kerosene traps placed below. This is possible under irrigated conditions because the farmers have pumpsets to generate electricity. One trap per 20 acres will suffice.

- For dryland (rainfed) conditions, the adults can be trapped by lighting bonfires (using old tires and waste material) in the fields and collecting the insects trapped in the water with kerosene troughs kept nearby.
- Alternatively, place petromax lamps in the field or on the bunds, on top of a small stack of bricks and the insects will be trapped in water basins with kerosene.
- Collect egg masses from the area around the light traps.
- Place branches of Ipomea, Calotropis and Jatropa around the field to attract the young caterpillars. Collect and destroy caterpillars.
- Intercrop with cowpea, castor or sunflower as trap crops, because adults prefer these to groundnuts.
- If these methods do not work, spray with neem oil. Commercial formulations are available from ECOMAX and Fortune.

Pest and disease control: August

Bud necrosis

- Bud necrosis is a virus infection transmitted through a sucking insect, thrips.
- Bud necrosis can be controlled by early planting of groundnut, intercropped with pearl millet (*bajra*).
- Bright blue or yellow sticky traps can be used to attract and control thrips.
- Cultivate resistant varieties.

Spodoptera control

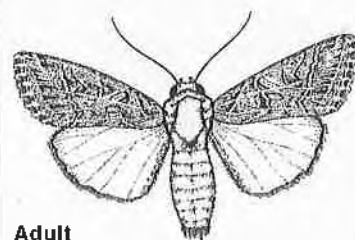
- Intercrop with ladies finger (2:8), castor or sunflower as trap crops, collect and destroy caterpillars — one plant for every 25 m.
- Intercrop with pigeonpea or provide erect perches for predating birds to sit on. Plant pigeonpea in east-west rows to prevent shading.
- Start monitoring measures from 30 days after planting, beginning with the use of pheromone traps, having *Spodoptera*-specific lures.
- Check daily, collect the adults and count.
- Once the trapped insect count reaches 20, start checking for egg masses on top of the leaves.



Caution

- Fuel and labour requirements are high. Burning of tires is not ecologically-friendly.
- Petromax requires pumping to keep up brightness and is easily stolen.

Spodoptera litura



Adult



Egg masses



Larva



Note

Collect 200 larvae, crush them and mix with water. Spray solution on the crops.



Caution

Do not plough under drought conditions and do not come too close to the stems as roots might be damaged.

- Pick affected leaves and burn. If this cannot be done, then release *Trichogramma*.
- Place the egg cards at the rate of 20,000 eggs/acre.
- If the previous measures do not work, spray with neem oil.
- If all these methods fail, use NPV (Nuclear Polyhydrosis Virus). Recommended dosage is 100 units per acre. Three sprayings should be done at weekly intervals.

Gypsum application

Flowering

- Stop weeding when flowering begins.
- Apply 100 kg/acre of gypsum on rainfed lands and 200 kg/acre on irrigated lands.
- If possible, work the gypsum into the soil to a depth of about 5 cm. The most simple way would be through spreading the gypsum and using a bullock-drawn harrow.
- Alternatively, apply by dusting it on the top of the plants, on a dry day. However, gypsum will be less effective when applied like this.

Suggestion: At early pod development, foliar nitrogen applications through diluted cow urine enhance yields as requirement for nitrogen but usually exceed the supply of the same through fixation.

Control of *Cercospora*

Late blight/leaf spot

- Crop rotation is very important in controlling *Cercospora*. Cultivate groundnuts only once in two years.
- *Cercospora* can be avoided by growing the semi-bunch type varieties which are of slightly longer duration.
- Chemical control measures can be taken only after the condition for *Cercospora* growth becomes favourable. This can be measured using a device being tested in ICRISAT.
- Prepare a solution of 3 grams Dithane M45 per litre or Bavistin 100 grams/100 litres (latter is more effective). Spray at the rate of 100 litres/acre for rainfed or 200 litres per acre for irrigated conditions.
- Presently, leaf-extracts are being tested to control *Cercospora*. Hopefully, in 1998 a recommendation can be made.

Information kit produced by
MYRADA and the International
Institute of Rural Reconstruction

Contributors: H. Lanting, Chitra Suresh and K. Ravi

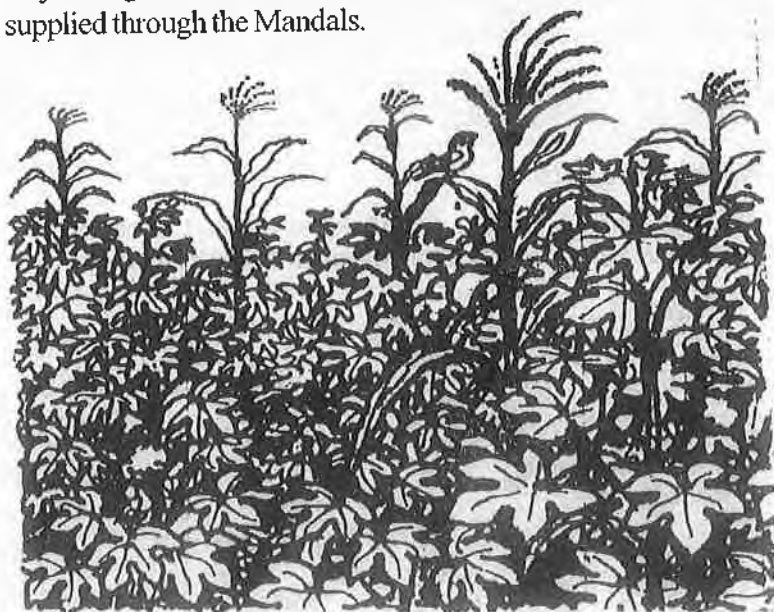
Integrated pest management: The Gujarat experience

Over 75,000 tonnes of chemical pesticides are being used per year. Indiscriminate use of chemical pesticides adversely affects soil health and contaminate the ecosystem. Sometimes, these pesticides even enable pests to develop resistance. Realising the dangers, an eco-friendly integrated pest management (IPM) programme was initiated in 1980. IPM is a farmers' participatory community activity rather than one imposed from outside.

Integrated pest management means the use of different methods to effectively control pests to minimize the loss and optimise the returns from crops. It favours greater use of all eco-friendly practices, like natural pesticides (bio-pesticides), beneficial insects and birds and special cultivation practices. Yet, it does not rule out the use of less harmful chemical pesticides in a complementary role, in critical conditions.

This is the experience of the Aga Khan Rural Support Programme (India) [AKRSP(I)] which is implementing IPM in parts of two rainfed districts — Bharuch and Surendranagar of Gujarat. This deals with particular reference to hybrid cotton crop, the main cash crop in this area, which is pest-susceptible.

Before launching the program, the Gram Vikas Mandals were activated, training programmes conducted through Gujarat Agricultural University, Anand and necessary inputs supplied through the Mandals.



Cotton mix-cropped with maize

Components of IPM

IPM is an integrated approach for effective pest management to save crops. The different components in IPM are:

- use of cultural methods;
- use of mechanical methods;
- use of bio-pesticides and bio-control agents;
- use of avian predators; and
- use of chemical pesticides, in a complementary role.

Area profile

Bharuch district

- Heavy black soils
- Average rainfall: 700-800 mm
- Undulating land
- Predominant tribal population
- Cotton is the main cash crop

Surendranagar district

- Low rainfall area (400-500 mm)
- Traditionally cotton growing area
- Sandy to sandy loam soils
- Cotton is the main cash crop

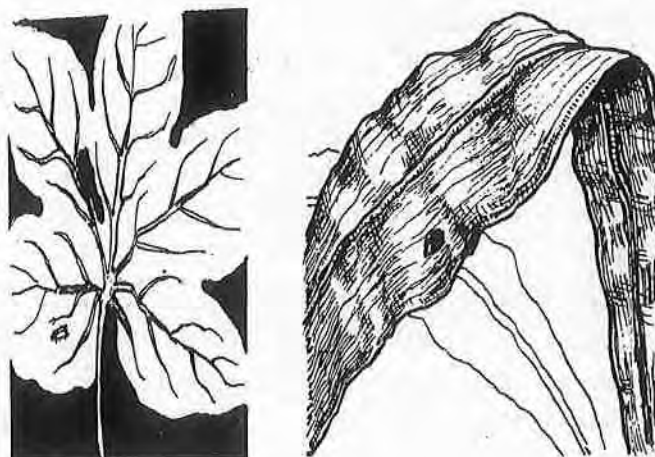
Benefits

- Farmers' participation.
- Community action.
- Eco-friendly.
- Low cost and effective in pest management (40% of cost on cotton production crop goes to chemical pesticides).
- Minimizes pesticide residues in agricultural produce.
- All inputs are made of generally local produce (availability in local markets must be ensured).
- Neem oil is cheap -- as low as Rs. 30/kg in Mahemadavad, Kheda district, Gujarat.

Among the different components of the IPM programme, here are some: cultural method, castor/neem cake, bio pesticides, avian predators and chemical pesticides.

Cultural method

One of the cultural methods is mix cropping of maize. It aims to attract and preserve the natural predators on the field. They prey upon soft-bodied sucking pests like aphids, jassids and white flies. If there are 10 to 20% maize plants mixed with hybrid cotton crop, the mixture helps attract and preserve lady bird beetle and lacewing (*Chrysopa sceletes*). The *Chrysopa* lays eggs on long maize leaves. The larva prey upon the sucking pests and eggs of heliothis. Maize may marginally reduce cotton output but helps save the cotton crop.



How neem works

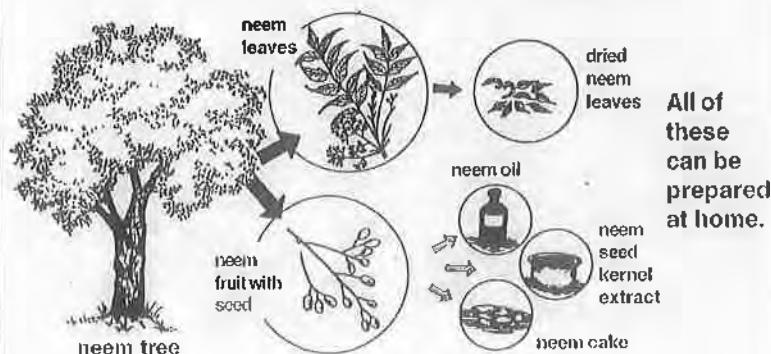
- Neem products such as oil, cake, etc. contain a substance called azadirachtin. This acts on the pests in different ways.
- The substance reduces the egg laying capacity of insects.
- This substance goes into the plant and sucking pests cannot feed on the plants.
- The substance alters the physiology of insects and breaks their life cycle, reducing the spread of pests.
- It causes premature hatching of eggs, which reduces numbers of insects.

Castor/Neem cake

Application of neem/castor cake (600 kg per hectare) in the furrows before sowing cotton seeds is extremely beneficial to control soil pests like termite. This cake is not just a pesticide but also an excellent organic manure.

Neem products

Although most parts of the neem tree can be used, its seeds are the most valuable. The main neem products include:



Bio pesticides

There are two kinds of bio pesticides.

1. **Neem oil.** This is very effective to repel sucking pests and also an ovipositional deterrent against heliothis and spotted boll worm. The bitter taste acts as an antifeedant for larvae in the field. A mixture of 30-35 ml neem oil and 10-15 ml endosulphan in 15 litres water, will be ideal spray on the crop.
2. **Nafatia solution** (*Ipomoea fistula*). This is another bio-pesticide extracted from the leaves of the poisonous hedge plant *nafatia*. About 1,000 leaves in 100 litres of water can be boiled until the water turns milky white. This toxic solution, containing ipomose and anthacin glucoside, controls the larvae of heliothis, spotted boll worm and army worm.



Caution

This solution will have to be sprayed within four days from its preparation.

Preparation of Neem oil emulsion

- Put 30-35 ml of neem oil in a spray tank or bucket.
- Add 10-15 ml of endosulphan and stir well (5-10 g soap powder or caustic soda can also be used).
- Add 15 litres of water and stir until a white creamy liquid is formed.
- The crop should be covered completely and all plants sprayed with this solution.

Avian predators

Bajra is planted near the cotton crop. This attracts rosy pastor birds. Generally arriving in groups in September, these birds damage the *bajra* plants but also prey upon larva of the pests affecting cotton. This saves the cotton crop.

Chemical pesticides

If all these pest control methods fail, it is necessary to use safer chemical pesticides like endosulphan and malathion. They must be used alternately to minimise the development of resistance. Spraying synthetic pyrethroides can be undertaken in acute conditions, after flowering of the crop.

IPM: increasing acceptability (Surendranagar)

IPM Components (kg)	1994		1995		1996	
	Adopters	Quantity	Adopters	Quantity	Adopters	Quantity
Maize	54	25	153	40	180	100
Neem oil	71	125	92	240	153	800
Organic manures	134	11,000	67	10,000	150	41,000

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Contributor: M.S. Vahora

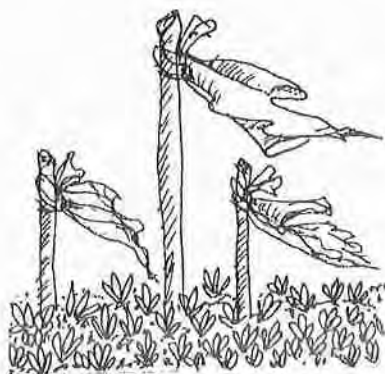
Indigenous ways of protecting crops from birds and wild animals

Scarecrows



Scarecrows, a common sight in planted fields, are useful to scare away birds and animals that would otherwise feed on newly-sown seeds or grains ready for harvest. Farmers usually erect them at the time of sowing and near-harvest time.

Scarecrows are usually made to resemble human figures and can easily be assembled on the fields by farmers themselves. A long pole (6-8 ft) is fixed perpendicular to the ground, at a strategically-visible location. A shorter pole is then tied horizontally across the long pole, towards the top end. A worn-out shirt and trousers stuffed with straw are then draped to the pole structure. An earthen pot is overturned on the top end of the vertical pole and painted with a human face.



Flags

Worn out and coloured lengths of fabric/polyethylene sheets are tied to sticks and placed in several locations on planted fields such that the sheets flap about in the breeze. The colour, movement and sounds made by the flapping sheets scare predatory birds and animals away.

Noisemakers



An example of a popular noisemaker is an empty large tin can (biscuit tin or kerosene tin) strung to a wooden pole structure such that it has free movement in the breeze. A few large stones are placed on the ground around the tin so that whenever the tin sways with the breeze, it strikes one or more of stones, thus producing a noise that scares predators away. A bell hung from a pole also serves the purpose. Several noisemakers can be strategically erected in planted fields.

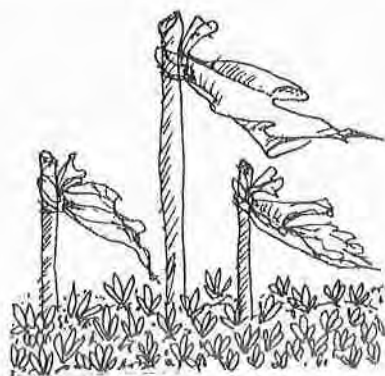
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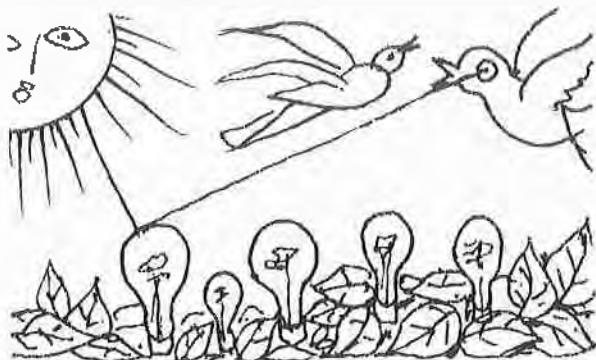
Noisemakers



An example of a popular noisemaker is an empty large tin can (biscuit tin or kerosene tin) strung to a wooden pole structure such that it has free movement in the breeze. A few large stones are placed on the ground around the tin so that whenever the tin sways with the breeze, it strikes one or more of stones, thus producing a noise that scares predators away. A bell hung from a pole also serves the purpose. Several noisemakers can be strategically erected in planted fields.

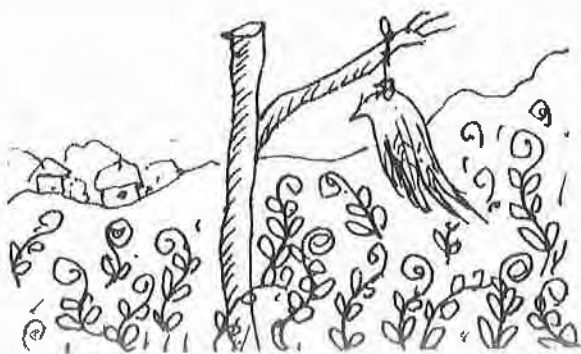
Fused bulbs in nursery beds

Fused electric bulbs planted upright at scattered intervals in nursery beds serve to reflect sunrays that temporarily blind birds and prevent them from homing in on the nurseries to feed on newly-germinated seeds.



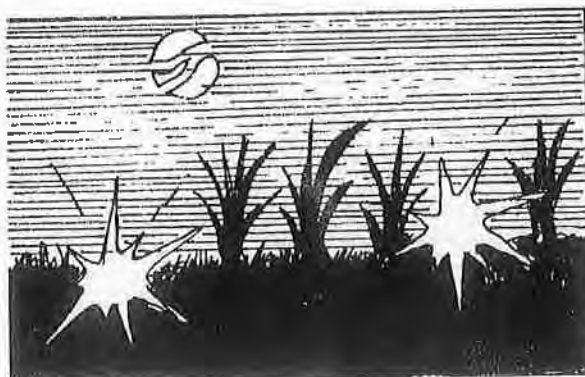
Displaying the remains of dead birds and rodents

Displaying the remains of recently dead birds and rodents at several locations in planted fields deter both birds and rodents from entering the fields.



Fires and crackers

Where larger wild animals are a major problem, e.g., in fields bordering forest areas, farmers follow a relay system to keep vigil on the planted fields. They also take the additional precaution of lighting small fires on the field boundaries, flashing torchlight and bursting fire crackers at random intervals to keep predators away.



Note

The indigenous practices described here lessen but do not entirely prevent damage to crops from birds and wild animals.

Change strategies and/or use the various methods in varying combination or else the birds and animals learn to figure them out and are no longer scared.

*Information kit produced by
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Contributor: Naganna

4 Soil management

1000-1000-1000

4

Integrated nutrient management for dryland agriculture

Need for integrated nutrient management (INM)

- Use of mineral (chemical) fertilisers is the surest and quickest way to increase crop production.
- The high cost, unavailability and risks associated with fertilisers deter farmers from using them in recommended and balanced proportions.
- INM is essential to maintain soil fertility and increase food production without harming the environment.

Sources of nutrients for crop production

- Soil organic matter.
- Soil reserves.
- Biological nitrogen fixation (BNF)
- Organic manures.
- Mineral fertilisers.
- Precipitation and irrigation water.

INM strategy

- The INM strategy includes maintenance or adjustment of soil fertility and plant nutrient supply to sustain the desired level of crop productivity.
- INM is a holistic system approach focusing on the cropping system rather than on individual crop.
- INM also focuses on the farming system rather than on individual field.
- It does not preclude the use of mineral fertilisers.
- It relies heavily on optimal use of renewable nutrient sources such as BNF and organic manures and minimal use of mineral fertilisers.

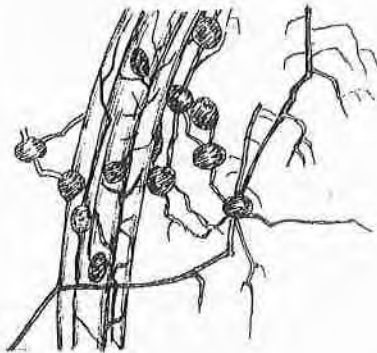
Do you know that?

- Annual growth rate of population in India is 1.8%.
- Population pressure on arable land in India has doubled from 3 persons/ha in 1950 to 6 persons/ha in 1996.
- Plants require at least 13 elements for their growth and development.
- A cereal crop absorbs 35-46 kg N+P+K to produce 1 tonne of grain.
- A grain legume (e.g., soybean) absorbs 210 kg N+P+K to produce 1 tonne of grain.
- Total BNF is about 175 million tonne/year; of this, about 80% is accounted for through terrestrial fixation.
- Out of 17,000 legume species, only 200 are being exploited by human beings.
- Grain legumes fix up to 450 kg N/ha/year.
- All nitrogen requirements of grain legumes are not fulfilled through BNF alone.
- Application of 12.5 tonnes/ha farm-yard manure or compost in India increases average yields of different crops by 160-200 kg/ha.

Biological inputs for nutrient management

Biological process

- Several microorganisms in the soil decompose plant and animal residues.
- Microorganisms regulate nutrient flow in the soil by assimilating nutrients and producing soil biomass (immobilisation) and converting carbon, nitrogen, phosphorus and sulphur to mineral forms (mineralisation).
- Several groups of microorganisms are involved in important biological processes.



VAM

Beneficial microorganisms

- Symbiotic nitrogen fixers — symbiotic partnership between bacteria (*Rhizobium/Bradyrhizobium*) and legumes contributes substantially (up to 450 kg/ha/yr) to total BNF.
- Non-symbiotic and associative nitrogen fixers — inoculation with bacteria (*Azotobacter* and *Azospirillum*) reduces N requirement of cereals or non-legume crops up to 20 kg/ha.
- Plant growth promoting rhizobacteria (PGPR) — these improve plant growth through hormonal effects and reduce disease severity.
- Phosphate solubilising microorganisms — these bacteria and fungi solubilise inorganic phosphates and make them available to plants in usable form.
- Vesicular-arbuscular mycorrhizae (VAM) — these help increased uptake of nutrients such as P, S, Cu, etc. and improve plant growth.

Advantages of BNF

- An economically attractive and ecologically-sound process.
- Reduces external nitrogen inputs.
- Improves the quality and quantity of internal resources of nitrogen.

BNF

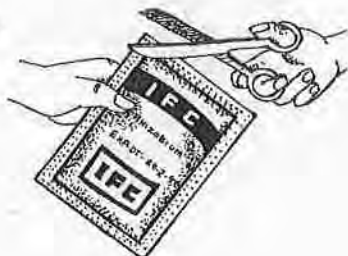
- BNF is an integral part of nitrogen cycling in nature.
- *Rhizobium* inoculation is practised to ensure adequate nitrogen nutrition of legumes instead of fertiliser nitrogen.
- Efficient strains of *Rhizobium/Bradyrhizobium* supplied as inoculants are used as biofertilisers by seed or soil inoculation.

Use of biofertiliser by seed inoculation

- Different crops require different rhizobia.
- Select the right type of biofertiliser (inoculant).
- The inoculant must be fresh and within the expiry date limit.
- Use well-tested inoculants produced by reputable manufacturers.

- Users in India must insist on inoculants with ISI mark.
- Prepare inoculum slurry using a sticking agent such as jaggery, rice porridge, gum arabic, etc.
- Mix seeds with inoculum slurry by hand.
- Dry seeds on a plastic sheet kept under a shade.
- Sow seeds within 48 hours after inoculation.
- Cost of biofertilisers varies from Rs. 20 - Rs. 80 per hectare.

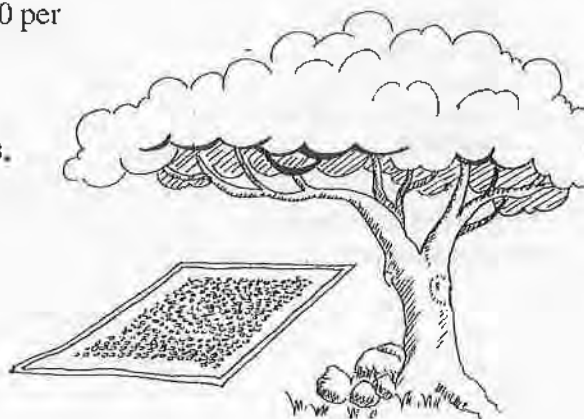
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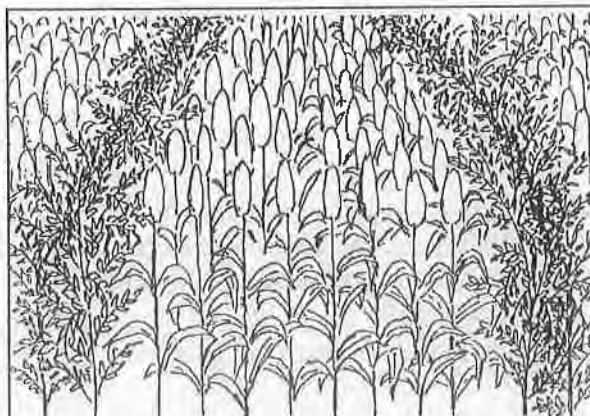
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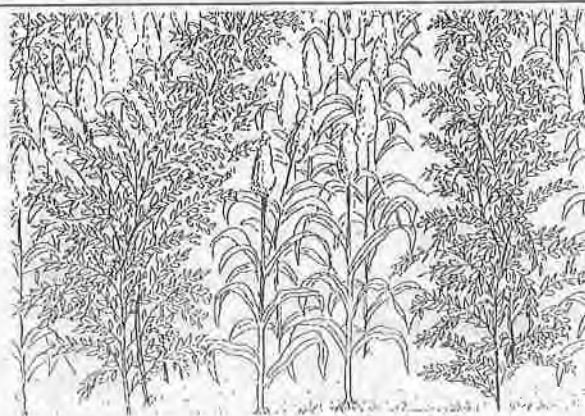
Management practices to improve plant growth and BNF in soil

- Use high nitrogen-fixing crops/varieties.
- Practice mixed cropping and intercropping (row and strip) with legumes.
- Use appropriate tillage practices, landform treatments and nutrient amendments.

Legumes, grown in rotation or as intercrops, increase crops yields of succeeding non-legume crop by 0.5 to 3 tonnes/ha saving up to 120 kg N/ha compared to sequential cropping of non-legume crops.



Row intercropping



Strip intercropping

Advantages

- Increases biological activity in the soil.
- Reduces nitrogen losses through immobilisation.
- Improves the performance of microorganisms such as azotobacters, azosporilla, PGPR and VAM
- Improves soil fertility, soil productivity and crop productivity.

Organic inputs for nutrient management

- Addition of organic matter to the soil is essential to maintain soil fertility and productivity.
- Organic manures are of two types: **bulky** — FYM, composts (rural and town), crop residues; and **concentrated** — oilcakes, poultry manure, slaughter house waste, etc.
- FYM is the most commonly used organic manure in India, particularly for high value crops. It is prepared from animal-shed wastes and straw and contains 0.5-1.0% N, 0.05-0.07% P and 0.03-0.035% K.
- Crop residues can be recycled by composting, mulching and direct incorporation. About 240 million t yr⁻¹ straw/stover is produced from rice, wheat, sorghum, pearl millet and maize.
- Based on N content, organic manures are less efficient than mineral fertilisers; however, combined use of these nutrient sources is superior than using mineral fertiliser alone.
- A combination of crop residue restitution (based on the availability), fallowing or green manuring can be used to maintain organic matter levels in the soil.

Mineral fertilisers

- Use appropriate mineral fertilisers to meet the demand for necessary nutrients.
- Ensure that efficiency of applied fertilisers is optimised through adoption of suitable practices.

Fertiliser application

- Form or type — as recommended for the crop.
- Method — furrow placement and covering with soil instead of broadcasting.
- Time — Split N doses instead of one application.
- Quantity — just sufficient to meet plant demand without adversely affecting BNF.

Implementation of INM

- The knowledge available about different sources of nutrients such as BNF, organic manures and mineral fertilisers can be used to develop a suitable strategy for INM to sustain crop productivity.
- INM strategy is realistic, attractive, and environment-friendly.
- INM will enhance the efficiency of biological, organic and mineral inputs for sustaining productivity of dryland soils.

- India is the fourth largest fertiliser user in the world.
- Fertilisers account for less than one fourth of the nutrients absorbed by the crop.

Contributor: S. P. Wani

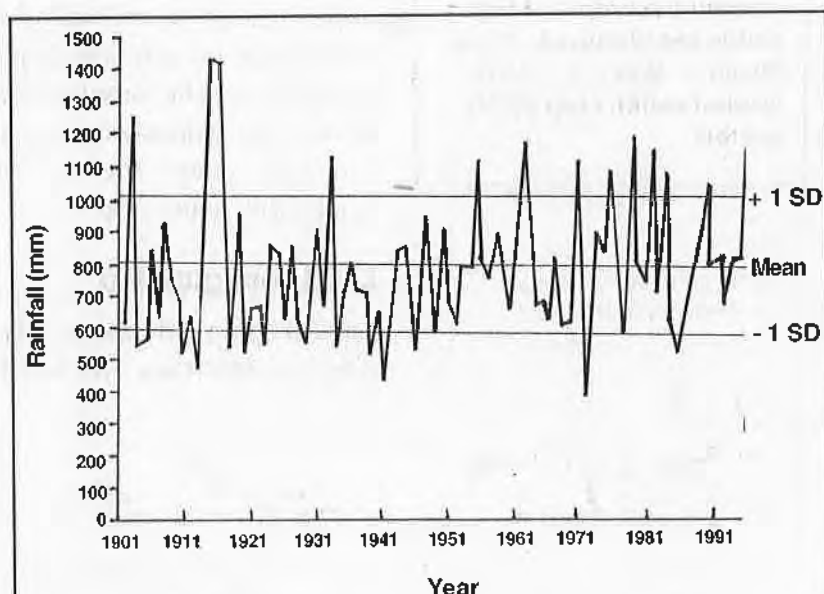
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Management of deep Vertisols for increased production in India's semi-arid tropics

Of 250 million ha of Vertisols in the world, 70 million ha are located in India. Only 12 million ha are deep Vertisols located in Central India.

Substantial Vertisol (black soil) areas are in Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu. Rainfall is uncertain and variable in these areas, typical of the semi-arid tropics. Therefore, water is the most critical limiting factor in crop production. Annual rainfall is 500-1300 mm received in 3-4 rainy months interspersed with droughts. Crop yields are low and vary from year to year.

Variability of annual rainfall in Hyderabad, Andhra Pradesh



Rainfall fluctuations cannot be controlled. But rainwater availability to crops can be enhanced with better management practices.

Note

Deep Vertisols are 1 m deep and are very productive soils.

Attributes of Vertisols

- Heavy soils.
- High clay content.
- High moisture storage capacity.
- Very hard and cracked and cannot be ploughed when dry.
- Very sticky and cannot be ploughed when wet.
- Deficient in plant nutrients, particularly nitrogen, phosphorus and zinc.

Annual yields

Annual yields (kg/ha) from farmers' fields on Vertisols in peninsular India are low:

sorghum (<i>jowar</i>)	500-900
wheat	300-700
chickpea (Bengal gram)	200-500
safflower	300-500
chillies	200-700

Yield-soil depth relationship

If soil depth is 1 m or more (i.e., in moderately eroded soils), the water-storage capacity is enough to sustain the crop and high yields are obtained. If it is 50 cm or less (i.e., highly eroded soils), crop yields are low.

Traditional practices

Soil management

Deep Vertisols are usually fallowed during rainy season and frequent cultivation by a blade harrow is done primarily to control weeds. Crops are grown during post rainy season on stored soil moisture.

Weed management

In low production systems, repeated cultivation is carried out during fallow period to control weeds.

Components of the improved technology

Land and water management

Improved practices have been developed to alleviate physical constraints of Vertisols and promote the intake of water, improve aeration and workability, reduce soil erosion and runoff and facilitate safe disposal of excess water. Runoff utilisation can be improved by constructing a water storage device. The watershed is the most efficient water conservation and reuse system. The improved practices enhance moisture availability to the crop.

Land configuration

Land shaping reduces runoff. The land should be rough with ridges and furrows. This facilitates ponding of rain water.



Dry season tillage

Primary tillage operations are carried out soon after harvest of post rainy season crops to loosen the soil. During summer, the clods formed gradually disintegrate due to pre-monsoon rains. The clods are easily shattered by blade harrowing soon after the pre-monsoon rains.

Dry sowing ahead of rainy season

Crops are planted in the dry soil just before the onset of monsoon rains to ensure early establishment and avoid inconvenience and difficulty of planting in the wet, sticky soil. Often, the seed is coated with dry insecticide and placed 5 cm deep in the soil. Good stands can be established by dry seeding of crops like mung bean (green gram), sunflower, maize, sorghum and pigeonpea (red gram). But crop establishment is poor in pearl millet (*bajra*), soybean and groundnut.

Improved cropping systems

Crop yields can be increased and high returns be obtained by using improved cropping systems. Crop growth occurs from the beginning of the rainy season well into the post rainy season, while soil moisture is available. Such systems are best suited in areas where annual rainfall is moderately favourable and dependable (>750 mm).

Fertility management

Crop response to nitrogen fertilisation is much higher than with any other nutrient, particularly when fertilisers are applied during the rainy season. For cereals, 15-20 kg per ha is recommended.

Pest management

The recommended integrated pest management practices should be applied to maintain low cost and environmental quality.

Advantages of improved technology

- Yields 3-4 times more than the traditional systems.

Average yield of most crops in traditional systems is 1 tonne/ha whereas in improved systems, it is 4 tonnes/ha.

- Effective soil conservation and reduced pollution in low-lying areas.
- Increase in family employment opportunities, both for men and women.

The improved technology increases employment from about 90 to 200 person-days on a small farm of 2 ha.

- Conserving water in small tanks increases the water table and availability of water for household use.

At the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru in Andhra Pradesh, the intercropping of a short- and long-season crop or sequential cropping of two short-season crops has been found most suitable. A number of crops can be fitted into these basic systems: pigeonpea can be intercropped with maize, sorghum, cowpea, sesame, and sunflower. In the sequential system, maize, sorghum or soybean can be followed by wheat, chickpea, safflower or post rainy-season sorghum.

Important pest management practices

- Weed control — hand weeding.
- Insect control — use pesticides only when a threshold of pests is built up.

Contributor: S. M. Virmani

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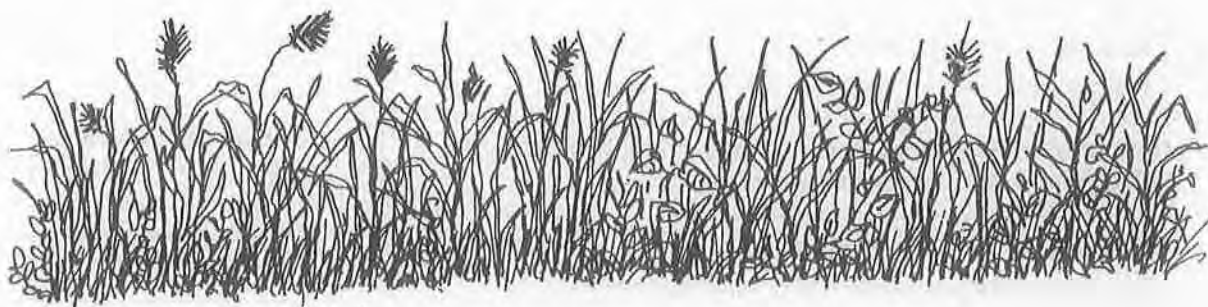
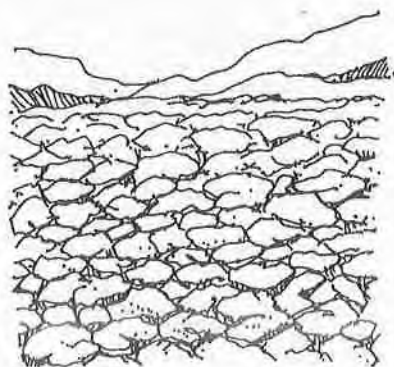
Management of deep Alfisols for increased production in India's semi-arid tropics

What are Alfisols?

- Alfisols are red soils derived from rocks—granite and gneiss.
- Alfisols comprise more than 100 million ha in India.
- These soils are found mostly in the semi-arid tropics of South India.
- Annual rainfall in this region varies from 500-1000 mm.
- Soil depth varies from a few cm to as deep as 2-3 m.
- Rainfall distribution during the growing season is more important than total rainfall in these regions.
- Cropping in rainy season is predominant under rainfed conditions.

Problems in Alfisols

- Crusting on drying
- High erodability
- Shallow soils with low moisture retention
- Low organic matter
- Phosphorus (P) deficiency; in some areas zinc, sulphur and calcium deficiency
- Low cation exchange capacity
- Neutral (pH 6.5 to 7.5)
- Saline-alkali under impeded drainage
- High evaporation



Current practices in Alfisols

- One or two seasonal and shallow ploughing along the land slope and fallow for more than six months.
- Delayed sowing using long-duration crop varieties (including non-responsive local landraces); the plants suffer from moisture stress due to intermittent drought and early withdrawal of monsoon.
- Broadcasting with high seed rate; inadequate cultural practices; untimely and imbalanced nutrient application.
- Uncontrolled off-season grazing.

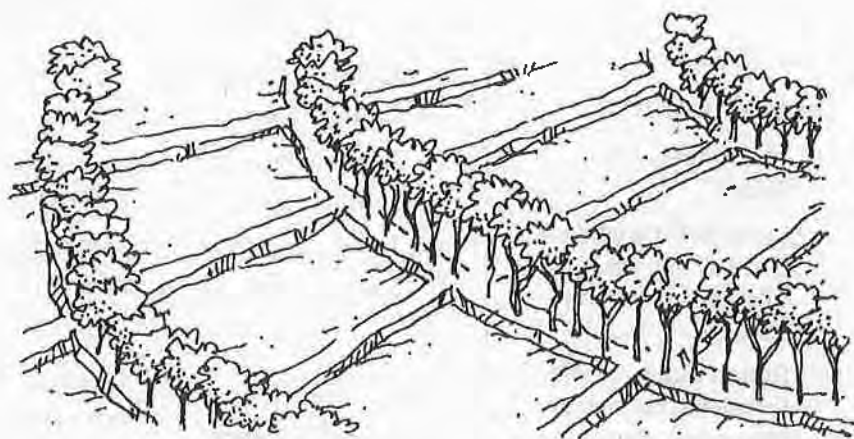
Implications

- Increases soil erosion
- Reduces crop yields
- Leads to low economic returns
- Affects ground flora and crop residues

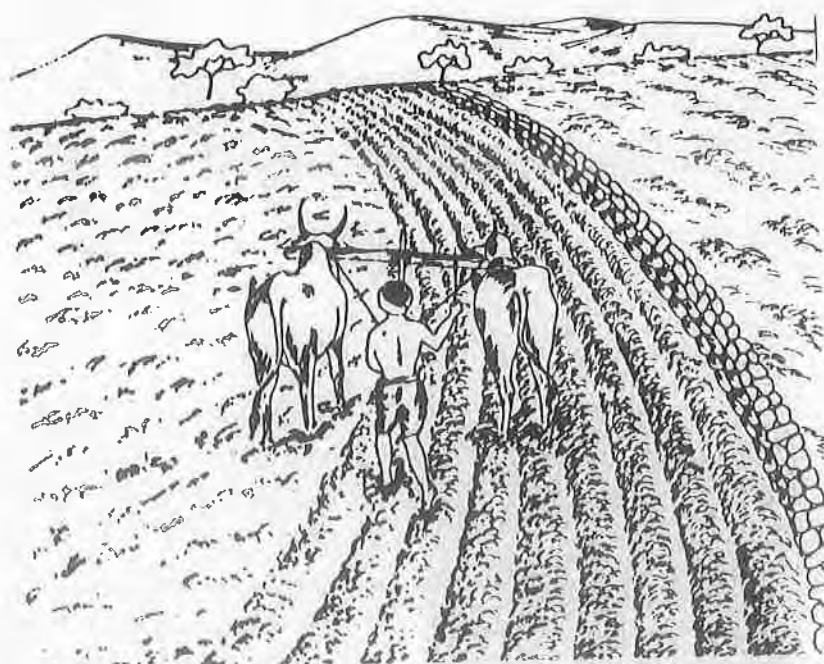
Components of the improved technology

Land and water management

- Realigning and strengthening the existing field/ boundary bunds with vegetative cover is essential.



- Graded bunds (0.2 - 0.4%) with 0.35 sq m cross section are made at a vertical interval of 0.5 m for lands having 3 - 5% slopes and at a vertical interval of 1 m for lands having slopes less than 3%.

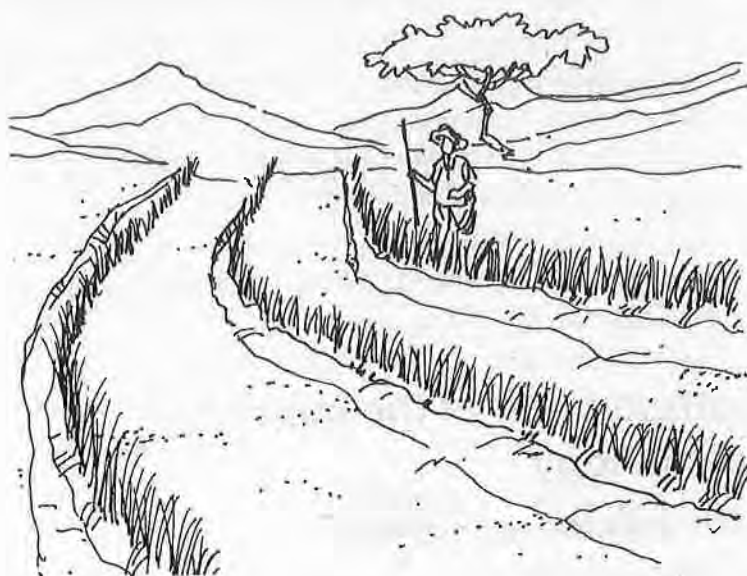




Note

Strips should be 10 - 12 m wide and up to 120 m long for uniform moisture conservation.

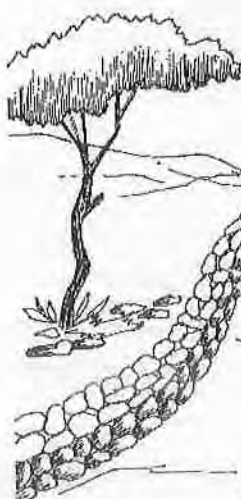
- Vegetative filter strips on contours at a vertical interval of 0.5 m are used as a key line for all tillage operations.



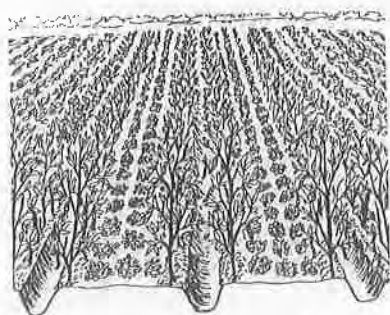
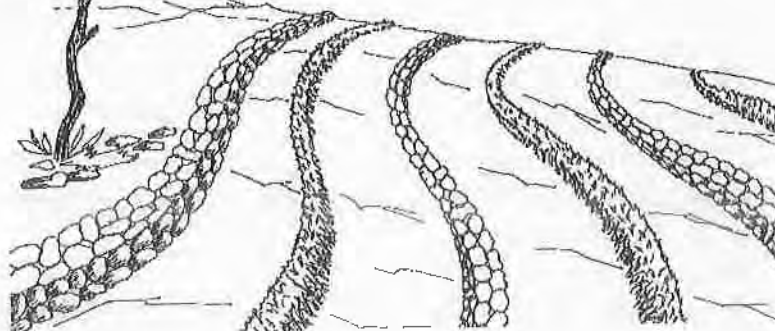
Dug-out pond

- Storage capacity — 250 m³
- Lined with 1:8 cement and soil of 5 cm thickness to reduce seepage
- Stored water — used for raising nursery of high-value vegetable crops, aquaculture, etc.

- Deep (> 90 cm) soils are levelled into graded border strips to minimise run-off.
- Waterways and field outlets stabilised with vegetation; promotes safe disposal of excess run-off.
- Rainwater is conserved by summer tillage and pre-monsoon ploughing, preferably with mould board plough.



- Contour tillage and seeding is more advantageous in slopy lands than the traditional practice at no extra cost.



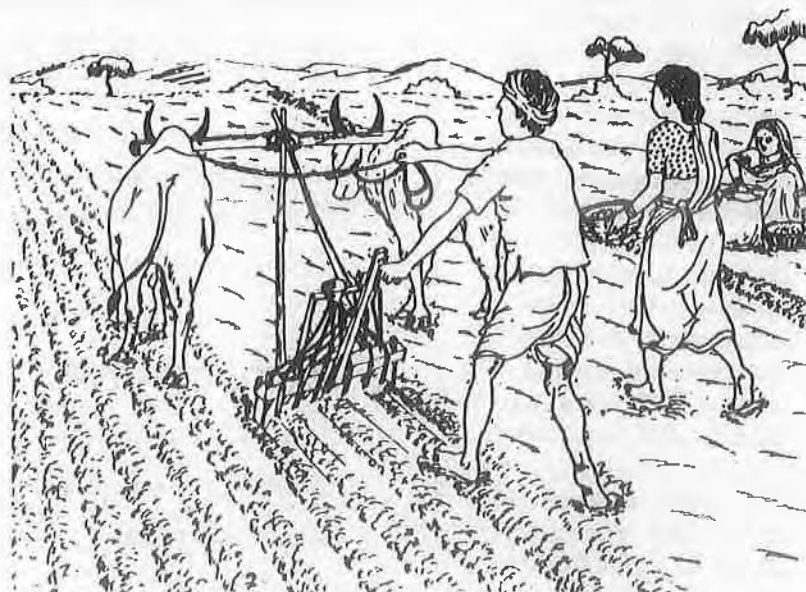
- Dead furrows are opened at two-seed drill width (3.3 m interval) on a grade of 0.2-0.4% for water conservation as well as for effective water disposal system during heavy rains.
- Surplus run-off from a catchment of one hectare having 25-30% runoff is collected in a dug-out pond. The silt is removed from the pond when dry.

Crop management

- In dryland areas, the cropping season is adjusted and adopted to coincide with safe period of rainfall. This period is selected depending upon the amount and distribution of rainfall and retention capacity of the soil. Sequential or intercropping systems are used.
- Double cropping (using suitable crops/varieties and timely management operations) can be used in areas with medium to deep soils and bimodal rainfall of five to six months.
- For crop establishment later than normal sowing (e.g., finger millet (*ragi*), seedlings should be transplanted instead of direct seeding to maintain yield levels.
- When soil fertility is low, traditional intercrops such as fodder, sorghum (*jowar*), castor, niger, etc. can be sown between the main crop to improve soil fertility level.

Fertility management

- Crop yields can be increased by applying phosphates.
- When soil moisture is adequate, apply P and K as basal doses whereas apply N at least in two splits.
- Application of lime in crops such as groundnut, cowpea and sunflower is essential. These crops respond to calcium as well as sulphur.
- Incorporation of crop residues at 4 tonnes/ha/year into the soil helps improve the physical characteristics and water retention capacity of the soil as well as crop yields.
- Application of fertilisers in bands is superior to broadcasting. A seed-cum-fertiliser drill is used for band placement.
- Mussoriephos® and bio-culture are beneficial as they reduce net cost and increase crop yields and soil phosphorus.
- Micronutrient application is essential for some crops such as soybean.



Recommendations

- In areas with four to five months rainfall, intercropping or mixed cropping with pigeonpea is recommended.
- Pigeonpea is sown early as it is initially a slow grower.



Caution

Incorporation of crop residues encourages termites; control of termites is essential.

Contributors: A. M. Krishnappa, P. Ramanagowda, and B. R. Hegde

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Control of salinity and sodicity

This technology is of particular relevance to dryland areas where facilities for irrigation are available. For areas dependent entirely on rains, cultivation of tolerant plant species is recommended.

Drainage of saline soils

For drainage of saline soils, perforated PVC pipes are laid out in the fields as laterals at 1.5 m depth maintaining a distance from one lateral to another of about 65 m. Fields are levelled. Good quality canal water is applied for leaching. About 50 cm depth of water can leach about 100 cm deep saline soil. Leaching water, laden with salts, moves into the laterals which is collected by bigger pipes called collectors. The water from collectors is received in sumps from where it is disposed off to safe places like seas and rivers. After a few years, the quality of the drain water improves and can be used for irrigation, especially in light textured soils. However, disposal of highly saline water poses serious storage and recycling problems.

Saline and sodic soils in India are mainly in semi-arid and arid regions where annual temperatures are high and the rate of evaporation exceeds the amount of rainfall. This results in accumulation of excessive salts in the surface layer of the soil. In India, more than 8.5 million hectares of land show the adverse effects of salt accumulation. These lands are mostly poor in organic carbon, available nitrogen and zinc. From the point of view of reclamation, salt-affected soils can be divided into two groups: saline soils and sodic soils.

Salinity control

Saline soils contain excessive soluble salts which adversely affect plant growth. These soils typically occur in areas where rainfall is less than 550 mm per annum. The dominant salts are chlorides and sulphates of sodium, magnesium and calcium.

The total salt concentration in the root zone as indicated by electrical conductivity (ECe) of saturation extract is generally more than 4 decisiemens per meter (dS/m).

Leguminous crops like gram, peas and beans are sensitive to salinity, whereas *jowar* (fodder), barley, mustard and cotton are more tolerant.

The soils are generally associated with water logging, saline ground water and aridity.

Measures to control salinity

- Free the root zone from excessive soluble salts by leaching with good quality water if water table is deep.
- Remove excessive salts by leaching coupled with drainage, if water table is high.
- Grow salt-tolerant plants like *Acacia* and *Prosopis juliflora*, which tolerate salinity, aridity and water logging.

Sodicity control

Conditions favouring the development of sodic soils are:

- low lying area where water accumulates;
- rise of water table;
- lack of drainage;
- irrigation with water containing high residual sodium carbonate; and
- evaporation in excess of rainfall.

Measures to control sodicity

In sodic soils, excessive exchangeable sodium percentage (ESP) has to be reduced to tolerable limits. Sodic soils contain insoluble calcium carbonate at high pH levels. If this calcium carbonate is dissolved by adding acids or acid forming materials, the released calcium will replace excessive sodium from the exchange complex. Once pH is reduced to less than 9.5, the solubility of calcium carbonate increases.

Readily available source of calcium can be applied in the form of gypsum. Chemically, gypsum is calcium sulphate. As a result of its application, calcium replaces sodium from the exchange complex and soluble sodium sulphate is formed. When this sodium sulphate is leached to deeper layers, the sodic soil is reclaimed.

Chemical amendments

Gypsum is the most common chemical amendment. Before application, it is ground. Agricultural grade gypsum should contain at least 70% calcium sulphate. Pyrite is another useful chemical amendment that contains sulphur as an active ingredient. Phosphogypsum is also useful but due to high fluorine content, it should be used with caution.

Organic amendments

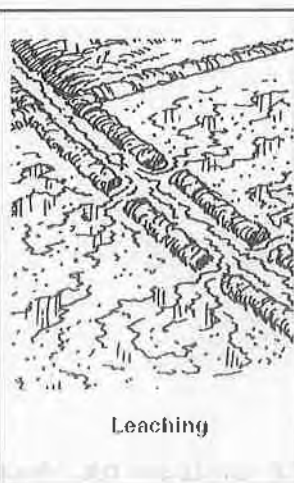
Using organic and green manure produces acidic conditions in the soil helping to solubilize calcium carbonate slowly.

Other recommendations

To control water logging, irrigation with tubewell water should be done. Alkali-tolerant plants/crops and their varieties can also be grown in controlling sodicity. For example, Para grass or Karnal grass can be grown with small doses of gypsum. If these grasses are grown for two to three years, the soil improves and can be used for rice-wheat cultivation. However, very little income from grasses can be expected.

Diagnostic characteristics of sodic soils

- After rains or irrigation, muddy water continues to stand on soil surface for many days.
- Very hard when dry and very soft when wet.
- Leaves black colour on bunds after irrigation.
- Electrical conductivity in saturation extract may be less or more than 4 dS/m.
- Carbonates and bicarbonates of sodium are the dominant salts. Exchangeable sodium is more than 15%.
- Loose layer of salts and soil particles can be seen on soil surface in summer, especially in areas where water table is high (1 to 2 m).
- Soils are poor in organic carbon, available nitrogen and zinc.
- Soils contain 2 to 4% calcium carbonate in the surface layer (0 to 15 cm) which increases with depth. At 1 m depth, hard *kankar* layer is generally present.



Sodicity control package

1. Plough the land, make strong bunds and level the land. Check level by light irrigation and plough again.
2. Take 0-15 cm soil samples. Test them for pH, EC and work out gypsum requirement. More gypsum is required for soils with high concentrations of soluble salts of carbonate type.
3. Apply gypsum by broadcasting in the month of June-July about 10 days before rice transplanting. A dose of 10 to 15 t/ha gypsum is required for highly deteriorated sodic soils having pH₂ of more than 10.2.
4. Mix gypsum by shallow ploughing. Irrigate and do leaching for at least three days.
5. Transplant 30- to 35-day old healthy rice seedlings.
6. Apply a total of 150 kg N/ha in the form of urea in three equal splits. Apply 25 kg zinc sulphate per ha before transplanting. The fertiliser dose can be reduced in the succeeding years.
7. After rice, grow wheat. After sowing wheat, each field should be divided into borders of six to eight meter width. Apply four to five light irrigations to wheat. First irrigation should be applied 28 days after germination.
8. Grow *Sesbania aculeata* (*dhaincha*) as a third crop for green manure if sufficient irrigation water is available.

Don'ts

- Do not start reclamation with a wheat crop.
- Do not puddle sodic soils after gypsum application.
- Do not apply phosphorus or potash fertilizers in the initial years.
- Do not use canal water where water table is already within 2 m.
- Do not keep land fallow for a long time.
- Do not plough deeper than 15 cm depth.

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Technology impact

- A rice yield of 46 quintals/hectare (q/ha) and a wheat yield of 16 q/ha was achieved in more than 600 plot demonstrations conducted by the Central Soil Salinity Research Institute (CSSRI), Karnal even during the first year of reclamation.
- Yields continue to increase and stabilised at 55 q/ha of rice and 30 q/ha of wheat without further application of gypsum.
- Higher crop yields were obtained when farmyard manure at 10 of 15 tonnes/ha was applied once in three to four years.
- Green manuring with *dhaincha* helped get higher crop yields.
- Dhainchia helped in checking soil erosion as well as water logging. It also promoted the conservation of precious rainwater for growing crops like rice, wheat and berseem.
- Flooding of low-lying areas downstream was checked.
- When pH levels were reduced to less than 9.0 in 0 to 60 cm depth, other crops like sunflower, sugarcane, basmati rice, mustard, *jowar* (fodder) and selected vegetables could be grown successfully. These crops require less water compared to rice and help in checking the downward movement of water table to excessively deeper depths.

Contributors: K.K. Mehta and D.K. Mittal

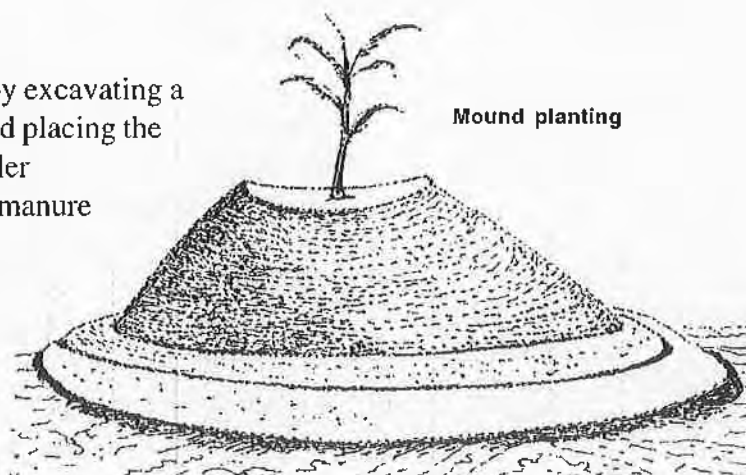
Rehabilitation of uncultivable salt-affected lands

Salt-affected lands are devoid of vegetation or have very scanty vegetation. These lands, which may be saline or sodic (with or without calcareousness), occur in arid, semi-arid and sub-humid conditions. To rehabilitate these lands, situation-specific treatments are required.

In Rajasthan, India, two successful models have been developed — one for lands lying in depressions where during monsoon, temporary water logging occurs and during summer salts accumulate on the surface (model 1); and the other for a situation where hard layer of calcium carbonate that exists under the sodic soil does not allow the penetration of roots (model 2).

Model 1

A mound with a flat top is formed by excavating a circular ditch (1 to 2 m diameter) and placing the excavated soil in the centre. The filler comprising gypsum (if sodic soils), manure and pesticide mixed with tank silt is added in the mound and planting is done after the first rain.

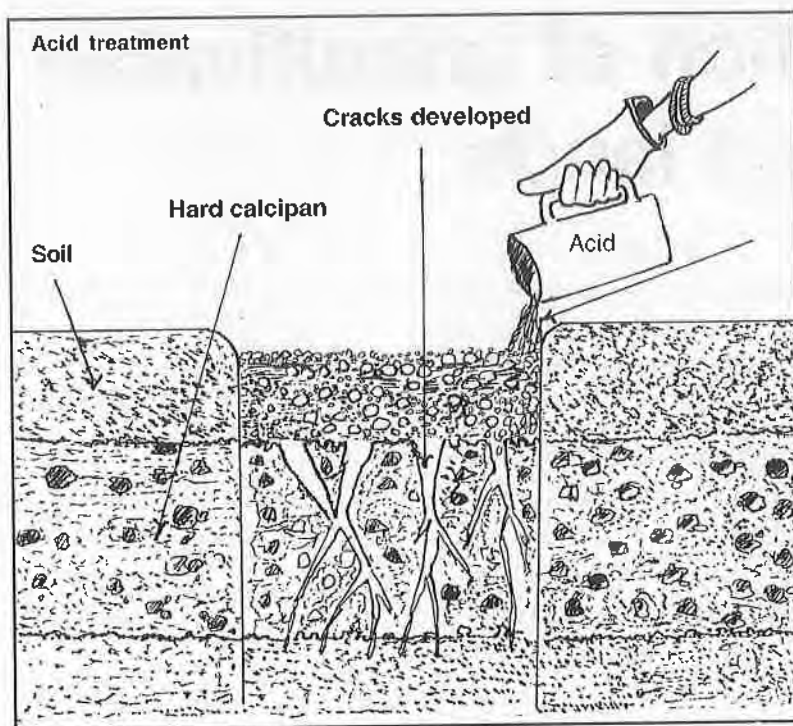


Advantages

- Suitable for saline and saline sodic soils, especially for low lying areas or depressions.
- During the rain, salts are leached away from the root zone into the excavated ditch around the periphery of the mound which can be collected manually and disposed off.
- Has scope for replicability.

Limitations

- Creates moisture stress in the plant root zone and needs watering at initial stages.
- Plant growth is restricted due to limited soil mass.



Model 2

In sodic and hard strata of calcium carbonate, the dug up pits (45 x 45 x 45 cm³) are treated with concentrated commercial sulphuric acid (H₂SO₄), which breaks the hard layer and produces gypsum *in-situ*.

The gypsum works as an ameliorant. After the reaction is over (about two days), the filler comprising tank silt and manure is added and mixed well with the gypsum produced in the pit.

Planting is done after a week.

The quantity of acid depends on the amount of calcium carbonate present in the soil. Normally, 250-500 ml of acid is required for a pit. The cost of acid treatment may vary from Rs. 1 to Rs. 2 per pit.

Advantages

- Breaks the hard calcareous layer under the surface soil, helping plant growth.
- Requires one time treatment only.
- Specially suited for raising trees in unculturable lands.
- Gypsum produced *in situ* acts as an ameliorant reducing soil sodicity.
- The earth work done manually provides jobs to local people, especially during lean season.
- High ionic concentration of calcium, which is normally present in calcareous soil, does not increase.
- Acidity of sodic soils is reduced to safer limits that help in the uptake of nutrients.
- Reduction of pH creates a favourable environment for microbial and other biological activities.
- Conserves soil moisture.
- Has scope for vast replicability.



Caution

- Sulphuric acid (H₂SO₄) is a dangerous chemical and should be handled only under the supervision of specialists.
- Use rubber hand gloves and knee-high gum boots for protection against sulphuric acid.

Limitations

- Requires skill and protection while applying the acid.
- Transportation, preservation and handling of sulphuric acid require special care.

Selection of plant species

Selection of salt-tolerant plant species is done considering the agro-climatic zone, soil characteristics and the choice of local people. Priority is given to species which can regenerate even if browsed by animals. Selection is generally done from xerophytes, halophytes and broad-leaf plants. If soils are calcareous, calcium-loving plants are selected.

Facts speak

- About 55 ha of land have been rehabilitated by applying Model 1 technique in Kaparda Rann area in Jodhpur district, Rajasthan, India.
- More than 5,400 ha of sodic calcareous land have been revegetated by applying Model 2 in Kotri Macro Watershed, Bhilwara district, Rajasthan, India.
- About 3 million plants of different species have been raised during 1992-96 using approximately 428 metric tonnes of sulphuric acid.
- Acid treatment and other activities in the field have been done by the villagers, particularly women.
- The techniques applied in the fields have changed the ecology of the area, improved the soil physical conditions as well as fertility and helped in the emergence of flora and fauna.

Developed plants after treatment



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Contributors: U.S. Pokharna and V. Srinivas

In situ farmyard manure application

This is a widespread practice in areas where herders traditionally migrate with their flocks each year in search for better pastures. There is a mutual advantage to both herders – who need a place to settle their sheep each night – and farmers, who get urine and manure right in their fields for a small fee.

Objective

To incorporate sheep droppings directly into the field to increase soil fertility

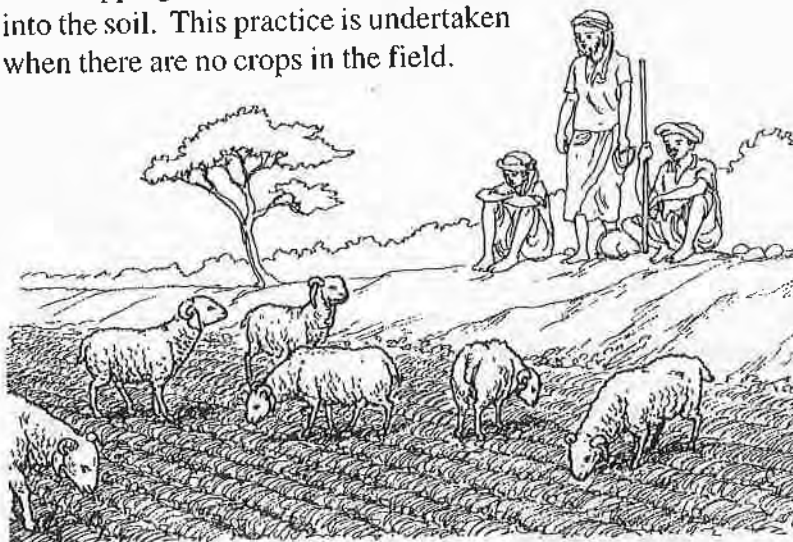
Note

Undertake this practice when the field is ploughed.

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One method of farm yard manure application is the herding of sheep into the field (in some parts, donkeys are used). The sheep are allowed to remain in the field overnight. Urine and excreta deposits are available right where they are needed.

The droppings are later ploughed directly into the soil. This practice is undertaken when there are no crops in the field.



Advantages

- Useful to small and marginal farmers who do not own cattle and have limited land.
- Useful to farmers having limited farm yard manure.
- Transportation and labour charges are avoided.
- Pastoralists can generate income by charging a fee for this service.
- Manure decomposes easily.
- Releases nutrient into the soil through decomposition.
- Promotes easy infiltration in vertisols.
- Utilises urine which is normally wasted.

Limitations

- Difficult in areas with low sheep population.
- Farmers have to depend on migratory practices of the herders.

Contributor: Neelkant Pandhare

Bio-fertilizer in cotton

H.D. Kote Taluka in Karnataka, India has a rainfall of 800 mm to 850 mm. Black cotton soils and red loamy soils are the major soil types. Biofertilizer (*Azospirillum brasilense*), a non-symbiotic strain was tested on cotton variety DCH 32. The rate of biofertilizer used per acre was 800 g. Here are the results of two farmers:

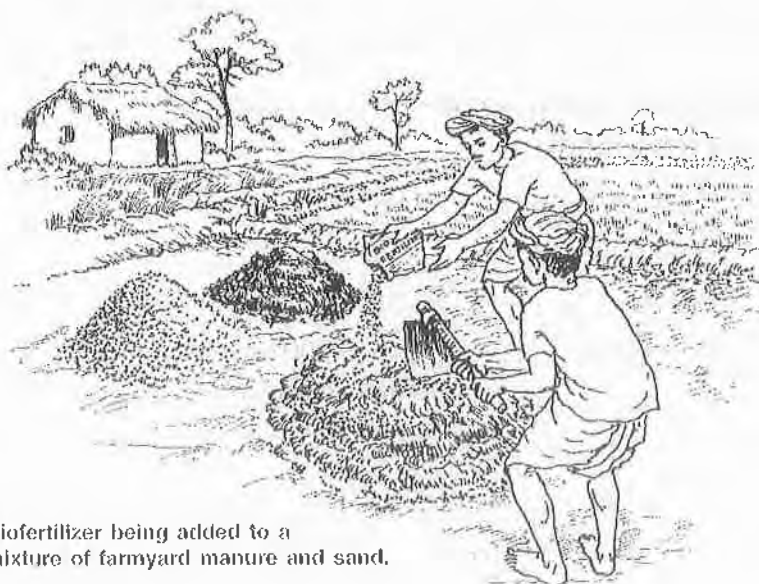
Name	Cotton yield	
	With biofertilizer	Without biofertilizer
Ms. Puttaningamma Madappa	5 quintals/acre 70-80 bolls/plant	4 quintals/acre 50-60 bolls/plant
Ms. Mallagamma Basappa	8 quintals/acre 120-130 bolls/plant	7 quintals/acre 90-100 bolls/plant

Requirements

- Four packets of 200 g each of biofertilizer for one acre of cotton.
- About 10 kg of powdered, well-decomposed farmyard manure and 20 kg of sand.

Method of application

1. Mix the biofertilizer, farmyard manure and sand.
2. Apply the mixture along with the seeds during the dibbling process.



Biofertilizer being added to a mixture of farmyard manure and sand.

Advantages

- Fixes nitrogen.
- Helps in plant growth.
- Increases soil fertility.
- Cost effective and eco-friendly.

Limitations

- Farmers are not aware of biofertilizers.
- Not readily available in the market.

Precautions

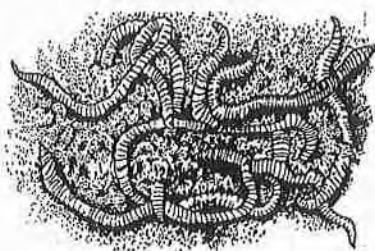
- Do not apply the biofertilizers simultaneously with chemical fertilizers.
- Biofertilizers should be used before the expiry date (printed on the packets).
- Biofertilizers should be kept in a cool dry container.



Contributor: C. Ramdas

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Eco-friendly vermicomposting



Advantages of vermicompost

- Adds 4-6 nutrients for quicker absorption and faster growth of plants.
- Maintains humus content of soil.
- Increases crop productivity.
- Increases water holding capacity of soil.
- Low cost.
- Easy to produce.

It is now recognised that chemical fertilizers, while increasing crop yields, also have adverse effects on soil health and land fertility. To reverse this trend, use organic manures.

There are several kinds of organic manures, vermicompost being one of them. Farmers regard earthworms as their friends in agriculture. Earthworms are living composters because they help speed up the conversion of biomass in the field into organic manure and also make the soil porous. Unfortunately, increased use of chemical fertilizers has almost eliminated them from fields.

Earthworms can be bred in containers like masonry tanks or pits to prepare organic manure. They convert organic wastes into very rich manure — or vermicompost. This is called vermicomposting. This homemade manure is rich in nutrients and also improves the soil quality.

Vermicompost has 0.66% nitrogen, 0.99% phosphorus and 0.4% potash.

The tank method of vermicomposting is ideally suited for dryland conditions. It requires about Rs. 600 at current prices as a one time investment, for constructing a 2m x 0.80 m x 0.80 m tank. About 35 kg of vermicompost can be obtained from the tank per month. This is sufficient for about 350 trees.

In addition, the liquid extract collected from the tank can be applied to about 250 plants every week. This is a highly concentrated liquid extract and has to be diluted in 1:10 ratio with water or cattle urine.

Approximately valued at Rs. 3 per kg of manure, the investment can be recovered in six months.

Inputs for compost per 1.5 cu m tank (per 2 months)

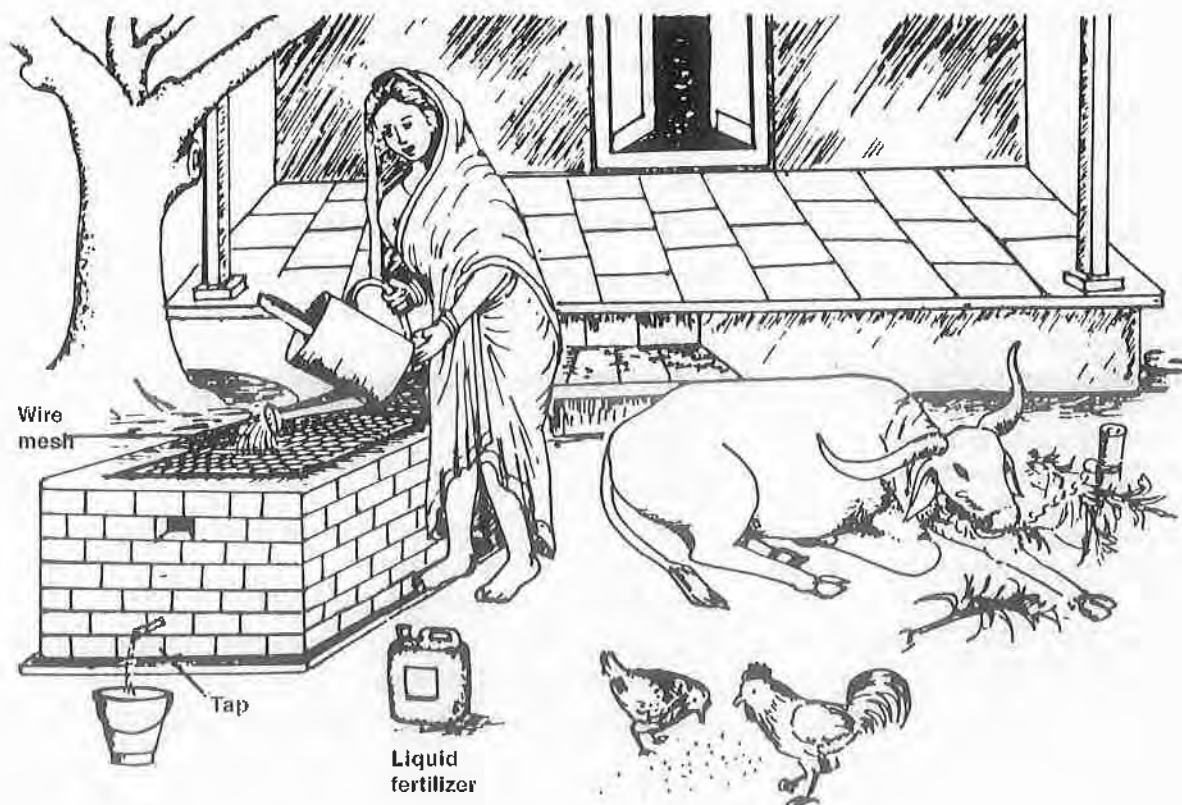
- | | |
|----------------------|---|
| • Dry organic wastes | 100-120 kg |
| • Dung slurry | 30-40 kg |
| • Water | 8-10 litres every three days |
| • Earthworms | 1,000-2,000 (one time introduction as they multiply 20-25 times every 70-75 days) |

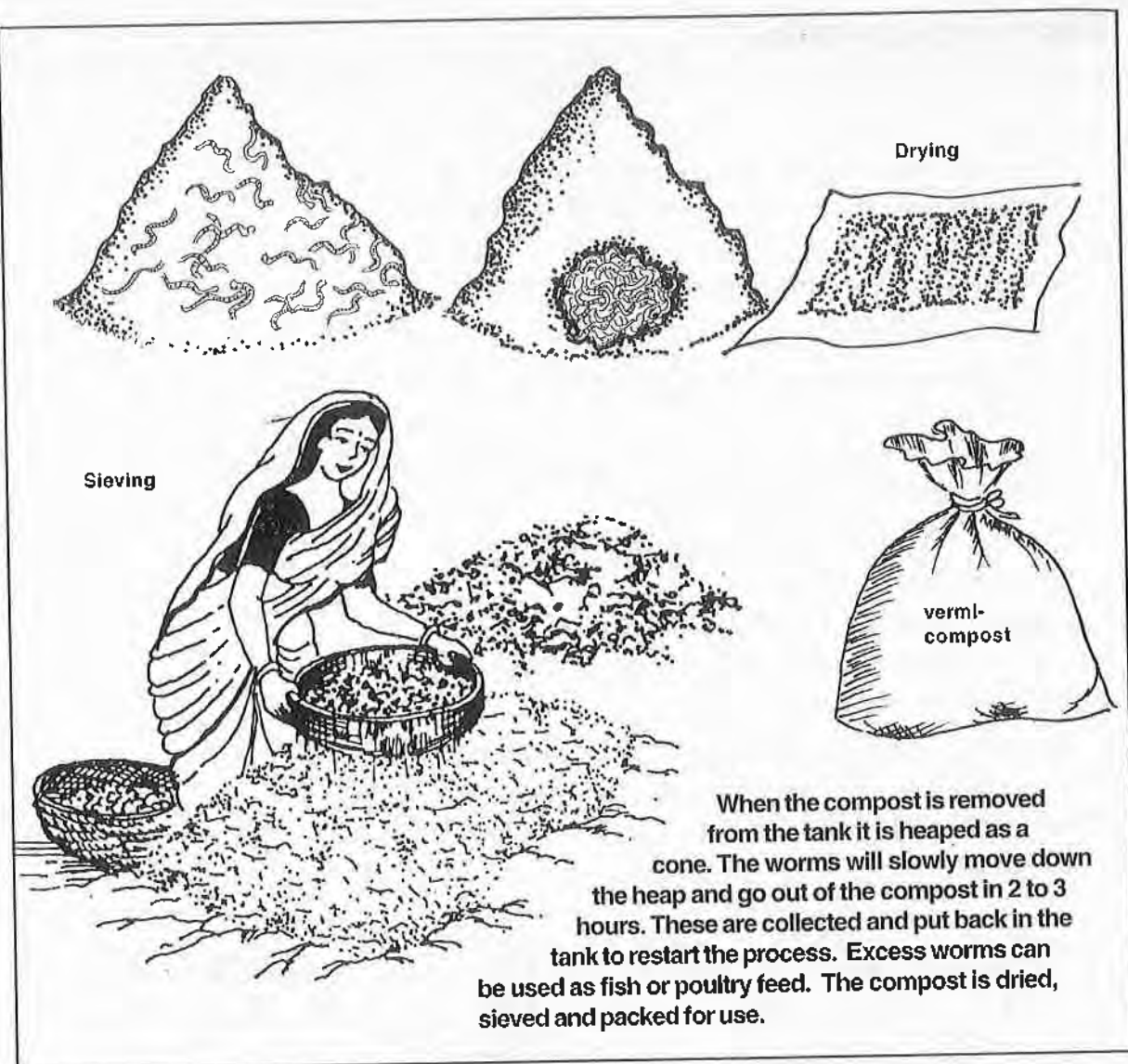
Steps in preparation

1. Fill the bottom of the tank with a layer of broken roof tiles or coconut husk.
2. Fill a layer of leaves or other organic wastes or sericulture wastes, mixed with dung slurry. Allow to decompose for 15 days.
3. Release the earthworms (1,000-2,000).
4. Fill a layer of organic wastes.
5. Cover the tank with wire mesh to prevent birds from picking worms.
6. Sprinkle water every three days to maintain adequate moisture and body temperature of worms.
7. Collect the liquid fertilizer from the tap into a bucket at regular weekly intervals.
8. Compost is ready in four weeks if sericulture waste is used, and eight weeks if agricultural waste is used.

Second filling

9. About 20 days before removing the compost, mix organic waste and dung slurry and decompose in a separate pit. When the tank is emptied, transfer this to the tank and start the process again.





Experience

A recent introduction in dryland areas, vermicomposting is slowly gaining acceptance from farmers. In Karnataka, farmers are getting benefits by applying vermicompost, with better yields on mulberry and vegetable crops. They now harvest four crops of mulberry leaves, against two to three crops per year earlier.

Precautions in vermicomposting

- African species of worms, like *Eisenia foetida*, *Eudrilus eagei* etc., are ideal. Most Indian species are not suitable.
- Use only plant-based materials like vegetable peelings, leaves or grass.
- Do not use matter of animal origin (egg shells, meat, bone, dairy products, etc.).
- Protect against termites, ants, rats and frogs. A small trench around the tank is helpful.
- Maintain adequate moisture in the tank.
- Stagnant water or dryness will kill the worms. Sprinkle 10 litres of water every three days.
- Remove compost at regular intervals and refill with wastes.

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Contributors: S. M. Doni, P. Ramachandrappa and C. Ramdas

On-farm production of biomass and compost in drylands

Activity

Planting of green manure trees on field bunds for on-farm production of biomass and compost and modifying the micro-climate.

Objectives

- To increase soil fertility and organic matter status by using the biomass produced on drylands (where green manuring is not normally practised).
- To stabilise field bunds and improve fuelwood supply for household needs.

Method

- Make earthen bunds across the slope of the field during summer.
- Dig a pit for compost in one corner of the field.
- During the rainy season (in July), plant a mixture of 2-4 species of green manure trees (*Cassia siamea*, *C. spectabilis*, *Gliricidia sepium*, and *Derris indica*) on the field bunds as well as around the compost pit.
- Plant one-year-old seedlings in a zigzag format with 1.2 m intervals on the field bunds.

Participatory Rural Appraisal (PRA) and tree ranking exercises must be used to identify Indigenous and farmer's tree preferences and appropriateness of species for dry areas.



Management practices

- Apply cow/buffalo/sheep dung slurry on the young green manure plants during summer to protect trees from being grazed.
- Sometimes, the green manure trees produce luxuriant growth prior to sowing of field crops. The shade can reduce emergence of field crop seedlings. Cut leaves of such trees are broadcast and ploughed into the field soil.
- Normal planting of monocrops and intercrops such as finger millet (*ragi*), groundnut, horsegram, lablab and pigeonpea (red gram) can be carried out in the fields.

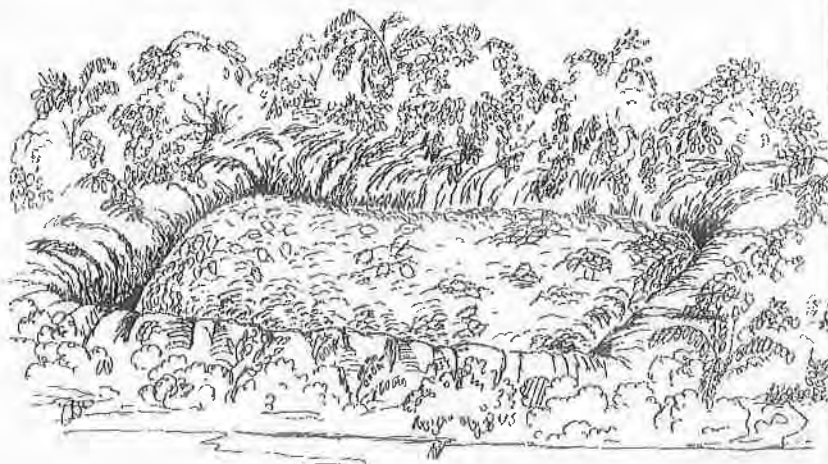
- Start pruning the plants after the first year (first pruning in March-April). Pruning is done at 1 - 2 m height.
- Add leaves (and twigs) into the compost pit and use the bare branches for fuel. Cover the pit with silt.
- Leave the biomass in the compost pit for decomposition.
- Use the compost as manure after four to six months.
- Prune the plants again after six months (second pruning in September-October) and add the leaves into the compost pit.
- Continue pruning the plants at six-month interval and use the compost produced from the biomass as manure.



Zigzag planting design

Compost pit

- For a 0.4 ha-field, the compost pit should be 3 to 5 m in length x 1.5 m in width x 1 m in depth with a sloping bottom to drain excess water into the deep end to prevent destruction of entire bottom compost layer during rains.
- The depth of the compost pit must not exceed 1 m to ensure aeration.



Advantages

Organic manure

- Increases soil fertility and the microbial activity in the soil.
- Reduces the need for inorganic inputs.

Soil and water conservation

- Trees serve as windbreaks.
- Reduces soil erosion.
- Increases the water-holding capacity of the soil.
- Improves the microclimate (i.e., the agroclimatic conditions within the field).

Diversity

- Increases the population of predators and reduces pest populations in the field crops.
- Increases diversity of trees.

Food

- Increases crop yields and farm income.

Fuel

- Provides fuelwood and promotes on-farm afforestation.

Limitations

- If green manure trees are not pruned regularly, plant height increases and the shade affects crop growth.
- Root growth increases and roots penetrate into the field if the pruning is not initiated in the first year and continued every year thereafter. Maintaining a trench of 0.5 ft at a distance of 0.5 m from the trees will also cut surface roots and keep them from spreading into the fields.

Associated activity

Sow seeds of drought-resistant grasses — *Stylosanthes scabra* (erect) and *S. hamata* (spreading) by broadcasting on the field bunds soon after the green manure trees are established.

Advantages

Fodder

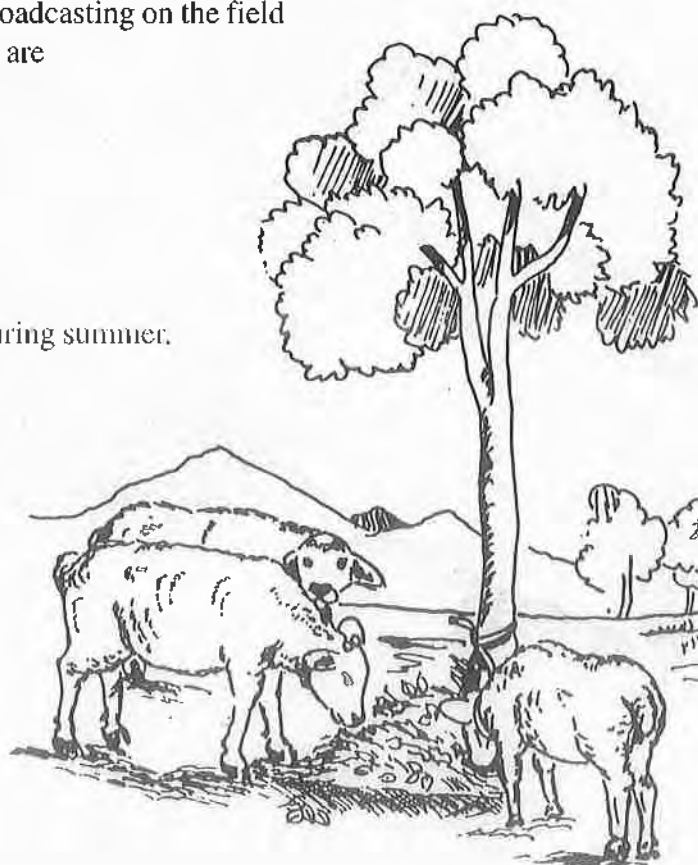
- Increases fodder production.
- Serves as a source of fodder even during summer.

Food

- Increases milk production in milch cattle.

Soil and water conservation

- Serves as a vegetative barrier and reduces soil erosion.



A case study

Project

MYRADA Kamasamudra Project

Test — On-farm production of biomass and compost

The project was conducted in 1991-95 by MYRADA, in collaboration with IIRR, in partnership with farmers and with support of the Ford Foundation. It was initiated in 1991 on 21 ha of land. Seventeen farm-families in Srinivasanagara village in Kolar district, Karnataka, India participated. The technology was tested for the first time in dryland areas of Karnataka.

Impact

- By 1996, the technology was adopted by 483 farmers on 200 ha in 11 villages in Kolar district.
- Increase in the use of composting technologies owing to improved and easy access to biomass sources.
- Soil fertility has improved, permitting the cultivation of a wider range of cereal crops.
- Food shortage among participating households has been reduced.
- Livestock production has increased.
- Household fuelwood needs are being met; women engaged in other economic activities and have been saved from the drudgery of collecting fuelwood from distant places away from the farm or village.
- Farm income has increased due to increased biomass production on previously degraded farms.



*Information kit produced by
MYRADA and the International
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Contributors: P. Ramachandrappa and S. N. Doni

Multiple benefits from silt utilisation

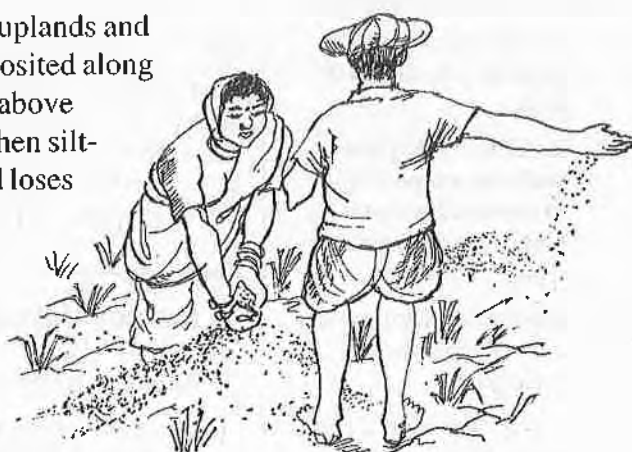
Silt is soil carried by run-off waters from the uplands and deposited in low-lying areas. It is usually deposited along stream beds, tank beds and reservoir beds or above earthen barriers and checks across gullies. When silt-laden run-off water encounters resistance and loses velocity, silt gets deposited at various points.

Silt contains plant nutrients in varying quantities.

The rich deposits are a source of good fertility inputs for the fields. It has been an age old practice to collect silt from tank beds and apply this to enrich the fields. This is one way of recycling nutrients.

Unfortunately, the practice is neglected as farmers are attracted to the use of chemical fertilisers. If the practice is revived, it will provide an alternative and effective natural manure.

Desilting of tanks has to be undertaken as a community activity and the NGO can play a crucial role in mobilising and motivating the villagers. The active participation of farmers, who share the cost and also reap benefits, is a prerequisite for its success.



Physico-chemical properties of tank silt of Kolar and Bangalore districts

	Range	Mean
Sand (%)	5.6 to 80.8	45.6
Silt (%)	5.6 to 33.0	20.5
Clay (%)	9.6 to 47.6	32.0
pH (acidity)	5.9 to 7.1	6.5
EC (mmhos)	0.03 to 0.11	0.06
Organic carbon (%)	0.39 to 0.86	0.63
N.P (ppm)	0.8 to 2.9	1.4
N.K (ppm)	55.8 to 305.0	189
Copper (ppm)	1.4 to 2.0	2.39
Zinc (ppm)	0.84 to 1.51	1.16
Iron (ppm)	12.2 to 49.1	26.9
Manganese (ppm)	9.4 to 34.4	21.9

Source: UAS, Bangalore

Multiple benefits from desilting of tanks

Desilting is not for manure alone. There are several direct and indirect benefits:

- it augments the storage capacity of the tank;
- it ensures adequate water for community purposes like water for cattle and domestic uses;
- it provides a source of water for plants and cultivation;
- it helps pisciculture, a source of food and employment; and
- higher water storage results in percolation and recharge and improves the water table in the area.

Note

It is recommended to test silt before applying it to the fields; more so in areas known for saline-alkaline soils.

Benefits of silt

- The application of silt to depressions levels the surface and makes the land more productive and easy to cultivate.
- When applied to sandy soils, silt improves water holding capacity and helps aggregate soil particles.
- When silt is applied to clay soils, soil depth and its ability to drain excess water is enhanced.
- Apart from improving physical properties, silt application also improves the chemical and biological properties of both sandy and clay soils.

Successful experiences

Ananthapur Dt. (Andhra Pradesh)

- In Ananthapur district of Andhra Pradesh, Chaitanya, an NGO promoted partial desilting of 20 tank beds by involving the villagers. Encouraged by the success of the programme, the district administration launched a programme to desilt another 100 tanks through NGOs.
- The farmers transported the desilted soil and spread it on their fields. The cost of desilting and transporting 10 cubic metres of soil was about Rs. 200. The cost of spreading a 1 cm thick layer was Rs. 2,000 per ha.
- This cost was shared equally between the government or the funding agency and the villagers or beneficiaries.
- Local fishers were eager to participate as it gave them better fishing opportunities.

Madurai district (Tamilnadu)

- In Madurai district of Tamilnadu, Pradan, an NGO undertook desilting of tanks at the foothills of Alagarmalai which were not desilted for nearly 40 years. The desilting done was up to 2 m deep, using manual labour and earth-moving machinery. The silt was transported to the fields. The cost was also shared equally by villagers and the funding agency.



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Contributor: C.R. Sharmugham

Neem and its various uses

Benefits of neem

- Multi-purpose tree.
- Suitable for dryland agriculture.
- Excellent as bio-pesticide and organic manure.
- Eco-friendly, cost-effective and an easily available resource.

Although all parts of the neem tree have very good multiple uses, the seeds are the most useful of all in agriculture. Neem wood has many excellent properties but to cut a neem tree for its wood is to kill the goose that lays golden eggs.

Recipe

Pick neem flowers in season and dry them in the sun. Store in airtight bottles/jars.

To use: Heat a blob of butter and fry a tablespoonful of dried flowers in it, stirring all the while. Add salt, mix with hot steamed rice and eat.

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Neem (*Azadirachta indica*) is a fast-growing, drought-tolerant tree suitable for growth in dryland conditions.

The active ingredients (*Limonoids*) of Neem are as follows:

1. Azadirachtin — pest repellent: disturbs the process of insect metamorphosis.
2. Salanin — anti-viral properties: helps control viral diseases in crops.
3. Meliatriol — pest repellent.
4. Nimbin and Nimbidin — anti-viral and nematicidal properties.

Propagation

Neem can be propagated in the nursery or through direct seeding.

Direct seeding

- Can be done at the start of the monsoons (June to July).
- Seeds should be sown within 7 days of their ripening to ensure germination.
- The growing neem plant can be best protected if sowing is done adjacent to *Prosopis juliflora* or cactus. Cactus helps keep out cattle because of its prickly thorns. In case of sowing close to prickly plants, it is suggested that seeds be dibbled through a hollow metal pipe to avoid injury. This process also helps reduce the labour involved in direct seeding.

Neem as manure

- De-oiled cakes of neem seeds make good organic manure as they contain 5% nitrogen.

Neem cakes, when used as coating agents for urea, increase its efficiency because of the slow release of nitrogen.

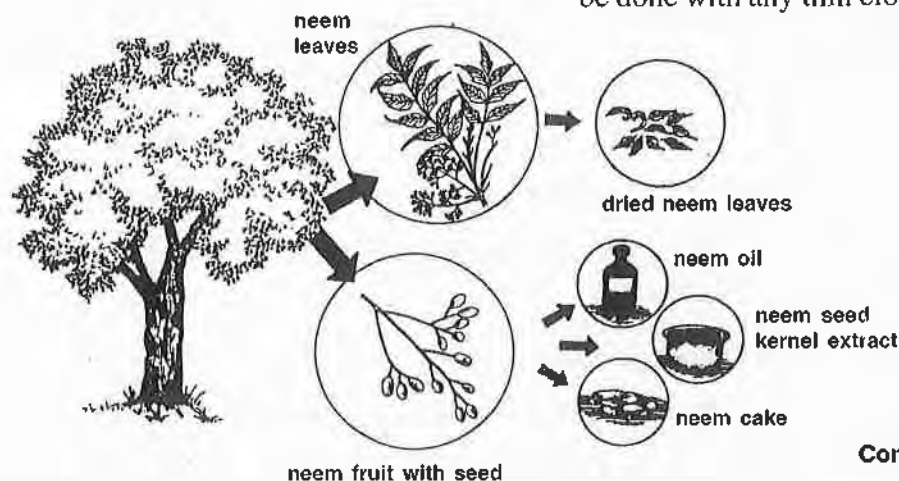
Neem as pest repellent

Neem cakes serve as good pesticides for controlling cut worm (in potatoes) and termites (for crops like cotton, wheat, groundnut, etc.).

A filtered residue from finely crushed neem leaves and water protects groundnut seeds from birds after sowing (the proportion is 100 g of neem leaves mixed with one litre of water for 1 kg of groundnuts).

Neem oil

A solution prepared from 30 - 35 ml of neem oil and 10 - 15 ml of endosulphan mixed with 15 litres of water (1 spray pump) acts as a deterrent for sucking pests like aphids, jassids, white flies and thrips. It also acts as an anti-feedant for the larvae of *helicoverpa armigera* and the spotted ball worm. (10 g of washing soap powder, i.e., the equivalent of 2 match boxes can also be substituted for endosulphan).



Contributor: M. S. Vahora

Neem-seed extract

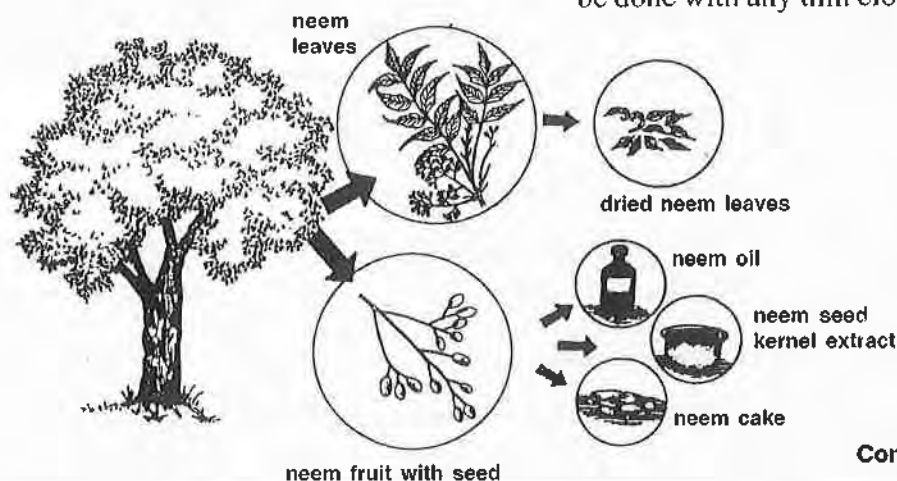
1. Take 20 kg neem seeds and crush them.
2. Keep the crushed seeds in a bag and tie the end.
3. Immerse the bag into a bucket of water overnight.
4. Filter the solution through a muslim (fine-mesh) cloth.
5. Mix with a low quality soap solution.
6. After which, spray the solution.



Contributor: P. Ramachandrappa

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Contributor: R. Ramachandrappa

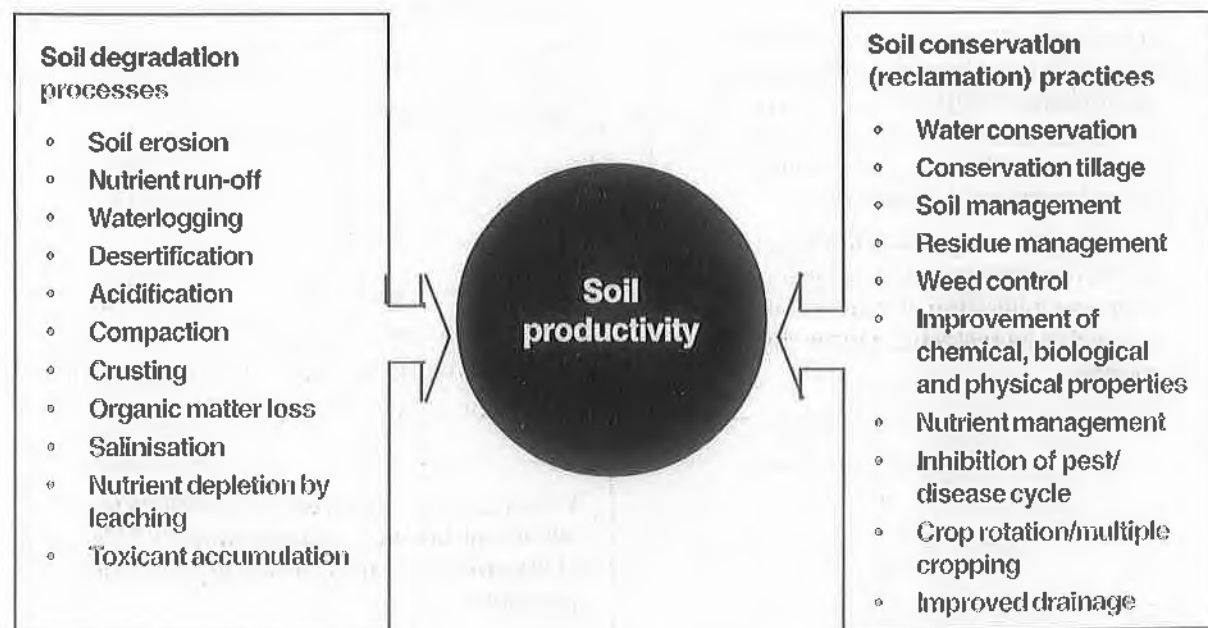
Tillage requirements for black, red and sandy soils

Vertisols, alfisols and laterites are prone to water and wind erosion. Nearly 65 tonnes/ha/year of soil is lost from vertisols alone, while it varies from 8-40 tonnes/ha/year in other related soils. The nutrients and finer soil materials are also lost along with soil, posing enormous hazards to crop productivity. Conserving soil and water not only reduces degradation but also improves soil fertility and productivity. For effective control of erosion, permanent vegetative cover is essential. However, this is not often compatible with seasonal crop production and consequently, alternative conservation practices are suggested for cultivated lands which may simulate the benefits derived from permanent cover of grasses or trees (such as conservation tillage which retains a cover of residues on the soil during critical erosion periods). A complete cover of surface residues gives the most protection, but under dryland conditions, due to reduced dry matter production, it may provide enough protection only as long as the annual erosion does not exceed 10 tonnes per hectare.

This paper discusses several tillage methods in dryland areas dealing with:

- conservation tillage methods for situations where crop residues are available; and
- clean tillage methods for situations where residues are limited or where it is not desirable to use conservation tillage.

Soil productivity decreases in accordance with soil degradation processes and increases with the implementation of soil reclamation and conservation practices.



Stubble mulch tillage

Advantages

- Facilitates the preparation of smooth seedbeds.
- Breaks weed, insect and disease cycles.
- Buries plant residues from the previous crop.
- Allows for the incorporation of fertilizers and other amendments to soils.
- Breaks surface crust to increase infiltration rate and water availability.
- Fractures plough pans or indurated horizons to allow for the deeper penetration of water and plant roots.
- Reduces evaporation by disturbing continuous capillaries.

Disadvantages

- Soils with low fertility are readily dispersed by water that causes surface sealing and increases run-off and erosion.
- Weed control is poor for stubble-mulch tillage when tillage is performed while the soil is moist or when precipitation occurs soon after tillage.
- Tilling at inappropriate times enhances moisture evaporation from the soil restricting the availability of water for crops.



Caution

- In the initial stages of rainfall and until run-off occurs, tillage depressions can help in conserving moisture. Later, run-off increases with increased soil loss. To reduce these ill effects, follow tillage operations along the contour.
- In making tied ridges and furrows, scooping with scooper/basin lister improves infiltration of rainwater by increasing its residence time at the soil surface.

Tillage

Tillage refers to the manipulation of soil by implements such as mouldboard and disc ploughs. In stressed environments, improper tillage can cause severe soil degradation if not done according to prevailing climatic conditions.

Example: In degraded lands, tillage before the onset of rains could further erode soils. Tillage at an inappropriate time could enhance moisture evaporation from the soil aggravating the limited availability of water for crops.

Types of tillage based on soil surface residue coverage

Conservation tillage

Conservation tillage is a tillage system that leaves at least 30% of the soil surface covered with crop residues after the crop is planted. This definition implies that this amount, or more, of residue would be present at all times during the interval between crops.

Stubble mulch tillage

Stubble-mulch tillage was developed to control wind erosion in the Great Plains of the United States, but it also reduces water erosion and enhances water conservation.

Stubble mulch tillage is accomplished with implements (sweeps or blades) that undercut the soil surface, thereby retaining most crop residues in the surface. Stubble-mulch tillage can also be done with a chisel plough, but a rotary rodweeder may be needed to improve weed control.

One disadvantage of stubble-mulch tillage is poor weed control. This occurs when tillage is performed while the soil is moist or when precipitation occurs soon after tillage.

Presence of 11 t/ha of surface residues on fallow soil increases storage water by 34% of the precipitation as against to 16% under no residue.

Disk tillage

Tillage is carried out with the help of a disk to bury 30 to 70% of surface residues. Disk tillage provides good weed control. However, where residue production is low and the potential for erosion is high, disk-type implements should not be used.

Ridge planting

Planter units are operated on ridges made by the cultivation of the previous crop or after crop harvest. At planting, remove the ridge tops with wide sweeps that shove old stalks and root clumps into the interrow area. Plant the seed in the cleared area covered with loose soil.

Advantages

- Run-off control benefits occur if the ridges are formed on the contour.
- Ridge planting benefits poorly-drained soils such as vertisols, because ridges are usually drier and better aerated than furrow bottoms or land that is managed in a flat condition.

No-tillage

Opening of soil for seed placement is usually with a coulter operated in front of a planting unit equipped with disk or chisel openers. With no-tillage treatments, herbicides are used to control weeds. Consequently, all crop residues are maintained on the soil surface which reduces erosion and enhances water conservation through improved infiltration and reduced evaporation. For no-tillage to be effective, adequate residues must be available. No-tillage cannot be effective in degraded soils with low residue amounts. Where residues range from about 1.5 to 2.5 tonnes/ha and weeds are controlled with herbicides, water storage and crop yields are similar to fields with stubble-mulch tillage.

Types of tillage based on time of operation

Primary tillage

Tillage operations primarily carried out to prepare smooth seedbed till the sowing of crop.

Secondary tillage

Tillage operations carried out after/during cropping period to reduce weeds and evaporation and to increase water intake.

Types of tillage based on depth

Deep tillage

Ploughing and chiselling the soil up to 25 to 30 cm depth.

Shallow tillage

Tilling the soil up to 10 cm depth.

Application of organic residues: addition and incorporation of any organic residues through shallow tillage.

Draft requirements for certain types of soil

Light soils (sandy soils)	20 - 45 kg
Medium soil (red sandy loam)	45 - 60 kg
Heavy soil (black and red loamy soils)	60 - 125 kg

Vertisols/black soils

Vertisols occupy 70 million hectares in India, mainly occurring in the States of Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu. These soils occur in topography having slopes varying from 0.5 to 3%.

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Properties

- These soils have high clay content varying from 40 to 60% with high available water holding capacity (18-25 cm/m)
- Low infiltration rate (<10 mm/hour), leading to either run-off or waterlogging further aggravating salinity/alkalinity.
- pH > 7.5.
- Soil depth varies from 22.5 cm to more than 1.0 m.
- Deep and wide cracks occur when dry (self ploughed soils).
- Hard when dry, sticky and not trafficable when wet.
- Optimum soil moisture range for tillage is very narrow, leading to extremely high draft requirement when dry.
- Vertisols are much more prone to erosion than other soils.



Management of Vertisols/black soils

- Deep tillage up to 30 cm depth once in three years with 5 t/ha of crop residues/FYM.
- Fall ploughing immediately after the harvest of *rabi* crop.
- Shallow tillage up to 10 cm depth with blade harrow (two to three times).
- Shallow tillage with sweeps/intercultivators two to three times during cropping period.

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Alfisols/red soils

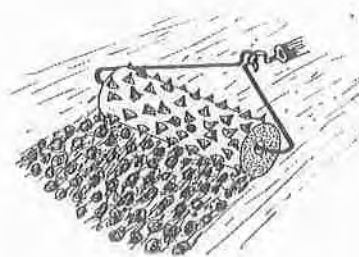
These soils occupy 45% of the geographical area in Karnataka and are highly erodable. Nearly 80% of red soils require some type of conservation measure. The slopes where these soils occur vary from 0.5% to 2.5%.

Properties

- These soils have low clay content (<40%) with low available water holding capacity (5-10 cm/m).
- High infiltration rate.
- Neutral soil pH (6.5 to 7.5).
- Shallow to medium soil depth.
- Surface crust formation within two to three days after receiving rains.
- Crusting after seeding results in poor seedling emergence. Moreso, in small seeded cereals, i.e., finger millet, pearl millet and sorghum that have a weak plumule.

Management of red and sandy soils

- Deep tillage every year to break crust and pulverize soil, along with addition of crop residues 2-5 tonnes/ha depending upon availability every year.
- Interculturing two to three times during cropping period.
- Dead furrow opening at 3 m during sowing and repeated at 30 to 40 days after sowing.
- Seeding on the ridge side and mulching seedline improves germination.
- Use of rotary type spiked roller on crusted soil to break crusts.



Breaking the crust
with spiked roller

Poor seedling emergence
due to crusting



Contributors: M. B. Guled, S. L. Patil and H. Mallikarjuna

Mulching: Means to mitigate drought

In drylands, every effort must be made to combat the problems created by drought. Mulching is one among many practices available to farmers that lessens the probability of poor harvests.

Mulching is a multi-pronged approach to conserve soil and water and manage weeds. Mulches are commonly used in areas subject to drought and weed infestation. A number of materials are used in mulching practices, depending upon land conditions.

Mulching can be categorised into three kinds based on the material, method adopted and purposes:

- surface mulching;
- vertical mulching; and
- live vegetative barriers.

Surface mulching

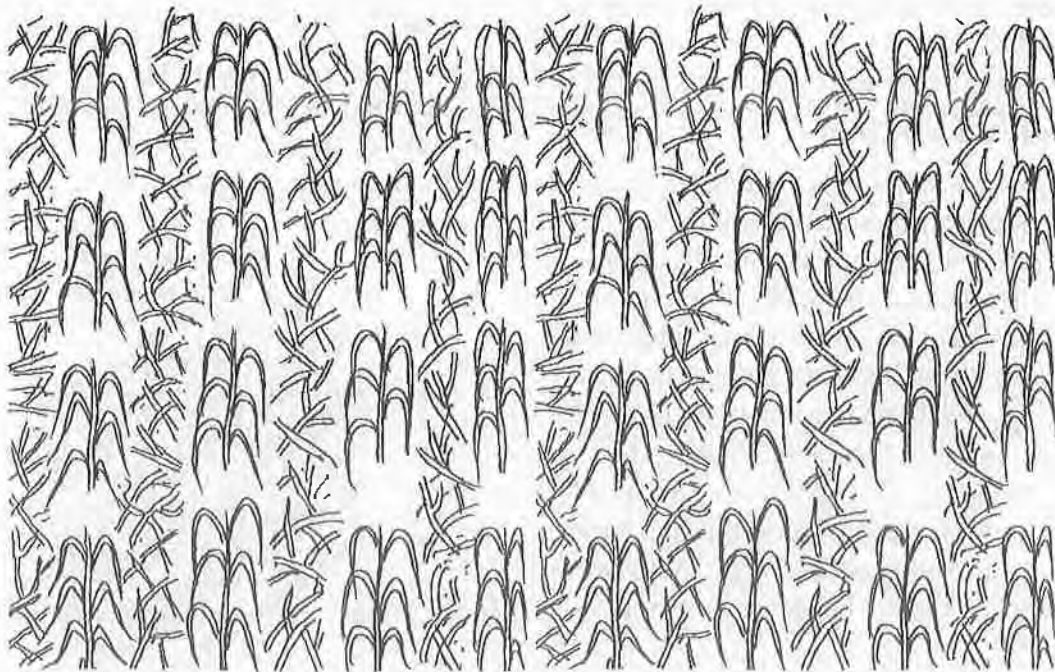
Surface mulching can be further classified into four kinds based on the materials used:

1. Organic materials/residues

Stubbles, crop residues and other organic residues are spread on the surface to reduce evaporation and increase soil moisture.

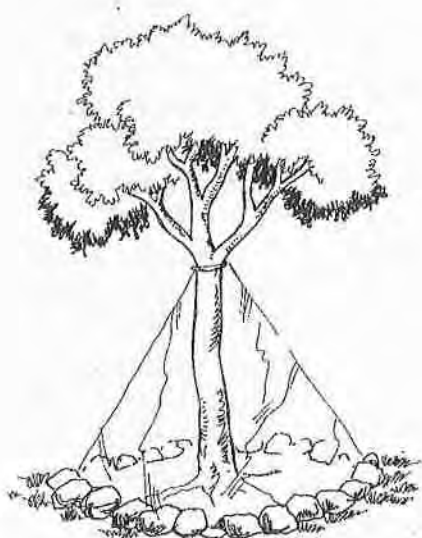
Advantages of mulching

- Intercepts raindrops and reduces run-off and soil loss.
- Suppresses weeds and reduces weeding costs.
- Increases soil organic matter.
- Improves soil chemical and physical properties.
- Increases the soil's moisture-holding capacity.
- Helps to regulate soil temperature.



2. Polythene sheets

Polythene sheets are spread on the soil surface between or around the tree trunk during summer, basically to prevent air circulation. This technique increases the temperature of the soil layer underneath. This, in turn, reduces the germination of weeds and controls soil-borne pathogens. This is known as soil solarisation.



Note

Polythene is a costly input. Cost effectiveness should be considered before adopting this method.

When polythene sheet is used around the tree trunk, care must be taken to provide sufficient space between the tree trunk and the polythene to avoid the problem of stem girdler. Sand and insecticide may be spread near the trunk.

3. Soil/ dust mulch

Long breaks in rainfall result in deep and wide cracks on the soil, particularly Vertisols, that increase the rate of evaporation through more surface area exposure. Dust mulching includes opening ridges and furrow at 90 cm intervals, 45 days prior to planting. Seeds are sown in two rows in the furrow and ridges are broken during first inter-culturing. This results in an adequate dust mulch. Frequent inter-culturing during the crop growing period using a shovel teeth hoe penetrates deep breaks and prevents evaporation.

4. Pebble mulch

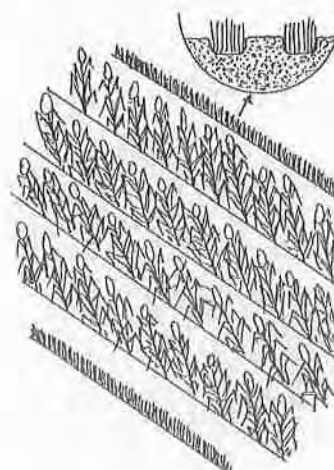
A uniform layer of pebbles on the soil surface will prevent transfer of heat from the surrounding air to the soil, reducing evaporation losses. It also helps control run-off water effectively. This is suitable for fields where pebbles in large quantities are present. It is also favourable for trees in the initial stages.



Vertical mulch

This involves opening of trenches of 30 cm depth and 15 cm width across the slope at vertical intervals of 30 cm. Sorghum stubbles/red gram/cotton stalks are stacked vertically in these trenches. The stalks should protrude up to 10 cm above the ground. These vertical mulches act as intake points and divert run-off water to sub soil layers.

This is ideally suited to soils with high clay content and low infiltration rate. Vertical mulch conserves moisture better than other methods during drought periods.



Live vegetative barriers

Under this mulching method, *subabul* is planted in the field and *gliricidia* on the contour keylines. They act as vegetative barriers and effective mulch. When *subabul* and *gliricidia* leaves are cut and spread in the field, it improves soil moisture and also supplies about 20 to 30 kg nitrogen per hectare.

Effect of mulches on crop productivity in drylands

Station	Crop	Mulch adopted	Productivity (qtls/ha)	
			with mulch	without mulch
Hoshiarpur	Maize	Basoti mulch	42.0	30.9
	Wheat	Basoti mulch	30.0	21.2
Rewa	Wheat	Paddy straw	17.2	11.5
Varanasi	Maize	Wheat straw	5.7	4.7
Akola	Cotton	Vertical mulch	10.3	8.0

Limitations of mulching

- May attract pests and diseases.
- Not applicable in wet conditions or under prolonged dry spells.
- Difficult to spread evenly on steep lands.
- Some grass species used as mulch may root and pose a problem as weed.

Factors affecting the adoption of mulching as a conservation technique

- Insufficient availability of mulch materials.
- Farmers burn crop residues instead of returning them to the soil.
- Labour for collecting mulch and applying could be a problem.
- Mulch is perceived to be more important in home gardens or for valuable horticulture crops than in less intensive farming systems.

Contributors: M. B. Guleed, S. L. Patil and H. Mallikarjun

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Composting using bulky and concentrated sources of organic matter



Composting using nutrient-rich, bulky and concentrated sources of organic matter may help control pests like termites.

The Aga Khan Rural Support Programme (India) [AKRSP(I)] promoted the idea of preparing mix manure composting through its extensive framework of village institutions.

A project in five villages involving a total of 10 farmers, attempted to address the following problems:

- deterioration in the quality of organic manures manufactured and marketed by some profit-oriented companies based in Gujarat;
- untimely and insufficient availability of phosphatic fertilizers;
- poor soil fertility with low humus content; and
- the need for effective use of farm waste and dung.

The experience and process presented below is based on AKRSP's field based trials in Gujarat.

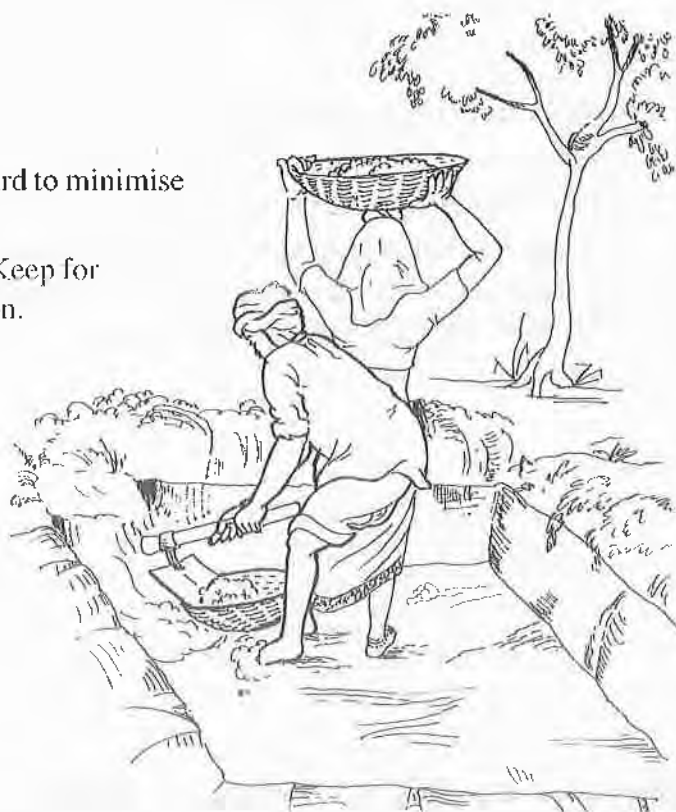
Composting process

The base of the pit should be relatively hard to minimise the leaching of nutrients.

Plaster the upper most surface with soil. Keep for 2½ - 3 months for adequate decomposition.

Spray water over the pit at intervals of 10 days.

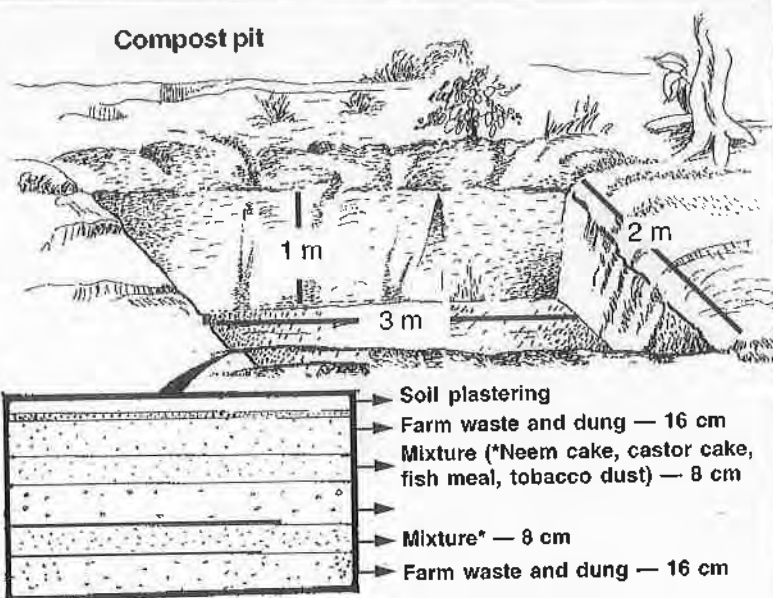
Turn the entire material in the pit once after a month during the composting process.



Time requirements

1. Pit digging: 3 m x 2 m x 1 m – 5 days
2. Mixing various bulky and concentrated organic matters, except farm waste and dung (i.e., neem cake, castor cake, fish meal, and tobacco dust) – 1 day
3. Layering the pit with organic mix and farm waste + dung in the proportion of 8 cm: 16 cm – 1 day (each layer to be lightly watered before sealing the top)
4. Sealing the top with soil plaster
5. Watering the top once in 10 days

Compost pit



Cost comparison of composting

Mixed manure composting	Compost available in the market
Rs. 55/ 50 kg (includes the 20% loss in weight after composting is over)	Rs. 80/50 kg

Type and quantity of materials used

Sl. No.	Material	Quantity (kg)	Price (Rs.)
1	Neem cake	70	245
2	Castor cake	140	240
3	Fish meal	80	160
4	Tobacco dust	100	130
5	Farm waste and dung	800	150
	Total	1,190	925

Micro-nutrient analysis

Village	Plot	Fe	Mn	Zn
Samatpar	Control	5.5	6.3	1.5
	Compost	7.5	9.4	3.2
Piyava	Control	3.9	5.0	0.78
	Compost	4.3	7.5	1.18
Dhandhalpur	Control	4.5	5.3	0.72
	Compost	20.0	9.0	2.3

* Analysis carried out by Dr. K P Patel, Unit in charge, Micro-nutrient Department, BA College of Agriculture, Anand, GAU

Benefits of composting

- Produces desired quality of compost material.
- Improves soil fertility and physical property.
- Decreases phosphorus application.
- Provides majority of the nutrients for crops.
- Can be done in 2½ - 3 months.

Contributor: Manish B. Pandya

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The first part of the book is devoted to a general survey of the history of the world, from the beginning of time to the present day. The author discusses the various stages of human civilization, from the earliest times to the modern era. He traces the development of the human mind, from the simple instincts of the primitive man to the complex reasoning of the modern philosopher. He also examines the progress of the human body, from the crudest forms of life to the most refined and perfect of the human race. The author's treatment of these subjects is both comprehensive and concise, and he presents his conclusions in a clear and logical manner. The second part of the book is devoted to a detailed examination of the human mind, and the various faculties which it possesses. The author discusses the nature of the intellect, and the different kinds of knowledge which it can acquire. He also examines the various emotions and passions which influence the human mind, and the different ways in which they can be controlled. The author's treatment of these subjects is both thorough and penetrating, and he presents his conclusions in a clear and logical manner. The third part of the book is devoted to a detailed examination of the human body, and the various organs and systems which it contains. The author discusses the nature of the body, and the different kinds of life which it can support. He also examines the various diseases and disorders which can affect the human body, and the different ways in which they can be cured. The author's treatment of these subjects is both thorough and penetrating, and he presents his conclusions in a clear and logical manner. The fourth part of the book is devoted to a detailed examination of the human soul, and the various faculties which it possesses. The author discusses the nature of the soul, and the different kinds of knowledge which it can acquire. He also examines the various emotions and passions which influence the human soul, and the different ways in which they can be controlled. The author's treatment of these subjects is both thorough and penetrating, and he presents his conclusions in a clear and logical manner. The fifth part of the book is devoted to a detailed examination of the human world, and the various nations and peoples which it contains. The author discusses the nature of the world, and the different kinds of life which it can support. He also examines the various diseases and disorders which can affect the human world, and the different ways in which they can be cured. The author's treatment of these subjects is both thorough and penetrating, and he presents his conclusions in a clear and logical manner. The sixth part of the book is devoted to a detailed examination of the human future, and the various possibilities which it contains. The author discusses the nature of the future, and the different kinds of life which it can support. He also examines the various diseases and disorders which can affect the human future, and the different ways in which they can be cured. The author's treatment of these subjects is both thorough and penetrating, and he presents his conclusions in a clear and logical manner.

5 Alternative land use management

Composite land use systems

Alternate land is defined as an **effective economic utilization of land without harming the natural resource structure based on land capability**. This involves the addition of a perennial component which has drought tolerance, can withstand the aberrations of monsoon and imparts stability to production.

The Central Research Institute for Dryland Agriculture (CRIDA) identified six basic principles that determine the success of any alternate land use system. These depend on components like soil, climate, native vegetation and socio-economic aspects.

CRIDA research experiences

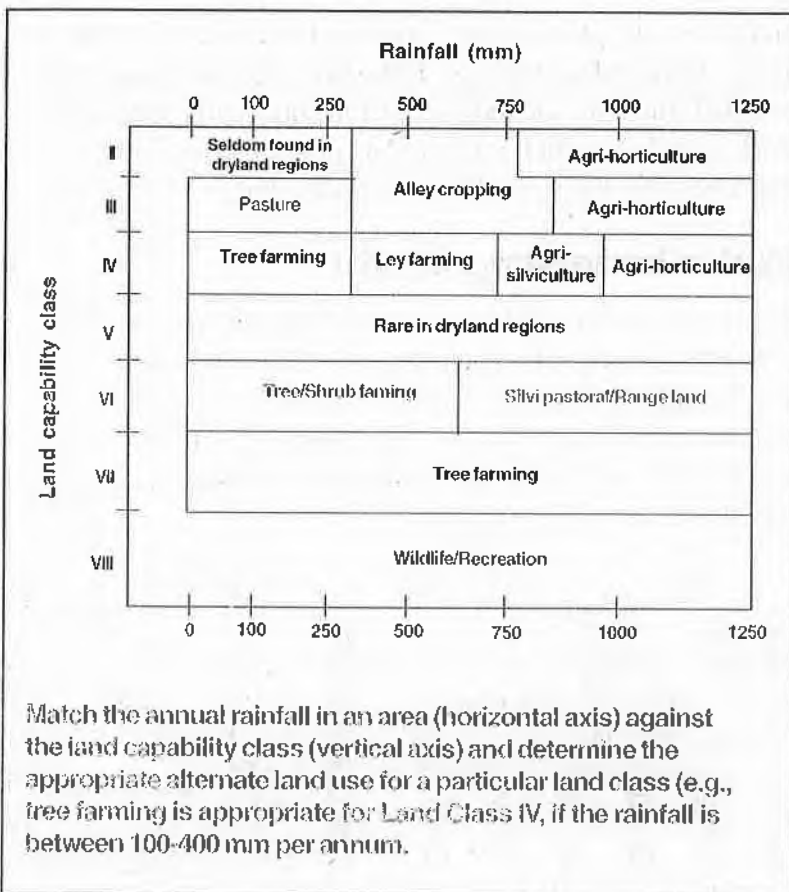
Several experiments were conducted by CRIDA on alternate land use systems during the past 15 years.

There is a continuous competition between trees and crops for soil water and light; the competition is more for light than for soil water. It determines the dry matter production of crops. Crops are more compatible with short shrubs than tall trees.

Why composite land use system?

To achieve better yields from low returns from drylands, varied systems are devised. Experiments over the years suggest wide range of applications. Several schemes were implemented to bring millions of hectares of economically-marginal or environmentally-sensitive cropland, forest and waste lands into sustainable use.

Instead of individual effort, a community approach, as in a watershed, will maximise benefits. Institutional support will be necessary.



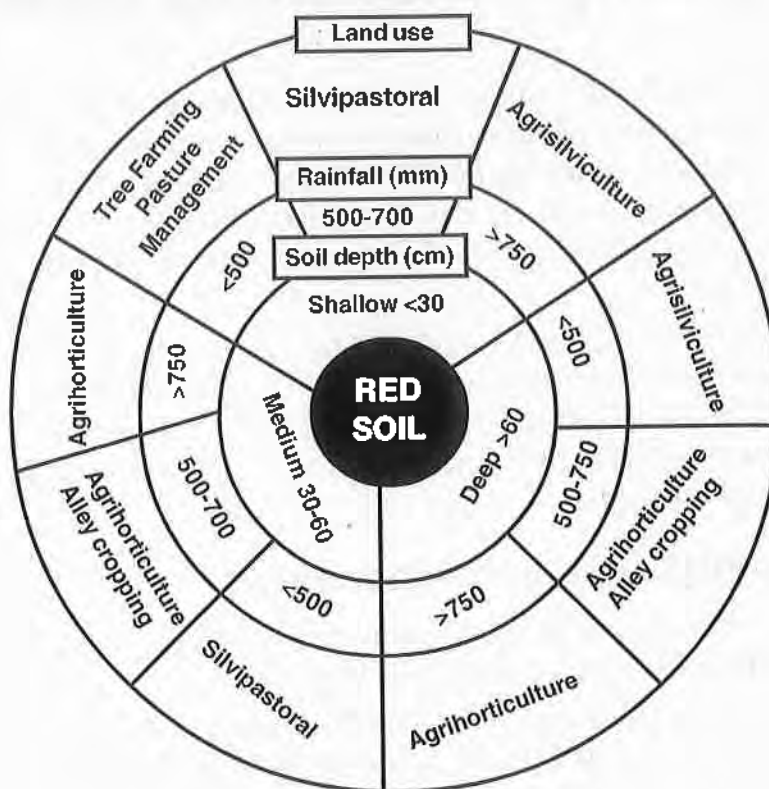
Basic principles

- Selection of a suitable land-use model.
- Identification of trees or shrubs that are not relished by livestock.
- Level of competition between bushes and crop for soil water and light is minimal.
- Consider the farmers' preference for fruit plants.
- Improved planting spot (dug out pit).
- Undertake *in situ* water harvesting (individual basin) measures.

Various models

- Agri-horticulture
- Agri-silviculture
- Alley cropping
- Ley farming
- Silvipasture
- Tree farming

Alternative land use options for red soils



Dryland horticulture

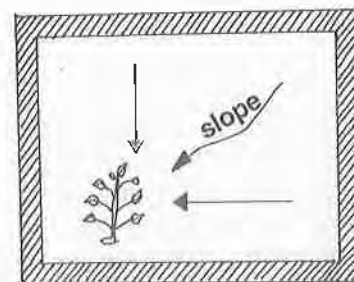
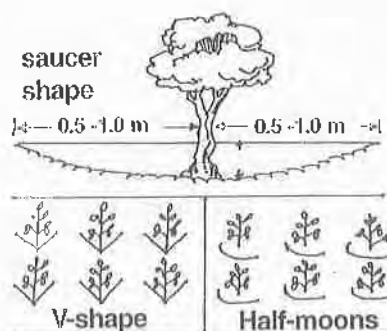
Improving the planting site is the key to success. Dug-out pit is the suggested technology. Filling the pit with a mixture of original soil, tank silt and compost in equal parts and paddy husk as surface mulch is ideal. The mixture effectively conserves and helps infiltration of rainwater.

Which fruit trees should be selected

- Experience showed that generally, custard apple, guava, tamarind, wood apple, amla and jamun were highly suitable for cultivation in drylands.
- The agri-horticulture system involving ber and grain legumes/vegetables gave higher yields than ber alone. Similarly, ber with 2 or 3 irrigations at appropriate times, gave very high returns on deep black soils with 650 mm annual rainfall.

Water harvesting *in situ*

Suitable reshaping of the land surface near the trees will help in harvesting a greater percentage of water whenever it rains. It will ensure collection of runoff water in the root zone, improving the chances of survival manifold. CRIDA recorded 26% increase in survival of custard apple trees, attributable to reshaping.



Alley farming

Alley farming is an alternate land use system where crops are grown in alleys formed by hedgerows of trees or shrubs. It involves three critical considerations, namely choice of crops, alley width and pruning heights. Short duration crops like pearl millet are advantageous to grow in semi-arid tropics (SAT).

To avoid unhealthy competition between the trees and crops for moisture, it is more profitable to plant hedgerows on contours with 10 to 20 m spacing. To avoid competition for light, adopt a hedge cutting height of 15 cm.



Why ecological interaction between trees and crops?

Trees control soil loss and runoff water. They improve soil properties through efficient nutrient recycling and nutrient conservation.

A combination of annual crops and trees/bushes can increase biomass production because of differences in their rooting depths.

Trees/bushes are less prone than annual crops to extreme soil and climatic conditions — they ensure at least some returns even if the crops fails.

Ley farming

Ley farming aims to generate *in situ* fertility through rotation of legume forages with cereals. Inclusion of a legume fodder in rotation in SAT conditions improved soil quality and increased yields of sorghum. It is equally important for increased fodder production, a critical component in rainfed farming.

Silvipasture

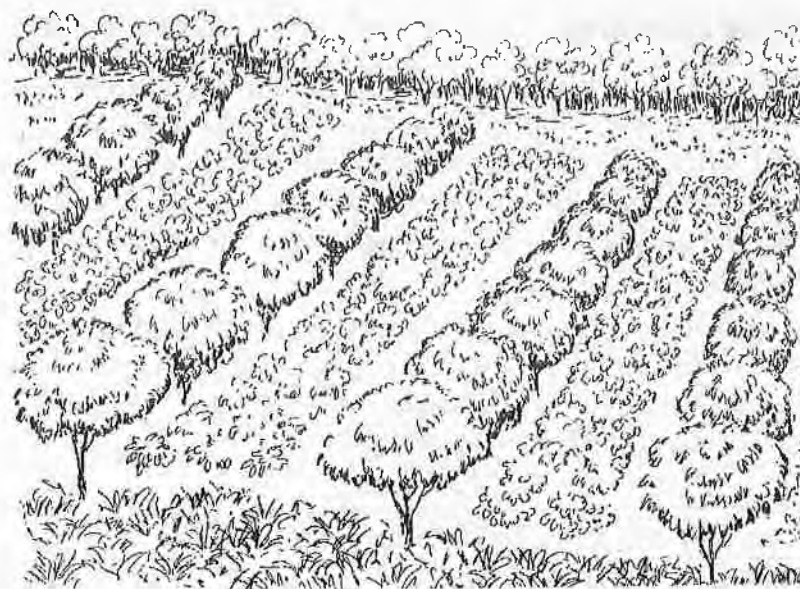
Marginal drylands, generally shallow and poor in nutrients, can also yield better returns through fuelwood and fodder. After six to eight year rotation, even arable crops can be grown on built-up soil fertility, without further fertiliser application.



Management of non-arable lands through silvipasture

It is found that African babul, a nitrogen fixing tree with 8 m x 8 m or more spacing, suit in inter cropping with black gram, green gram or ground nut. Similarly, bush farming using henna, curry leaf, jatropa, perennial pigeonpea, is compatible with crops.

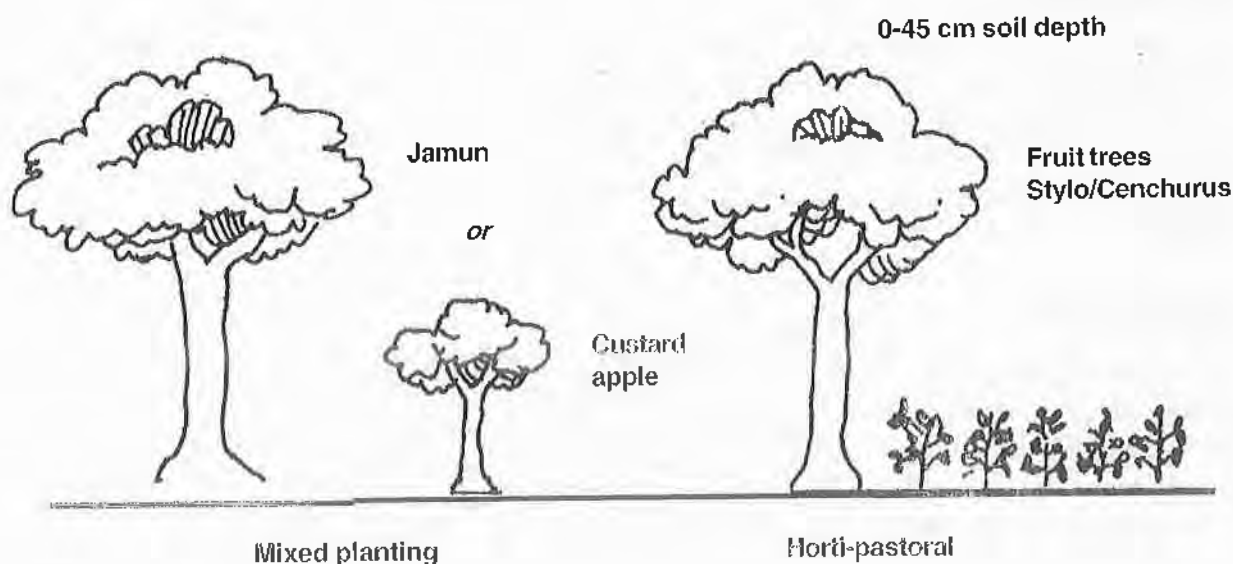
A combination of top feed trees like subabul and stylo legume or buffel grass was found ideal for non-arable drylands.



Bush farming: Minimal competition between bushes and crops.

Tree farming

Not all varieties of trees are suitable under this system. CRIDA conducted trials on 60 species and two thirds of them could survive. Subabul and maharukh were found promising for fodder and paper pulp while paradise tree is good for oil.

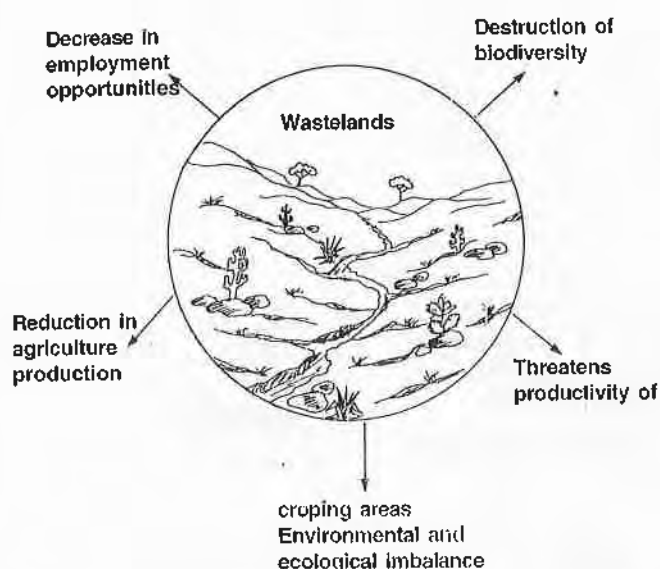


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Contributors: M. Osman, G.R. Korwar and J.C. Katyal

Sustainable development of wastelands through afforestation

Over 30 to 50% of land in India are wastelands. Current conservation methods of rain water in these lands are not effective resulting in flooding of rivers in monsoon, scarcity of drinking water in summer and indicating a prelude to desertification.



Types of wastelands

- Sand dunes
- Shallow gravelly
- Soils of high pH
- Fertile soils with moisture stress

Causes of wasteland formation

- Deforestation and overgrazing
- Soil erosion and moisture scarcity
- High or low pH due to soil composition, excessive irrigation and poor drainage
- Severe biotic pressure and poor management.

Effective management of afforestation in wastelands

Soil and moisture conservation

- Contour bunding
- Staggered trenches (2 to 3 m long)
- Formation of farm ponds
- Gully plugging
- Continuous ridges and furrows along the contours (in slopy land)

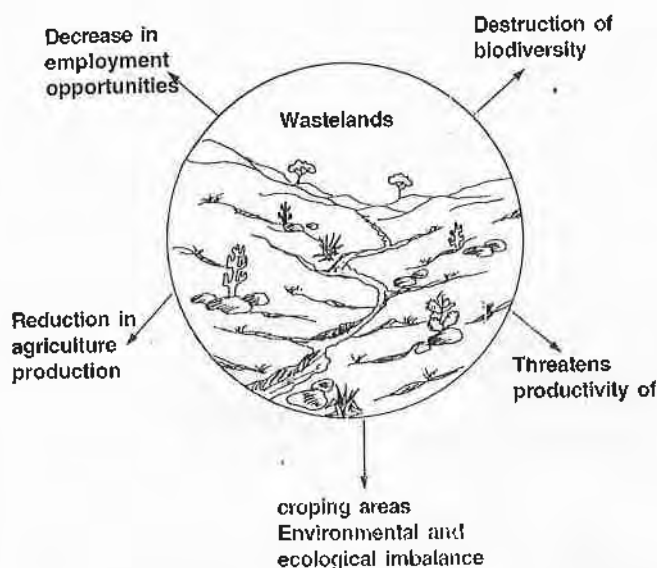


Strategies to combat wasteland formation

- Soil and moisture conservation
- Protection from biotic pressure and fire
- Enhancing soil fertility
- Promoting vegetative cover
- Plant protection and optimal plant density
- Timely harvest of the produce
- Support for post-production activities to sustain interest in caring for land.

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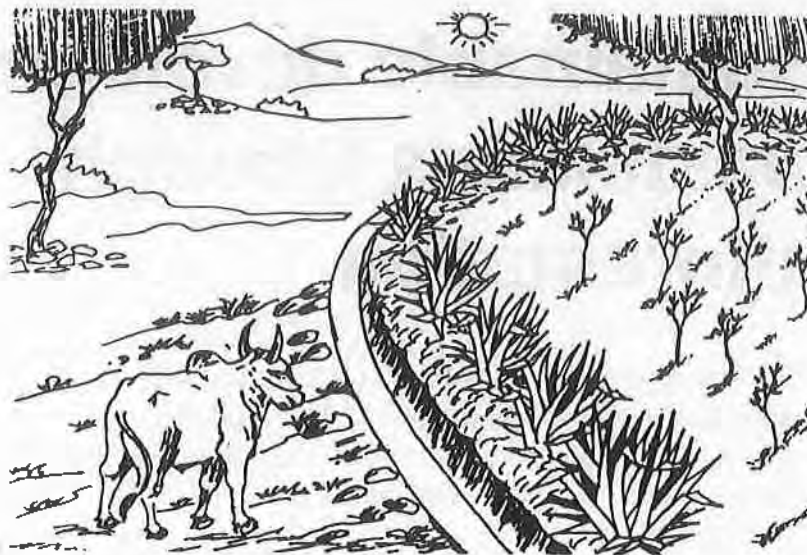


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Prevention of stray grazing

Cattle proof trenches and mounds should be made around the boundary. Trench should be 1.0 m wide, 70-90 cm deep. The mound should be on the innerside of the boundary. Live hedges can be planted on these mounds (see box on the other page for livehedges species).



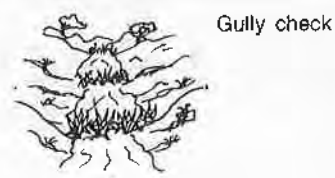
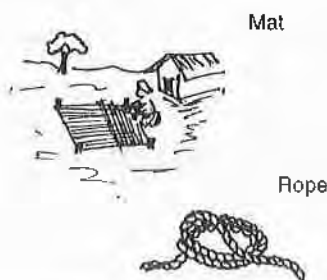
Enhancing soil fertility

Application of fertiliser is expensive and may not yield desired results. Alternative methods, which are less expensive and more environment-friendly, can be adopted. Factors which enhance soil fertility are: farmyard manure and compost; green manure; biofertilisers; and earthworms.

Agave is preferred for fences because of its adaptability to drought, easy management and ability to form an effective fence, as well as its multiple uses.



Uses: About 10,000 plants can be planted on contour bunds in a hectare. This yields leaves worth Rs. 5,000-6,000 from which fibre is extracted.



After establishing contour bunds and live hedges, the interspace can be used for arable crops, forage and forestry, depending on soil productivity and moisture availability. Species with non-wood produce may be grown so that farmers can generate income without cutting the tree.

Tree Planting

Criteria for selecting of trees

- Soil and climatic adaptability
- Soil fertility
- Moisture
- Growth rate
- Biotic interference
- Multiple uses
- Value of the produce
- Demand for the produce
- Potential for higher income
- Scope for additional employment

Species for livehedges

Common name	Botanical name	Uses
Sisal agave	<i>Agave sisalana</i>	Non-browsable, drought-resistant, yields twines, used in ship-cordage, webbing and sacking, paper making, hardware production; also useful in erosion control (Gully checks)
Shikakai	<i>Acacia rugata</i>	Yields fuel, reduces soil erosion and serves as cleaning powder
Agave	<i>Agave cantala</i>	Non-browsable, checks soil erosion, of commercial value, used in rope making, cordage, mats, twines and nets
Molucca bean	<i>Caesalpinia crista</i>	Reduces soil erosion
Coral tree	<i>Erythrina variegata</i>	Non-browsable, soil and water conservation
Thor	<i>Euphorbia</i> sp	Non-browsable, of medicinal value
Jatropha	<i>Jatropha carcus</i>	Non-browsable, soil and water conservation
Lantana	<i>Lantana camara</i>	Non-browsable, resistant to adverse conditions, improves fertility of exhausted areas and rocky gravelly or hard infertile soil, used in soil conservation, adds humus, green manure, convertible to compost
Kewada	<i>Pandanus odoratissimus</i>	Non-browsable, soil binder, controls erosion from wind and water, shelter belt to sand drifts, of food value, used in making paper, ropes, cordage, hats, baskets, umbrellas and fancy articles, roots for brush and basket making.
Horse bean	<i>Parkinsonia aculeata</i>	Used as fuel, fodder, paper making, of medicinal value
Vilayati babul	<i>Prosopis juliflora</i>	Immunity to grazing, yields firewood, fodder.

Tips

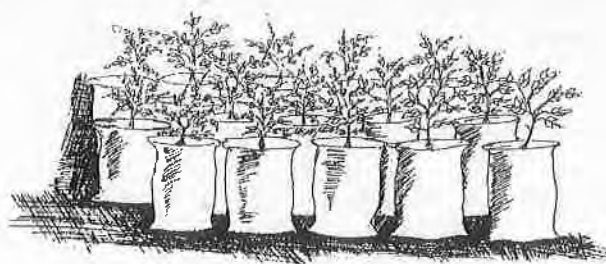
Seedling should be of proper age and size.

Direct seeding is cheaper but growth may not be satisfactory in poor sites of dry areas.

Fruits and seeds of superior varieties, and early fruiting may be obtained through grafted / budded plants, raised through tissue culture.

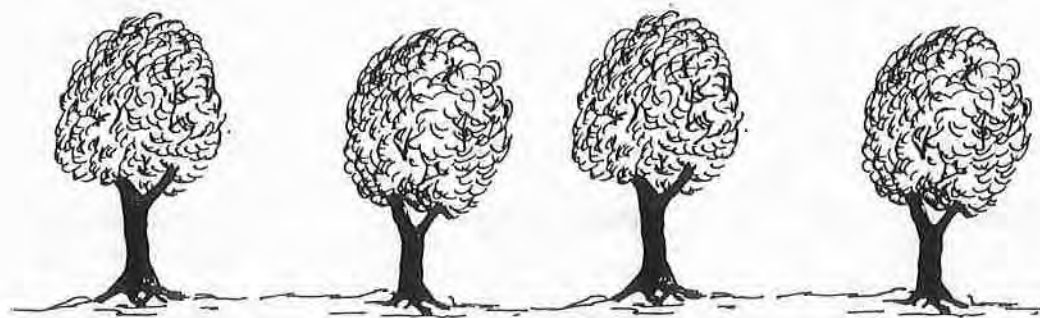
Planting

Seedlings of 30-40 cm height, raised in polythene bags are ideal for planting.



Spacing

Density of 1,500 to 3,000 trees per hectare is preferable, depending on soil fertility, moisture availability and canopy spread of trees.



Marketing and management

Facilitate promotion of infrastructure and information services for effective people's participation. Timely harvesting and marketing can be arranged on a joint/cooperative basis through farmers' organisations. With the opening of profitable marketing options, people's interest in the regeneration of wastelands will grow.

Conservation of moisture

- Contour bunding
- Mulching
- Planting of shrubs and trees as shelter belt around the boundaries of plantations
- Creation of a small basin around each tree/a partial ring towards the lower side of the slope

People's participation

Families are reluctant to develop wastelands for a variety of reasons, financial constraints being one of them.

Avenues of finance

- Various banking institutions
- National Wastelands Development Board
- Central and State Governments under various forestry schemes
- Non-government organizations
- Investments on private wastelands by individuals for gainful income-generating activities.

In local government owned wastelands and degraded forests, access can be made-through people's/farmers' organizations.

Contributors: M. G. Hegde and G. M. Vanaja

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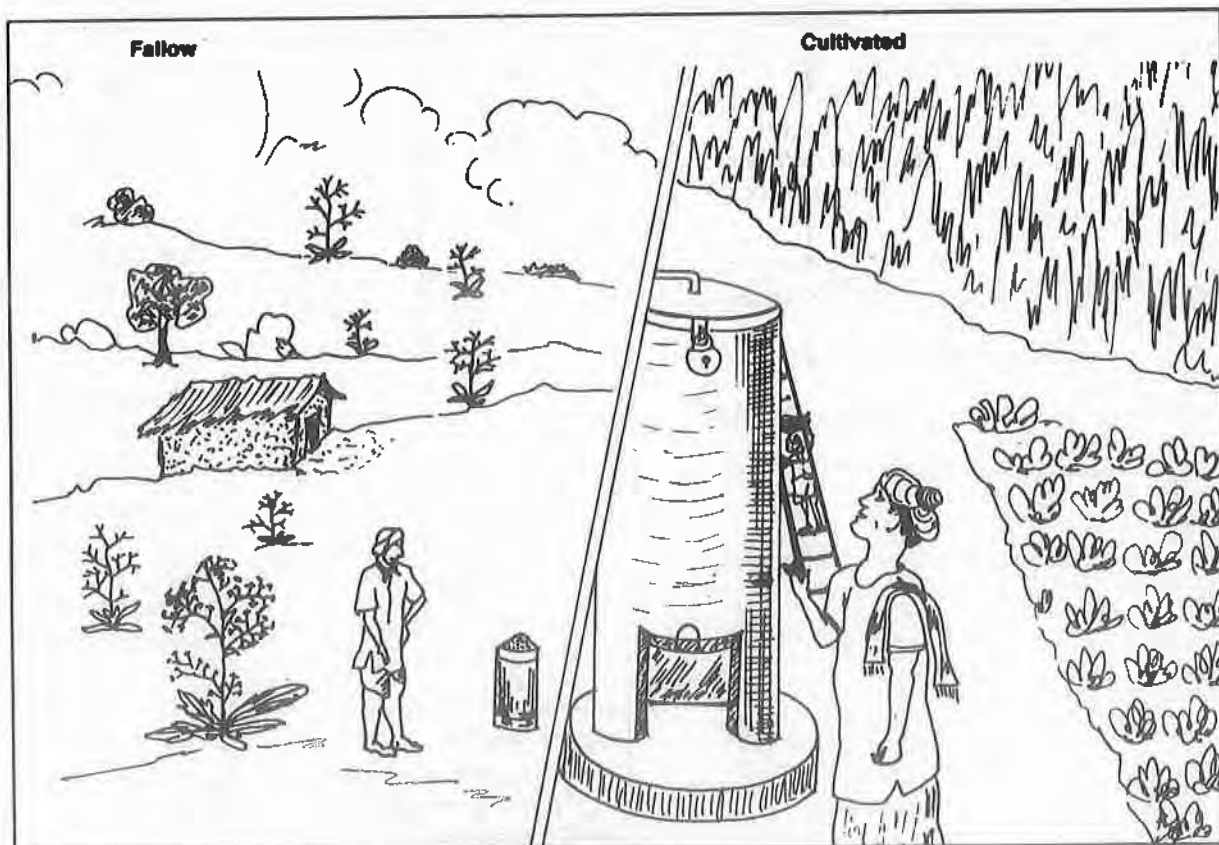
Fallows and village food security in rainfed areas of India

Land use and fallows

- Drylands are vulnerable to land degradation.
- When degradation occurs, it is often self-accelerating and causes irreversible damage to the land.
- Traditionally, lands are kept uncultivated for a period of 6-12 months to prevent stress on land resources; such that lands are called current fallows.
- In current fallows, the soil is protected by vegetative cover which promotes accumulation of vital nutrients in the top soil and increases organic matter in the soil.
- When lands are left fallowed for more than one year extending up to about 10 years or more, these lands are known as emerging fallows.
- In recent years, there has been a considerable increase in area of fallows in drylands in some parts of India due to neglect of rainfed farming.
- The nature, magnitude and time of fallows depend on the farmer's inability and unwillingness to use the land.

What are fallows?

Fallows are arable, uncultivated lands.



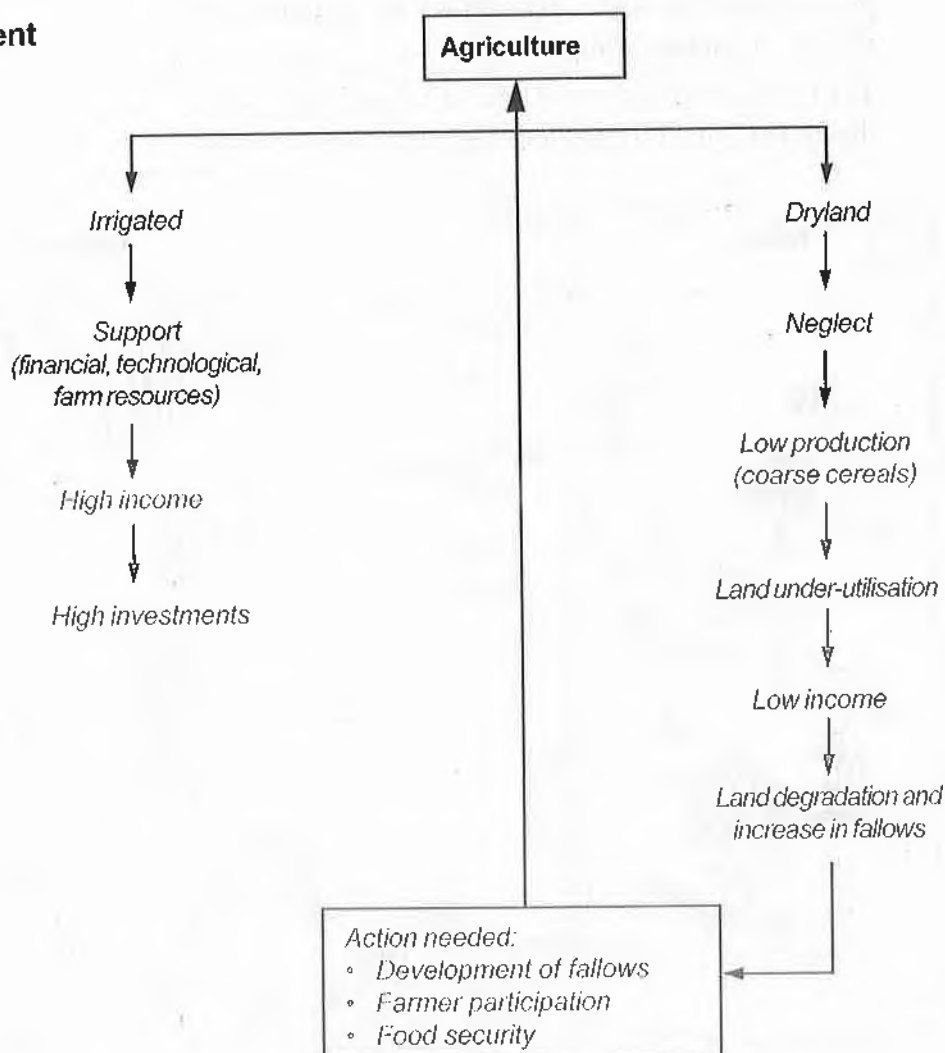
Note

Fallows in India exceed the total area of arable land and under permanent crops of four countries — Pakistan, Bangladesh, Nepal and Japan.

Under-utilisation of land

- Of the total land area of 329 million ha in India, wasteland area is 128.4 million ha. Of this, 82.5 million ha are degraded lands.
- The availability of cultivable land per capita which was 0.48 ha in 1950 is estimated to decline to 0.15 ha by the year 2000. In a related paper (of J.C. Katyal's) in this publication (page 5) it is already 0.15 in 1994-95 and will decline to 0.07 by 2020 AD.
- The area of fallows in India has increased from 10.6 million ha in 1951 to 29 million ha in 1991.
- More than 80% of the fallows are in the states of Andhra Pradesh, Rajasthan, Bihar, Uttar Pradesh and Karnataka.
- In Andhra Pradesh, the area of fallows has increased from 29.5% of total cultivated land in 1960 to 33.3% in 1988.
- Increase in the area of fallows is not due to erratic rainfall alone.
- Economic and technological factors influence land utilisation or under-utilisation.

Land development



Food security

- Farmers in drylands operate in high risk and low productivity farming.
- The major constraint in rainfed dryland agriculture is the resources (land, water, technology, etc.).
- Proper planning and development programmes by government and aid agencies, in partnership with farmers, can provide better opportunities for food security of the farming community.

A case study

The Fallow Land Development Project of the Centre for Environment Concerns (CEC), Hyderabad, was initiated in 1993 in the village of Ibrahimpur, Medak District, Andhra Pradesh, India. At that time, the village had 212 households and a total arable land area of 419 ha, of which, approximately 49% was made up of fallows.

The scheme envisaged by the CEC was to bring the fallows owned by small and marginal farmers (constituting 56% of the total household; another 15% was landless and the rest were medium and large farmer households) under cultivation.

The components of the scheme included: input support for one acre of the land per farmer; tractor ploughing of land (first year only); progressive increase in the use of farmyard manure and decrease in the use of chemical fertilizers. Other components include emphasis on coarse cereal production and crop rotation principle, with sorghum every alternate year; all inputs in the form of loans, with manageable repayment schedules; and all loan repayments in the form of grains valued at the prevailing market rates. The grains, thus, procured would be sold and the proceeds used to grant loans for the next cropping season. The management of the entire scheme is to be vested upon the participants themselves.

Forty-six farmers came forward in the first year to participate in the scheme. A five-member committee of participating farmers (two men and three women) was formed to oversee the scheme. Average costs per acre came to Rs. 2,100, inclusive of tractor ploughing, two tractors-loads of FYM per acre, half a bag of fertilizer per acre, seed costs, and labour costs (in the second year the investments on the same land were Rs.700 per acre - no tractor ploughing, FYM application, and seed purchase - and from the third year onwards, Rs.1,000 per acre - mainly because of more FYM application.)

Results:

- Participation went up from 46 to 85 farmers by 1996.
- Fallows in the village reduced from 49% in 1993 to 25% by 1996.
- Sorghum production increased from 13.5 tonnes in 1993 to 36 tonnes by 1996.
- More than 14 tonnes of grain were purchased by the Village Bin' (godown/ grain bank) for sale and creation of a loan fund.
- Seed stocks produced from the best harvest and sold to participating farmers.
- Landless people enthused to lease fallows from non-participating big farmers for their own use.

Contributor: K. S. Gopal

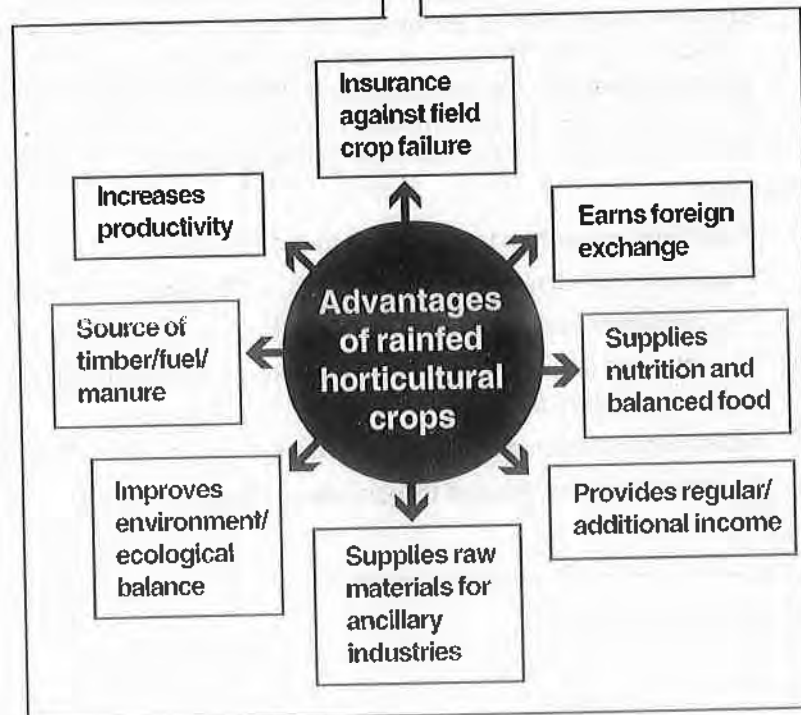
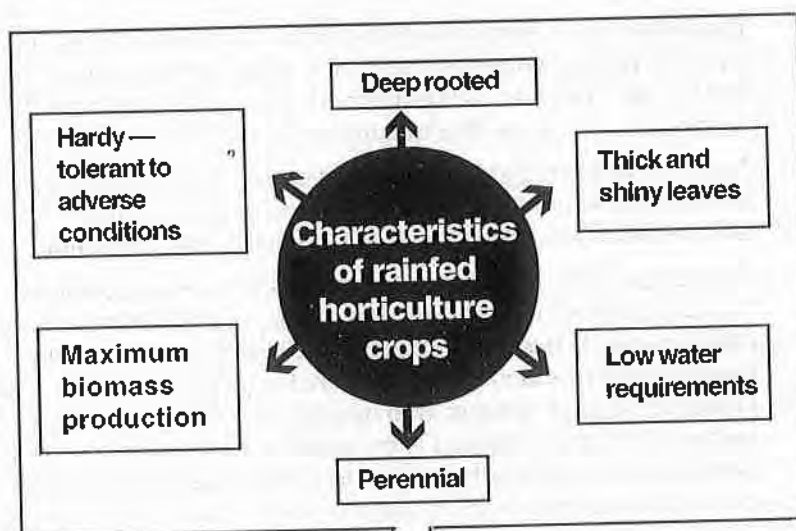
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Principles and techniques of dryland horticulture

Outstanding features of drylands

- Low, erratic and uncertain rainfall with long dry spells.
- Adverse climatic factors like high temperature, low relative humidity and high wind velocity.
- Frequent occurrence of drought and very low water table.
- Generally, soils are highly eroded, poor fertility and with poor water holding capacity.

The uncertainties and scarcity conditions prevailing in dryland areas increase the risks involved in agriculture. Tree-based cropping systems make a viable alternative. Of the various tree-based cropping systems, horticulture offers the most promise towards sustainable livelihoods in drylands.



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Crops suitable for dryland horticulture

Fruit

Mango (*Mangifera indica*); Sapota (*Achras sapota*); Guava (*Psidium guajava*); Ber (*Zizyphus mauritiana*); Tamarind (*Tamarindus indica*); Custard apple (*Anona squamosa*); Woodapple (*Ferronia elephanta*); Jamun (*Eugenia jambulana*); Bael (*Aegle marmelos*); Jackfruit (*Artocarpus heterophyllus*).

Plantation

Cashew (*Anacardium occidentale*); Rubber (*Hevea brasiliensis*)

Vegetable

Drumstick (*Moringa oleifera*); Curry leaf (*Murraya koenigii*); Tomato (*Lycopersicum esculentum*); Chili (*Capsicum annum*); Cluster beans (*Cyamopsis tetragonoloba*)

Aromatic

Lemon grass; Citronella; Khus grass; Bursera

Medicinal

Periwinkle (*Vinca rosa*); Bitter eggplant (*Solanum virum*)

Horticulture based cropping systems

Agri-Horti

Mango + Ber/Custard apple + Oilseeds/Pulses/Cereals

Silvi-Horti

Cashew + Casuarina

Horti-Pastoral

Mango + Fodder grasses

Agri-Horti-Pastoral

Sapota + Legumes + Grasses

Dryland horticulture technologies

- Summer ploughing prior to onset of rains.
- Timely planting with clonal material of high-yielding varieties.
- Planting along the contours.
- Raising of root stocks and *in-situ* grafting.
- Preparation of wider basins around plants.
- Providing of mulch and shade.
- Formation of bunds/crescent bunds.
- Opening of catch pits.
- Provision of micro-catchment area.
- Formation of farm ponds and recycling.
- Adoption of top working technique to rejuvenate old plantations.
- Adopting multi-storeyed/mixed/intercropping systems for fetching additional and sustained returns.

Efficient rainwater management and soil conservation measures are the most important technologies.

Contributors: M. M. Khan and J. Venkatesh



Mulberry as an alternative crop for drylands

Sericulture

Deals with the study of rearing silk worms. It includes the cultivation of mulberry, the rearing of silk worms, silk reeling and weaving. Silk is the natural fibre from the saliva excreted by silk worms in the form of fine thread.

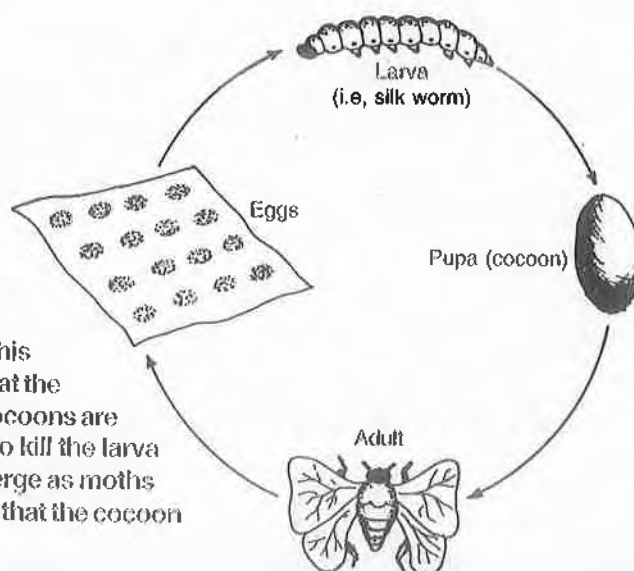
Mulberry is mainly cultivated for rearing silk worm. Most of the silk goods produced in the world are from mulberry silk worms. Mulberry is grown as a dryland crop as it adapts quite well to a wide range of soils with good moisture holding capacity. Mulberry is one of the more promising alternative crops for dryland areas because of its potential for augmenting household income.

Requirements for mulberry cultivation

Though mulberry, like most crops, does better under irrigated conditions, it is a versatile crop that adapts well to even less than optimal conditions.

- It can grow under climatic conditions ranging from temperate to tropical.
- It can grow with as little as 600 mm or as much as 2,500 mm rainfall per annum.
- It can adjust to sunshine of between five and 13 hours in a day.
- It can grow in elevations of up to 800 m above mean seed level.
- Though it requires deep, fertile, well-drained, friable, porous and slightly acidic soils, it can make do with much less, except for rejecting salt-affected.

Stages in the development of the silk worm



For extraction of silk yarn, this development is interrupted at the pupa stage. Fully-formed cocoons are immersed in boiling water to kill the larva which would otherwise emerge as moths by breaking the silk threads that the cocoon is made of.

Recommendations to increase the production of mulberry leaves from drylands

Soil: Red loam soil is ideal

Varieties: Improved varieties like M-5 and MR-2 have advantages over local varieties.

Planting season: The best season is July-August.

Planting method: Cuttings must be from healthy main shoots with three buds. Planting should be done in a slanting position with one bud above the ground level. Follow the row planting or pit planting system for a better yield.

Spacing: Pit planting/row planting — 1 x 0.5 m or 0.6 x 0.6 m.

Manuring: 5-10 tonnes of FYM or compost per ha/year.

Fertilisers: Use 50:50:50 kg of NPK per hectare as a basal dose and 50 kg nitrogen as top-dressing after every leaf harvest.

Ridging: It helps in weeding, prevents water run-off and improves water penetration.

Mulching: Pruned mulberry branches can be spread in between mulberry rows as a good surface mulch. Green manure crops like cowpea, horsegram, sunhemp and *dhaincha* can be grown in between mulberry rows to serve as a mulch.

Pruning: Rainfed mulberry should be initially pruned from July onwards. Pruning is done 3 ft above the ground level for free tillering and maximum development.

Mulberry tree

Field mulberry can be replaced by mulberry tree in areas where there is an extreme problem of animal grazing and wild animals. Mulberry is a perennial tree with less operational costs. These trees can also be grown on earthen bunds (the stability of the bunds is, thus, maintained).



Pests and diseases

Pests and diseases in mulberry crop should be managed by cultural, mechanical or biological means [as far as possible] and not with chemicals. Mulberry crops grown in drylands are less prone to disease and pest attacks and need less chemical pesticides and fertilizers compared to irrigated crops.

Harvesting and leaf yield

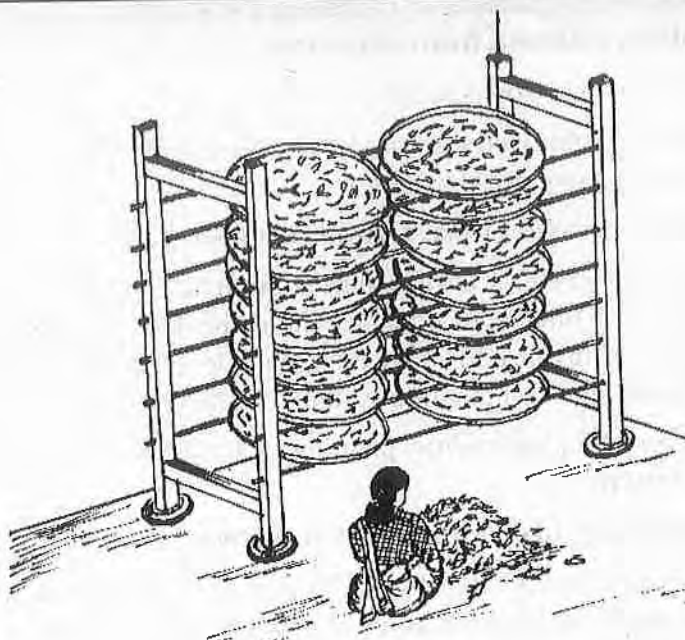
- **First harvest (leaf picking) of rainfed mulberry is done 10 weeks after pruning. This is followed by subsequent harvests at two to eight week intervals.**
- **A dryland crop can give four to five harvests a year.**
- **5000-7000 kg of leaves can be obtained per hectare, per crop.**



Leaf/shoot feeding

After the tiny larvae has hatched, it undergoes four moultings before the pupae stage. Care should be taken to feed the silk worm with sufficient quantity of leaves. Cut the leaves very finely for the first three instars and feed uncut leaves for the last two instars.

In certain areas, sericulturists are also successful with shoot feeding of the larvae with mulberry right from the first stage.



Cost

Approximate average expenditure for mulberry cultivation along with silk worm rearing on one acre (per crop) of land is Rs. 4,000 (average for a year). The income generated is Rs. 12,000. The net profit is Rs. 8,000.

Advantages

Technical

- Agro-based activity for rainfed dry areas.
- Low investment with high returns.
- Grows in a wide range of soils.
- Waste material has use as by-products.
- Easy to learn and adopt the entire technology.

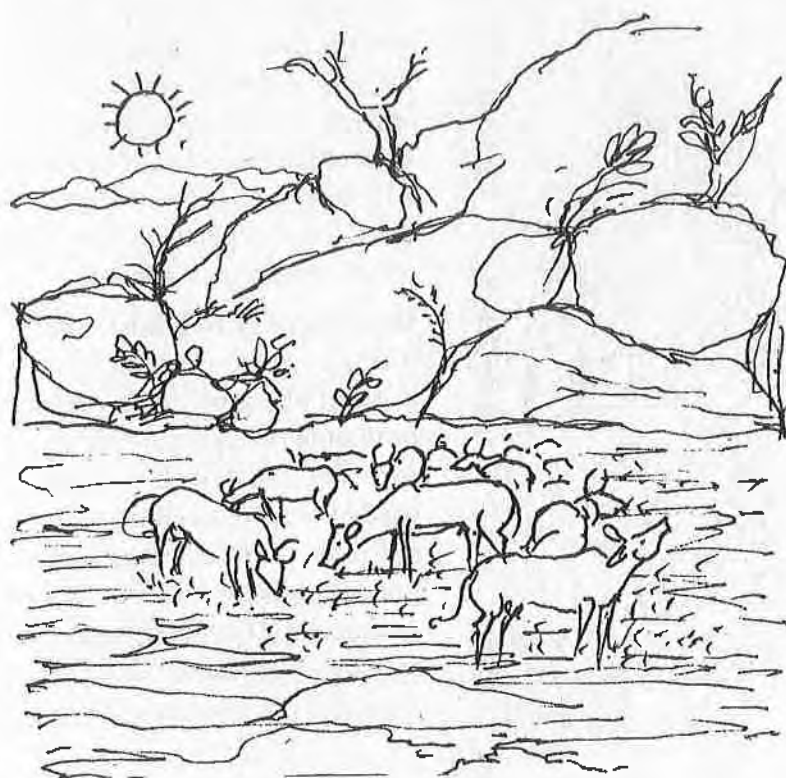
Non-technical

- Labour-intensive activity which generates additional employment.
- Provides self-employment to family members, especially women.
- Mulberry cuttings are easily available from the government, NGOs and farmers.
- Established markets are available in every locality for easy marketing of cocoons.
- Mulberry leaves produced by small and marginal farmers could be sold to landless people interested to pursue silk worm cultivation.

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Contributors: G. M. Chandra Mohan, K. Suresh Babu and Ramachandrappa

Grassland management



In South Asian countries, grasslands account for 80% of fodder required for livestock. With an increased number of livestock, grasslands are deteriorating and species with high nutritive value are at risk of extinction. It is, therefore, essential that grasslands be managed to address these problems.

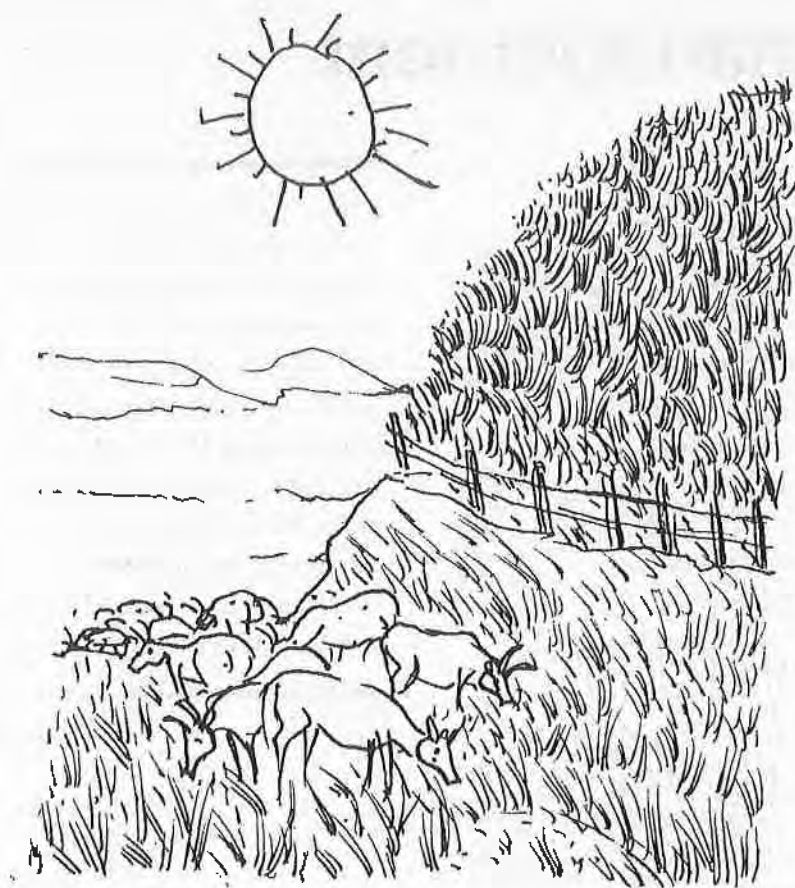
Most grasslands in South Asia, particularly in India, are under tremendous pressure because of increasing population and environmental degradation. Excessive grazing and mismanagement are transforming these grasslands into deserts.

The carrying capacity of a grassland is defined by the number of animals that can graze in a given area without overgrazing and undergrazing in an average season. By identifying this carrying capacity, it is possible to manage the grazing in grasslands to meet the limits identified by the carrying capacity.

By implementing the following management strategies, grasslands can be regenerated and maintained.

Treatments for increasing grassland fodder species

Soil and water conservation is integral to managing grasslands. Erosional processes can be reduced with treatments such as gully plugs, check dams and contour trenching/bunding. In arid and semi-arid regions, conserving rainwater is very important.



Herbaceous and shrubby weeds compete with grasses for moisture and nutrients. To increase availability of fodder species, **control weed** by digging, cutting, burning and using specific herbicides. The spread of other species not suitable as fodder species can be controlled by uprooting or nipping the earheads prior to seed establishment.

Burning of grasslands is the method used to eradicate weeds and shrubby growths as well as providing rich nutrients to the soil. Caution though must be used in areas receiving less than 600 mm of rain and where annual grasses predominate. Areas with perennial and rhizomatous grasses and higher levels of rain can be burned every alternate year.

Seeding for regenerating grassland areas can be successful with highly degraded grasslands immediately before the next monsoon, after a burning period. Seeds should be sown before the first rain when there is no fresh growth of existing grasses. Preferably, mix fresh seeds with cow manure and clay to form pellets, which will not be carried away by wind or water.

Fertilizers (such as manure, nitrogenous and phosphatic fertilizers) can be broadcasted to restore productivity of grasslands where continued removal of grass cover and consequent leaching depleted the soil of its nutrients.

Establishing a grazing system for grasslands

Important factors to consider in grazing systems are the number of animals, type of animals, type of grassland and the extent of grassland available. These factors, together with knowledge of the carrying capacity, can be used to identify an appropriate grazing system. The following options can be considered to manage grazing in a grassland area:

- **Controlled continuous grazing** is done when grazing continues until a set minimum amount of preferred grasses remain, then it is stopped. This system is easy to manage and involves no additional costs.
- **Deferred grazing** delays grazing in part of the grassland area until after seed maturity. The grassland is divided into three compartments alternatively. One compartment is completely closed to grazing during the growing season, while it is allowed in the other two compartments. Once the vegetation in the closed area has matured, grazing will be allowed in this section also. Selection of deferred area is rotated each year so that each compartment gets an adequate period of rest during which plants could recoup their vigour.
- **Rotational grazing** allows the grazing animals into different sub-units of the grassland area in rotation over the course of the grazing season. This provides young herbage for the animals and provides a period of rest during the growing season.
- **Hohenheim grazing** was developed in Germany during the First World War to increase milk production. The strategy involves ranking and separating dairy cattle according to their ability to produce milk. These cattle are rotated through equal sized plots of grasslands in such a way that the best milk producers will have first access to the most nutritious grazing.
- **Deferred and rotational grazing** involves dividing the area into three parts and rotating the grazing through these parts during the season. Each compartment is grazed for one third of the season and protected during seed maturation. Assuming the grazing period of three months, the grazing plan would follow this pattern:

	July	August	September
First year	I	II	III
Second year	II	III	I
Third year	III	I	II

Case study

Social fencing for the protection of fodder species

During a PRA in Sanipalli village (1989), the residents discovered that something had to be done on the barren hills surrounding their lands. For the previous 15 years, the land was used as grazing land, and was in a very degraded state. Through the Social Education and Development Society (SEDS) project funded by HIDAM/RADA, treatments were recommended. Soil and water conservation measures were applied and social fencing was used to keep grazing animals out of 1,200 acres. To keep the grazing animals out, the boundaries of the area were painted with white wash on boulders as markers to keep shepherds from grazing their animals inside these boundaries. Among the many benefits resulting from this project, 200 cart loads of fodder are available for harvest by eight villages every season.

*Case study contributed by:
Rajen Joshua*

Contributed by: S. Gumaste

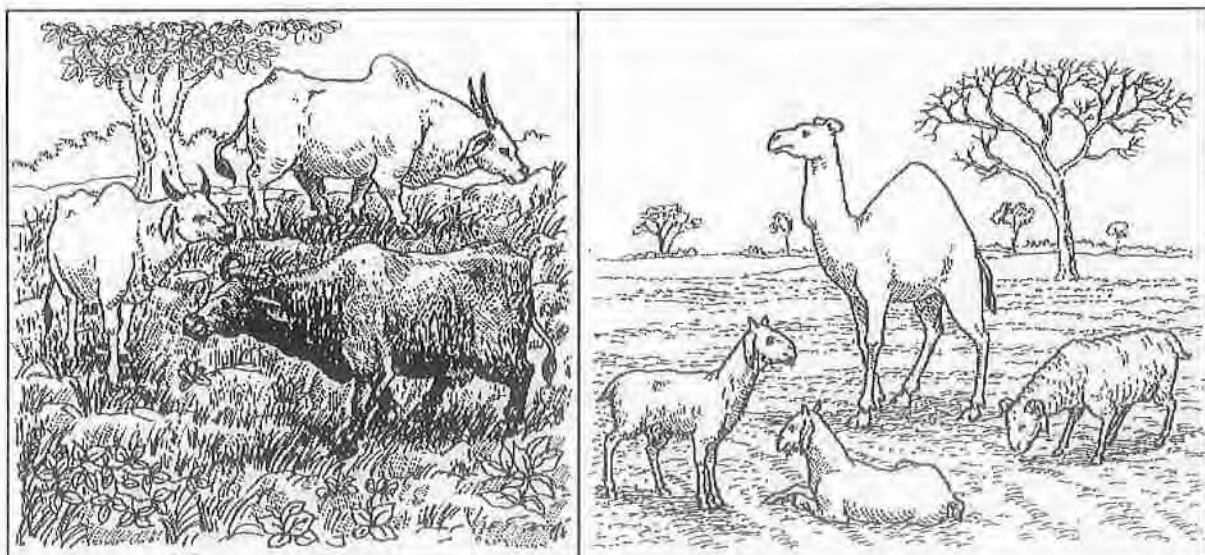
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Useful trees for arid and semi-arid areas



In arid and semi-arid areas, the main problem is the limited quantity of quality irrigation water. Rainfall is limited and temperature is high, especially during the summer season. These contribute to the scarcity of food, water, fuel and fodder.

Most farmers keep camel, sheep and goat because they can resist dry conditions. Cows, oxen, and buffaloes are less common due to shortage of fodder and water. Hence, trees which can provide fodder even during summer months, are needed.



Useful plant species

For strong roots and conservation

Soils in many arid and semi-arid areas, being sandy, are prone to wind erosion. To conserve these soils and check the spread of deserts, trees with well-developed root system are selected.

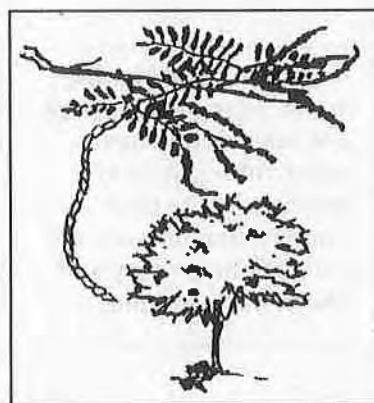
1. *Caparis decidua* (teend) and *Caparis aphilla* (dele)
2. *Prosopis juliflora* (vilayati babool)
3. *Azadirachta indica* (neem)
4. *Albizzia lebbeck* (siris)



For fodder and fuel

Due to the kind of animals maintained, the production of dung for dung cake is limited. Therefore, farmers depend largely on trees for fuel.

1. *Prosopis juliflora* (vilayati babool)
2. *Prosopis cineraria* (khejari)
3. *Acacia nilotica* (babul) and *Acacia tortilis* (israeli babool)



For income and nutrition

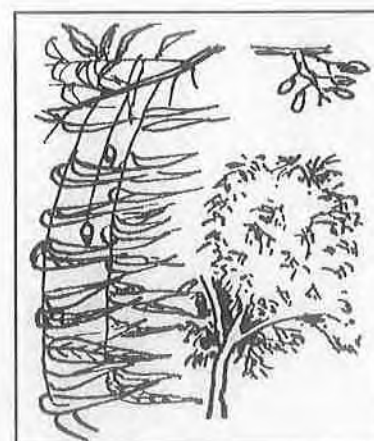
In some areas, good quality water is available which may be due to rain water collected in ponds/lakes. The other source is canal water. Under such conditions, fruit trees can be planted to provide more income as well as nutrition.

1. *Zizyphus mauritiana* (ber)
2. *Punica granatum* (pomegranate)
3. *Tecomella undulata* (rohira)
4. *Phoenix dactylefoum* (date-palm)

For salt-affected areas

In some parts of arid regions, soils are salt-affected. Many of these areas have brackish ground waters for irrigation. For such areas, only salt-tolerant trees can be planted.

1. *Prosopis juliflora* and *Acacia sp.*
2. *Prosopis cineraria*
3. *Azadirachta indica*
4. *Caparis aphilla*





Note

Before planting, it should be ensured that seedlings are at least three to six months older than under normal conditions.

Along with trees, grasses can also be planted.

Cenchrus is one of the suitable grasses for dryland areas. Under such conditions, multi-purpose trees like *Prosopis cineraria* are suitable.

In some canal-irrigated areas, water logging and soil salinity had developed. Although land drainage is the best remedy, planting of trees can also help delay and check water logging.

Planting techniques

For semi-dry and dry areas, tree saplings should be planted during the rainy season. In the initial stage, necessary care should be taken to conserve rainwater to ensure sufficient moisture in the root zone.

- Some small and marginal farmers plant trees along with cultivable crops.
- A suitable combination of crops with trees should be adopted for optimum returns.
- Excess number of trees may result in problems of birds, shade and nutrition competition. In such situations, the number of trees should be reduced.

Irrigation techniques

The irrigation technique adopted depends on the nature of the soil and trees to be grown.

Alkali (usar) soils

A small pit of 60 x 60 x 60 cm size should be dug. The pit should be filled with the mixture of farmyard manure (5 kg), gypsum (5 kg) and sand (5 kg). After refilling the pit, the saplings should be planted. Special care should be taken to guard the saplings against termites.

Hard layer (kankar)

An auger hole 15 cm in diameter up to 150 cm depth should be made with the help of a tractor driven auger. Soil from the auger hole should be mixed with 3 kg gypsum and 8 kg farmyard manure (FYM). Saplings should be planted in refilled holes. Dead plants should be replaced.

Saline soils

Keep the root zone moist by providing irrigation by water channel, drip or pitcher irrigation. This will help tolerate higher levels of soil salinity.

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Contributor: K. K. Mehta

Tree profiles

Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Wrightia tinctoria</i> (Apocynaceae)	Dudhi toy Wood tree	<i>Hale</i> (Kannada) <i>Palleri</i> (Telugu)	Deciduous tree of Indian Peninsula Travancore Region. Also found in Burma. Common on dry sandy soils.	Moderate size, irregularly-shaped trunk, rough and greyish bark, narrow and pointed leaves. Flower appear from March to June and fruit ripens in January/February.	Direct seed sowing.	- Young leaves and pods are eaten as vegetable in certain places. - Wood is used for carving, turning and toy making. - Leaves are extensively used as green leaf manure.
<i>Azadirachta indica</i> (Meliaceae)	Neem	<i>Devu</i> (K) <i>Yapmanu</i> (T)	Deciduous tree, native of Burma. Found all over India, except in the coastal regions.	Drought-resistant. Flowers during March to June and fruits up to August. Can grow well on saline and alkaline soils.	Seeds that germinate within a week's time. Fresh seeds are viable more than 30-45 days. Old seeds lose their viability.	- Neem cake can be used as manure. - Kernels are used as insect anti-feedents. - Neem seed meal can be used as feed for chicks and cattle, in certain concentration, mixed with other feed. - Leaves are placed in wardrobes and grain bins to repel insects. Leaf extracts are used in toothpaste and soaps. - Leaves and seeds contain Azadirachtin, an insect repellent.

Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Azadirachta indica</i> (Meliaceae) (cont.)						• Bark is used to extract tannin. • Seed oil can be used as an antiseptic for burns and lubrication for machineries. • Ripe fruits are edible. • Wood is used for construction, making furnitures and agricultural implements. • Leaves, bark and gum are used for medicinal purposes and religious rites.
<i>Acacia nilotica</i> (Leguminosae)	Babul	Karjia (K) Nellattumma (T)	Almost an evergreen tree/ spread all over India.	Medium-sized, paired whitish long, thin thorns at the base of each leaf. Flowers from June-September and sometimes during December-January. Pod ripen in May-June.	Seeds.	• Extremely valuable source of fuelwood and excellent quality charcoal. • Babul wood is heavy, very hard, strong and termite-resistant, popularly used for construction of carts, persian wheel and agricultural implements. • Bark and pods are used in tanning industry.

Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Acacia nilotica</i> (Leguminosae) (cont.)						- Babul gum is used in manufacturing inks and paints. - Leaves and pods are widely used as fodder and constitute the chief diet for goat and sheep in arid and semi-arid regions.
<i>Derris indica</i> (Pongamia glabra) (Leguminosae)	Pongam Karanj	Honge (K) Kanage Manu (T)	Native of India, Burma, Malaya and Indonesia. Spread all over India.	Medium-sized tree, starts flowering during April to June. The flower is white and purple in colour. Ripe pods are available from December-January, extending up to May. Tree is drought-resistant and can grow on poor soils. Suitable for saline and alkaline soils.	Propagated by seeds and stem cuttings, by roots and suckers.	- Wood is beautifully grained, often used for cabinet work. Wood is used as fuelwood. - Oil cake is used as manure. - Dried leaves are placed in grain stores as the odour repels insects. <i>Medicinal uses:</i> Oil is extracted from the seeds which is used for burning, soap making, in medicine for skin diseases and rheumatism.

Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Cassia siamea</i> (<i>Caesalpinaceae</i>)	Yellow cassia	<i>Kassada Seeme</i> <i>Tangedi</i> (K) <i>Pogadu Tangedi</i> (T)	Native of Malayan Islands and Indonesia	Medium-sized ornamental tree. Yellow flowers appear in September, fruits (pods) during December-February. Thrives best in deep, well-drained and relatively rich soil. Drought hardy and termite-resistant.	By seeds and by root suckers.	• Suitable for dry and arid areas, used in soil conservation and agro-forestry programme. • Good shade tree and wind breaker. • Wood is used for small timber and agricultural implements. Wood pulp is used in paper industry. • Twigs are used as firewood, flowers are edible.
<i>Cassia fistula</i> (<i>Caesalpinaceae</i>)	Golden shower, Amaltus	<i>Ralli Chettu</i> (T) <i>Kakke</i> (K)	Indigenous to India; also found in tropical Africa, South America and the West Indies.	Produces golden yellow fragrant flowers. Flowers from February-May. Flowering of some plants in September-October is not uncommon.	Seeds. Also by cutting under intermittent mist and possible, through budding.	• Wood is used for making agricultural implements; twigs can be used as firewood. • Pulp is used to flavour tobacco in some places. Pulp of the fruit is used as a safe purgative. • <i>Medicinal uses</i>: Bark is used as tan and has medicinal value.

Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Tamarindus indica</i> (<i>Caesalpinaceae</i>)	Imli Indian date	Hunase(K) Sinthmanu (T)	Indigenous to tropical Africa.	Grows well in tropical climate, tall, long evergreen tree with large spreading crown. It has a long life span. It flowers during April to June and the pods ripen from February to April. Drought tolerant.	Seeds. Also produces root suckers.	- Fruits are edible, also used to prepare chutney and in general cooking. Tartaric acid is extracted from unripe fruits. - Jellose is extracted from seeds; polyose extracted from seeds are used in industries. - The bark and leaves are used for tanning. - Wood is used for tools, furniture, turnery and fuel. Makes excellent charcoal used in gun powder and by gold smiths, wood used for firing brick kilns.
<i>Annona squamosa</i> (<i>Annonaceae</i>)	Custard apple	Sitaphal (K) Panase(T)	Native of tropical South America and the West Indies. Grows extensively in several parts of Central and Western India and the Deccan Peninsula.	Small-sized tree, leaves fall in January-February and are renewed in April-May when flowers also appear. It fruits in July-August.	Seeds.	- Ripe fruit is relished as a dessert. - Refreshing drink is made out of the sweet pulp. - Leaves also have insecticidal properties. - Seeds, unripe fruits and bark contain alkaloid, an anine.

Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Annona squamosa</i> (Annonaceae) (cont.)						• Root is a drastic purgative. • Leaves, bark fruit and seeds of the tree are of medicinal value.
<i>Ingadulce</i> (Leguminosae)	Manila tamarind	<i>Jangali</i> <i>Jalebi</i> <i>Seeme</i> <i>Hunase</i> (K) <i>Seem Sinth</i> <i>Manu</i> (T)	Found throughout India.	Tall, long-lived, deciduous tree. The tree produces flowers during January-February. Fruits develop rapidly and ripen during April-June.	Seeds and branch cuttings.	• Wood is used for making furniture, building construction and agricultural implements. • Twigs are used as fuelwood, leaves are fed to livestock. • Fruits are edible. • Tree has medicinal value and also extracts tannin.
<i>Erythrina indica</i> (Leguminosae)	Indian coral tree	<i>Varjeep</i> (K) <i>Varjupee</i> (T)	Indigenous in the coastal forests in Maharashtra, from Sundarbans to Andamans and Nicobars.	Soft-wooded shrub, medium-sized tree. The large bright scarlet flowers appear in February or March. Pod is large, contains up to eight seeds.	Cuttings; also through seeds.	• Often used to make hedges; also grown to support beetlevines and other climbing vegetables. • Young leaves are eaten in curries, mature leaves are used as cattle fodder.

Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Erythrina indica</i> (Leguminosae) (cont.)						• Red dye is obtained from the flowers. • Bark is used in tanning and dyeing. Bark yields fibre. • Wood is used to make boxes. • Bark and leaves are used as medicine.
<i>Butea monosperma</i> (Leguminosae)	Flame of the forest, Dhak, Palas.	<i>Muthuga</i> (K) <i>Motaga</i> (T)	Spread in almost all hotter and dry parts of India.	Medium-sized trees, orange-red flowers appear in February or March. Pods are broad and thickened near the tip.	Seeds.	• It is an important host for lac insect, yellow dye is extracted from the flowers. • Bark gives a coarse fibre used for rough cordage and caulking boats. • Leaves are used as plates, as umbrella covering and substitute for wrapping paper. • Foliage collected as fodder for buffaloes. • Wood is durable under water and used for well curbs, piles and scooped of wells.

Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Butea monosperma</i> (Leguminosae) (cont.)						• Seeds make good quality charcoal. • Red gum can be obtained from tank to be used in medicine. • Powdered seeds are used to cure skin disease. Bark and seed are used in treatment of snake bites.
<i>Gmelina arborea</i> (Verbenaceae)	Coom Teak	<i>Shivane</i> <i>Bachanke</i> <i>Mara</i> (K) <i>Durina</i> <i>Manu</i> (T)	Indigenous in most parts of the plains of India and Burma.	Fair-sized tree, with large shady crown, flowers grow in clusters, coloured white wood is yellowish, strong, light and even-grained. Flower appear in February to April. Fruits ripen from April to July.	Propagated through seeds.	• Wood valued for planking, furniture, door panels and ornamental work. Boat building and drums making. • Leaves are used as fodder. • Fruit is prescribed as tonic to promote hair growth. Juice of leaves is used as a lotion for wounds and ulcers. The tree has medicinal values. Flowers are used in leprosy and blood diseases.

Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Enierolobium saman</i> (Leguminosae)	Rain tree	<i>Maley</i> <i>Mara</i> (K) <i>Nidre Bage</i> <i>Manu</i> (T)	Native of Brazil, now seen in many parts of India.	Quick-growing tree of huge size. Small pink flowers appear from March to October, leaves fall at the end of the cold season and replaced in March	Seeds and cuttings.	- Leaves are used as cattle fodder. - Fruit pulp is eagerly eaten by horses and cattles. - A very good ornamental shade tree, commonly used in avenue plantation.
<i>Gilicida septium</i> (Leguminosae)	Mexican lilac	<i>Gobbarada</i> <i>Mara</i> (K) <i>Yeruvu</i> <i>Chetlu</i> (T)	Spreads in almost all parts of India.	Fast-growing tree, produces pinkish white flowers.	Seeds, stem cuttings and root or shoot cuttings.	- Nitrogen-fixing tree. - Good fuelwood. - Produces high quality green manure and mulching material. - Improves soil fertility through addition of biomass. - Serves as good hedge plant and live fence.

Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Syzygium cumini</i> (Myrtaceae)	Jamun Indian Black Berry	Nerale Mara (K) Neredu Manu (T)	Originated from India, grows throughout India.	Large evergreen tree suitable for arid regions. Soil preferred is deep loam and well-drained. It can also tolerate water logging condition and withstand prolonged flooding. A good coppicer and grows vigorously after pruning.	Generally propagated by seeds, also by grafting, budding, layering and cuttings.	- It is a good source of fuelwood, used in avenue plantations along riverbanks and streets. - Fruits are used in various forms, made into jelly, jam, wine, vinegar and pickles. - Fruits are edible and also liked by animals. - Bark is used for tanning purpose. - Leaves are lopped for fodder. - Flowers are rich in nectar.
<i>Ailanthus excelsa</i> (Simarubaceae)	Matchwood tree or Maharukh	Peetrimanu (T)	Indigenous in the Indian Peninsula and often in different parts of India.	Fast-growing, medium to large deciduous tree. Grows well in tropical and sub-tropical climate. Water logging is harmful. Produces small yellow-coloured flowers that appear in February-March. Fruits are ready for collection in April-May. Shows poor growth in clayey and rocky soils.	Seeds. Also by stem cuttings.	- It can be grown as a wind break and avenue tree. - Green leaves are highly palatable and nutritious. - Leaves are fed to sheep and goats. - Wood is useful in the match industry and making newsprint paper. - Twigs can be used as firewood.

Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Sesbania grandiflora</i> (Leguminosae)	Agasta Chogache	Agase (K) Auisa Manu (T)	Native of tropical Asia. Also grows widely in Assam, West Bengal, Uttarpradesh, Tamil Nadu and Karnataka.	It is a small, fast-growing tree. Pink flowers appear in winter (December-February). The ripe pods are available in April-May. Tropical climate, frost sensitive and comparatively drought-resistant. Good coppicer and pollarder. Has a very short life cycle. It is preferably grown to provide support and shelter for beetle and pepper vines.	Seeds.	• Excellent tree for soil improvement through nitrogen fixing. • Flowers, fruits and tender leaves are used as vegetable. • Poles can be used for temporary works like erecting pandals and huts. • Wood is soft and weak and used only for firewood. • Leaves are sources of good fodder for cattles. Leaves can also be used as green manure. • Bark yields gum.
<i>Acacia senegal</i> (Leguminosae)	Gum arabic, Kher Kumbhat	Senegal (K) Senegal (T)	Originated in Africa. Distribution in the Sahelian zone from Senegal to Somalia, Sudan, Nigeria, India and Pakistan.	Small deciduous spiny tree. Grows well in arid hot tropical to subtropical climate. Cannot withstand water logging. Can adopt poor rocky, clay and alkaline soils. It coppices well.	Easily established by seeds.	• Yields arabic gum used in various sectors. • Wood is hard and heavy, useful for poles, agricultural implements, fuel and charcoal. • Foliage and pods are protein-rich fodder. • Pods are used as vegetable.

Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Albizia lebbek</i> (<i>Leguminosae</i>)	Lebbek, Indian walnut	<i>Kakko</i> <i>Bage</i> (K) <i>Bage</i> (T)	Came from Bangladesh, Burma, growing in India, Pakistan, tropical and sub-tropical regions of North Africa and Nepal	Large, deciduous tree, needs tropical and subtropical climate, has capacity to tolerate drought, well drained loam is best suited. Has capacity to tolerate salinity as well as dry alkaline soils.	Seeds. Stem cuttings and root cuttings can also be used.	• Tree produces root suckers. • Wood is moderately hard and durable, is good for fuel, charcoal, furniture small timber. • Bark is used in tanning flowers; good source for nectar. • Foliage makes good fodder.
<i>Prosopis juliflora</i> (<i>Leguminosae</i>)	Babus	<i>Bellary Jali</i> (K) <i>Bellary Jali</i> (T)	Originated from Central and South America. Spread in arid zones throughout the world. Available throughout India.	Thorny, deciduous or evergreen-large crowned tree. Grows in arid and semi-arid regions. Adapted to very warm, dry climates. Takes on well on rocky, alkaline, sodic and saline soils.	Seeds.	• Also produces root suckers. • Wood is extensively used as fuelwood. Also for charcoal, fence pole and light timber. • Pods make nutritious feeds for livestock. • Foliage is not usually browsed.

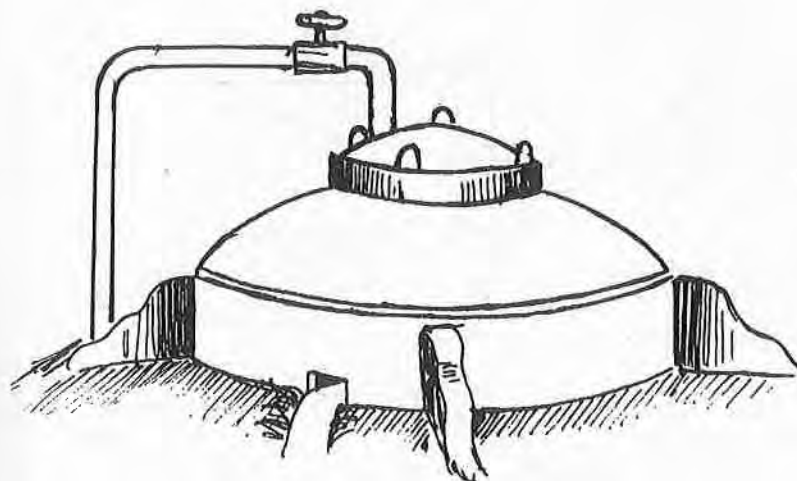
Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Prosopis cineraria</i> (Leguminosae)	Khejri	Banni(K) Banni(T)	Native of India, grows in almost every part of India and other countries like Pakistan, Afgan, Iran and Arabia.	Medium-sized, deciduous thorny tree, grows well in the arid tropics, grows on alluvial, coarse sandy, rocky black, cotton soils; can tolerate moderate saline and alkaline soils.	Root, suckers and seeds.	• Coppices well. • Wood used for boat making, house construction and farm implements. • Also makes excellent fuel and charcoal. • Foliage makes good fodder. • Good species for soil erosion control and agroforestry.
<i>Leucaena leucocephala</i> (Leguminosae)	Subabul Horse Tamarind	Subabul (K) Subabul (T)	Native of Mexico. Widely spread throughout the tropical world. Covers South, Central and East India.	Medium-sized, slender tree. Grows well in semi-arid tropical and sub-tropical regions. Grows on a variety of soils including high pH and water-logged conditions.	Direct seedling. Root cuttings can also be used.	• Wood is a good fuel, pole timber, furniture, paper and pulp. • Foliage makes excellent fodder. • Flowers are good source of nectar.

Scientific name (Family name)	Common name	Local name	Distribution and habitat	Silvicultural characteristics	Propagation	Uses
<i>Emblica officinalis</i> (<i>Euphorbiaceae</i>)	Indian gooseberry Amla	<i>Bettadanelli</i> (K) <i>Nelli</i> (T)	Native of tropical South Asia, abundant in South and Central India.	Medium-sized, deciduous tree; humid, tropical regions are suitable for the tree. Grows on a variety of soils, especially on poor dry soils, acidic and lateritic soils.	Grafted plants. Also, through seeds.	- Seeds are common source for propagation. - Fruits are sour and rich in Vitamin C, used for medicine as well as preservative. - Wood is moderately heavy, makes good fuel. - Foliage is browsed by live stock.
<i>Hardwickia binata</i>	Anjan	<i>Karachi</i> , <i>Kamara</i> (K) <i>Vepi</i> (T) <i>Yana</i>	Found throughout the drier parts of India.	A robust tree of hot, dry, rocky regions, thrives best on deep sandy loams. Cannot stand water logging.	Direct sowing produces root suckers.	- Leaves are good fodder, timber is tough, very hard, used for cart wheels, machine bearings, posts, carpenters, tool handles and flooring. - Excellent fuel and good charcoal.

Biogas: A rural energy source

Biogas and smokeless chulahs can be promoted in dryland areas to save on fuelwood needs and reduce smoke emissions in the kitchen.

A biogas plant is an airtight device that converts cattle dung and organic matter into flammable gas (methane) and good quality manure.



Feeding materials

- Dung — cattle, horse, goat, poultry, piggery and sericulture waste.
- Night soil
- Industrial wastes such as pulp mill effluents and fruit and vegetable wastes.

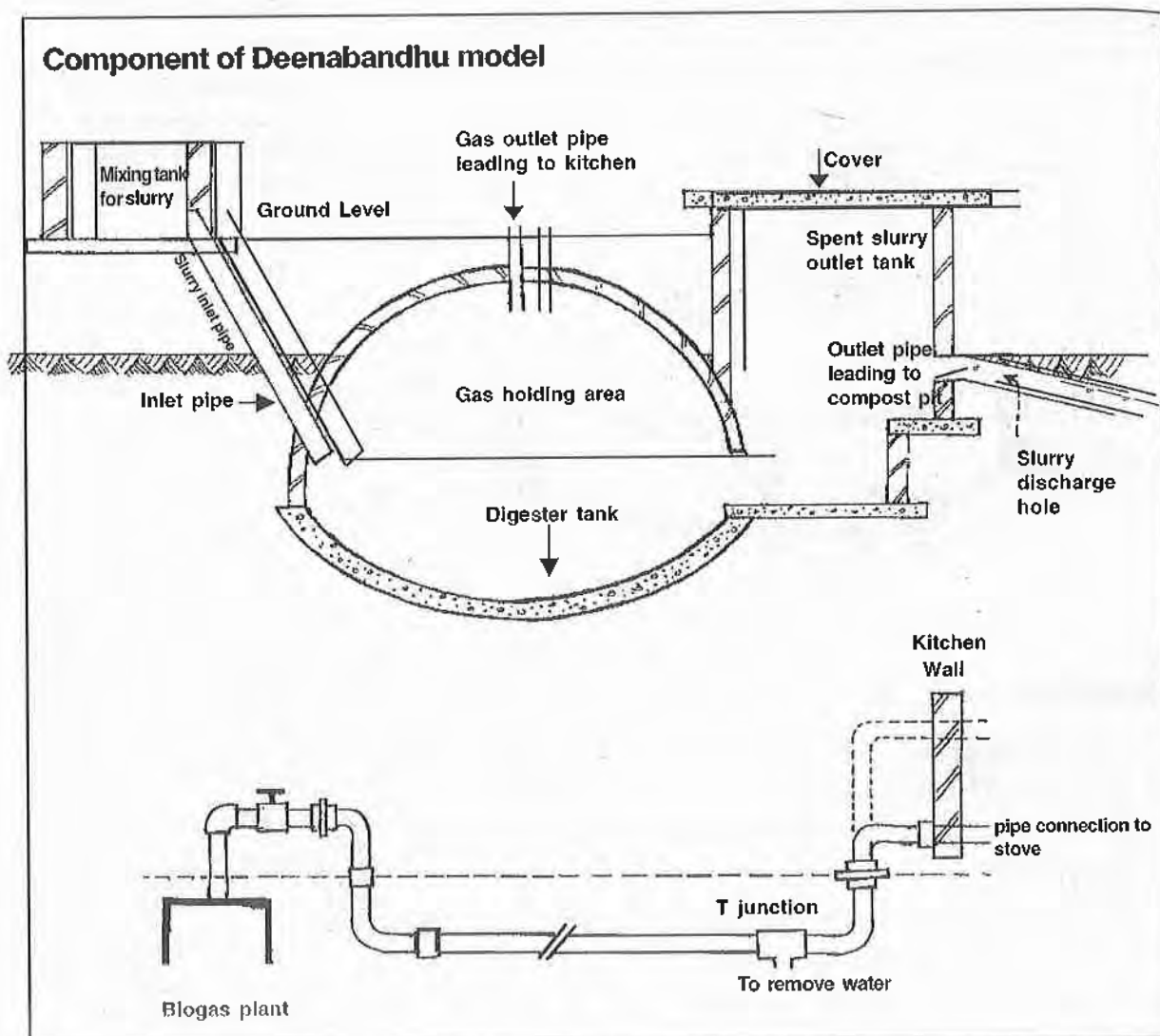
Benefits

- Converts dung into two useful products — flammable gas and good quality manure.
- Provides smokeless, high efficiency fuel for cooking and lighting.
- Manure obtained from a biogas plant has higher nutritive value compared to ordinary farmyard manure.
- Keeps the household and surrounding area clean.
- Prevents deforestation.
- Controls environmental pollution and promotes public health.
- Saves fuel, cooking time and reduces fertiliser cost.
- Saves time usually devoted to fuel gathering (mostly done by women).



Types

- **Floating drum type**
e.g. Khadi and Village Industries Corporation
KVIC biogas plant
- **Fixed dome type**
e.g. Janatha biogas plant, Deenabandhu biogas plant



Relationship between plant capacity and daily dung requirement and gas use

Plant capacity (m ³) (kg)	Daily dung requirement	Approximate no. of cattle needed	No of persons consuming food (to collect slurry)	No of compost pits (size in m)
1	25	2-3	3-4	2 (3 x 2 x 1)
2	80	4-6	5-8	2 (3 x 2 x 1)
3	75	7-9	9-12	2 (3 x 2 x 1)
4	100	10-12	13-17	3 (4 x 3 x 1)
6	150	12-20	18-25	3 (4 x 3 x 1)

Dos

- Select an elevated, open and dry site exposed to sunshine for most of the day and around the year.
- Decide on the size of the unit after considering the quantity of dung available.
- Install the biogas plant near the kitchen and the cattleshed.
- Feed biogas plant with cattle dung and water in the right proportion (1:1). A homogenous mixture is needed.
- For efficient cooking, use good quality, approved burners and gas lamps (for lighting).
- Light the match first before opening the gas valve.
- Cover the opening of the inlet and outlet with a wooden stone or RCC cover to avoid accidents.

Don'ts

- Do not install large-size biogas units if cattle dung or any other feed stock is not sufficient for gas production.
- Do not install the gas plant under a tree or shade or inside the house.
- Do not compact the soil around the plant otherwise, the unit may get damaged.
- Do not construct the plant in or near water-logged areas.
- Do not add more than the required quantity of either dung or water - it might affect the efficient production of gas.
- Do not allow soil or sand particles to enter into the digester.
- Do not leave the gas regulator (valve) open when the gas is not in use.
- Do not let any water accumulate in the gas pipe line — the required pressure of the gas cannot be maintained and the flame will splutter.
- Do not inhale the gas as it could be hazardous.

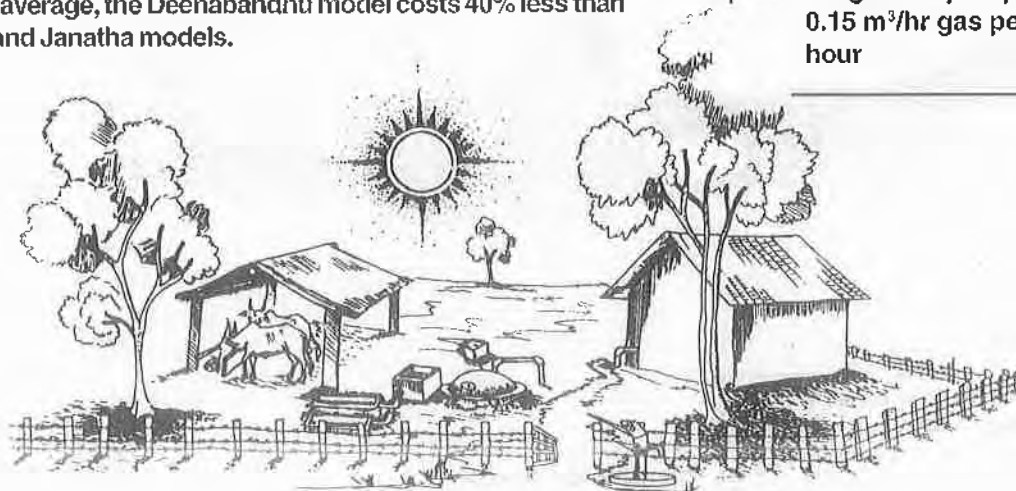
Cost of different types of biogas plant (in Indian rupees at current prices)

Capacity (m ³)	KVIC	Deenabandhu	Janatha
1	-	4,300	-
2	9,250	5,850	7,150
3	10,950	7,080	7,950
4	12,300	8,600	9,650
5	15,200	9,650	-

On an average, the Deenabandhu model costs 40% less than KVIC and Janatha models.

Tips

- 1 kg of fresh dung (cattle) produces 0.04 m³ of biogas
- Biogas requirement for cooking is 0.25 to 0.3 m³ of gas per head per day.
- Standard domestic biogas stoves consume 0.45 m³ gas per hr.
- Biogas lamp requires 0.15 m³/hr gas per hour

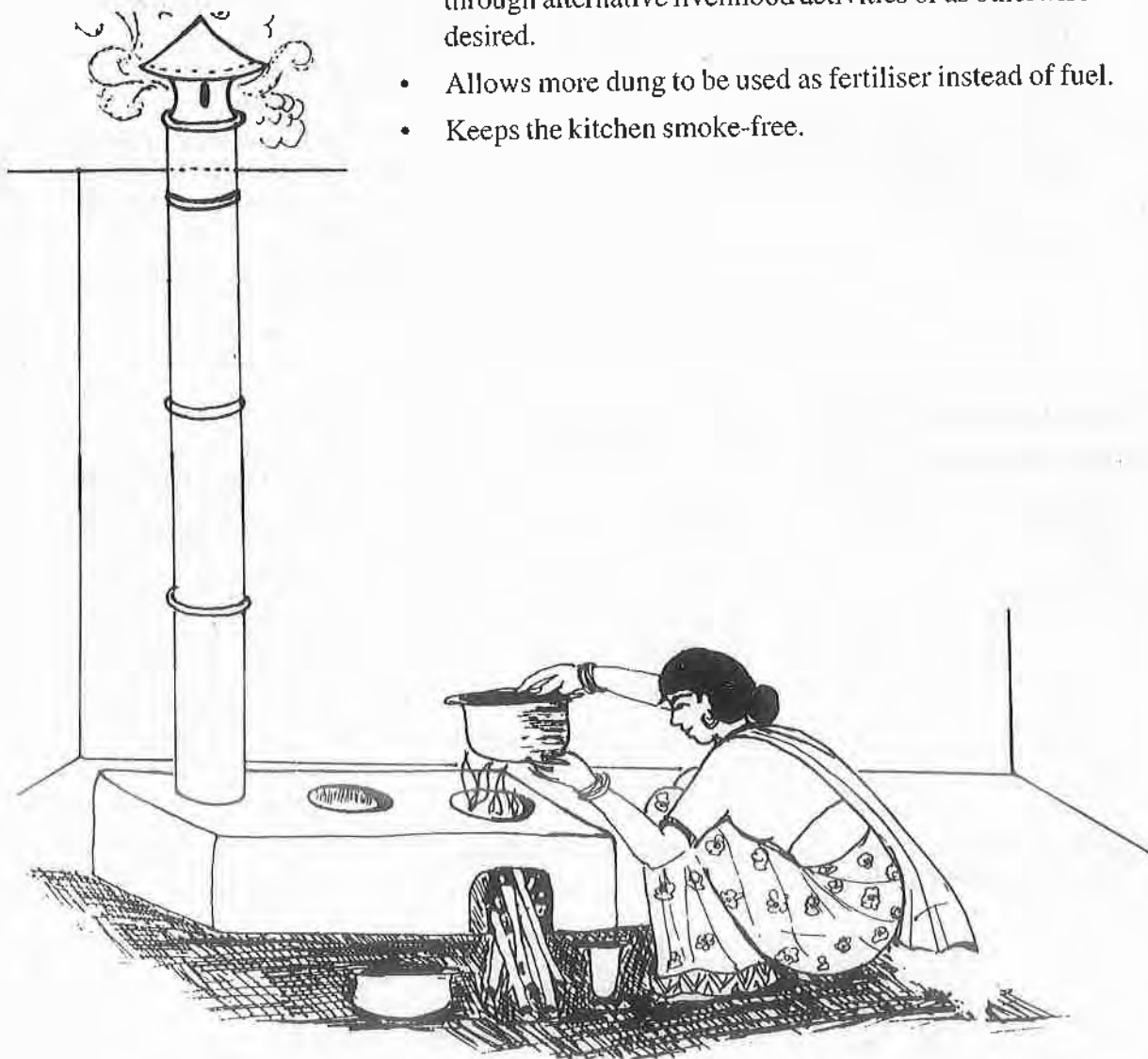


Smokeless chulah

A large percentage of women spend long hours collecting fuel and maintaining the kitchen. The smokeless chulah saves fuel and contributes to improved respiratory health of household dwellers.

Advantages

- Consumes less fuel. It reduces fuel expenses by as much as 15%.
- Reduces cooking time. The time saved could be invested into productive labour or to earn additional wages through alternative livelihood activities or as otherwise desired.
- Allows more dung to be used as fertiliser instead of fuel.
- Keeps the kitchen smoke-free.



*Information kit produced by
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Institute of Rural Reconstruction*

Contributor: Sridhar

6 **Implements and post-harvest applications**

W. A. KENNEDY
PRESIDENT OF THE BOARD



Traditional agricultural implements for drylands

Traditionally, farmers use agricultural implements designed to suit their own unique economic, cultural and climatic conditions. Some of these implements were adapted through generations to reduce the amount of labour and time required for agricultural operations.

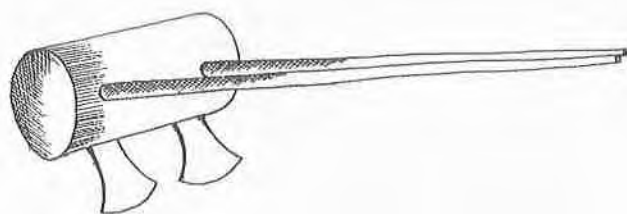
Indigenous technologies make use of local materials and simple technologies that can be constructed and repaired by farmers themselves. They have evolved over several generations because they only need minimal time and energy expense.

This article outlines the unique characteristics of a few such agricultural implements.

Seed bed preparation

Two- tyned hoe (*Dasi*)

This hoe consists of a beam and a handle attached to a wooden block that has two metal plates protruding from it. It is used to remove grass and root stocks of previous crop like gingelly, jowar, maize and ragi. It is the first implement used to clear the land. As it does not penetrate very deep, this tool can also be used in the dryspell.

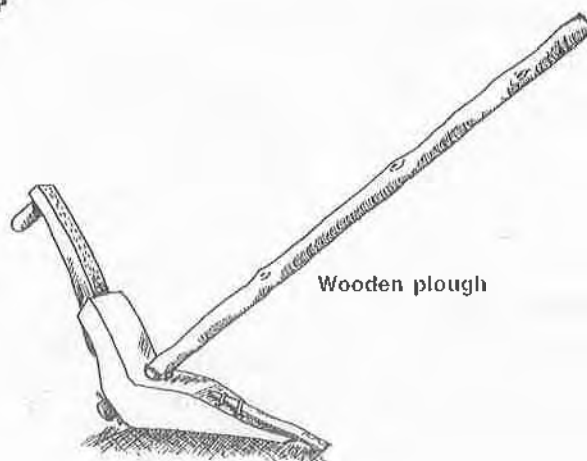


16 - Tyned Hoe (*Halube*)

The *halube* is an implement used for leveling the ploughed surface before sowing. It has 16 wooden teeth attached to a wooden block which also has a handle and two wooden beams.

Wooden plough (*Negilu/Konabe*)

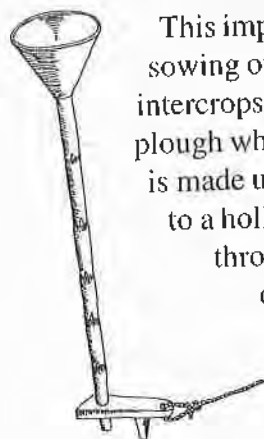
This plough is used in the pre-monsoon period for ploughing and creating furrows for seed cropping. The body is made of wood with an iron plate (*Kolu/Gula*) attached to the tip of the implement. It ploughs approximately 15 cm deep. It is believed that when the body is made of neem wood, insect larva are killed while ploughing. It is also used for soil tilling which increases water holding capacity of the soil.



Wooden plough

Sowing equipment

Seed Drill (*Kurige*)



This implement is used for line sowing of crops, especially in intercrops. It is tied behind the plough when it is in operation. It is made up of a funnel attached to a hollow bamboo tube through which seeds are dropped to lodge below the soil surface.

Four - Tined Hoe (*Kunte*)

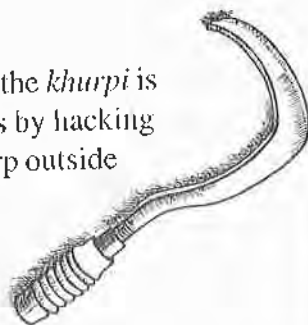
Thinning is the process of removing excess plants from the crops. After two to three weeks of germination, the *kunte* is used for thinning ragi and gingelly in broadcast fields.



Weeding tools

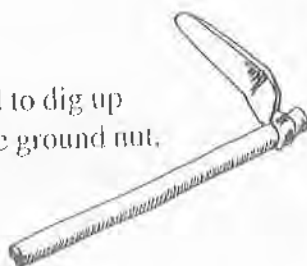
Khurpi

For manual weeding, the *khurpi* is used to remove weeds by hacking them off with the sharp outside blade.



Hand hoe

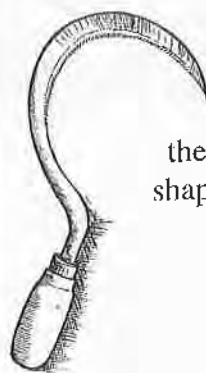
This hand hoe is used to dig up weeds from crops like ground nut.



Harvesting

Sickle (*Kudugolu*)

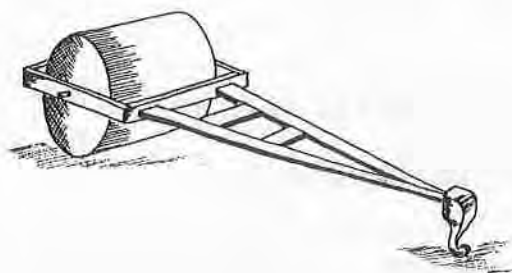
For harvesting, the commonly used tool is the sickle, which has a curved shape and an inside cutting edge.



Threshing

Stone roller

For threshing a stone roller is rolled by a pair of bullocks over the harvested crop.



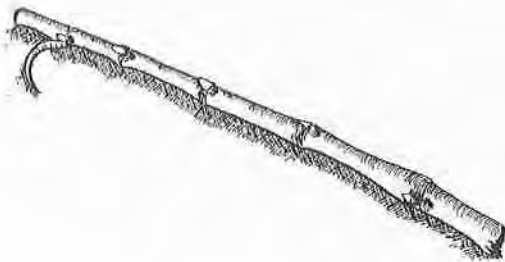
Threshing by bullock

This is an alternative method to the stone roller for small quantities. Three to four animals are tied to a central pole in a line and are encouraged to walk on the crop to be threshed. The experienced animals are usually tied at the outside end in order to guide the other animals.



Bamboo Hook (Kokke Basava, Maregol)

After threshing, the straw is removed using *kokke basava*. It is a long bamboo stick with a small loop of bamboo at one end of the stick.



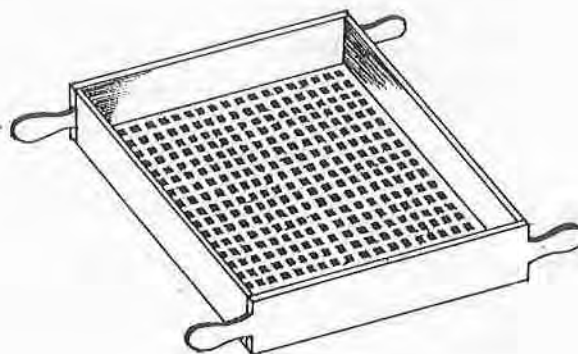
Kadugobbali

To remove fine straw from the grains, the Kadugobbali stick is used. It has small thorns on all sides which collect the fine straw and separates it from the grain.



Sieves

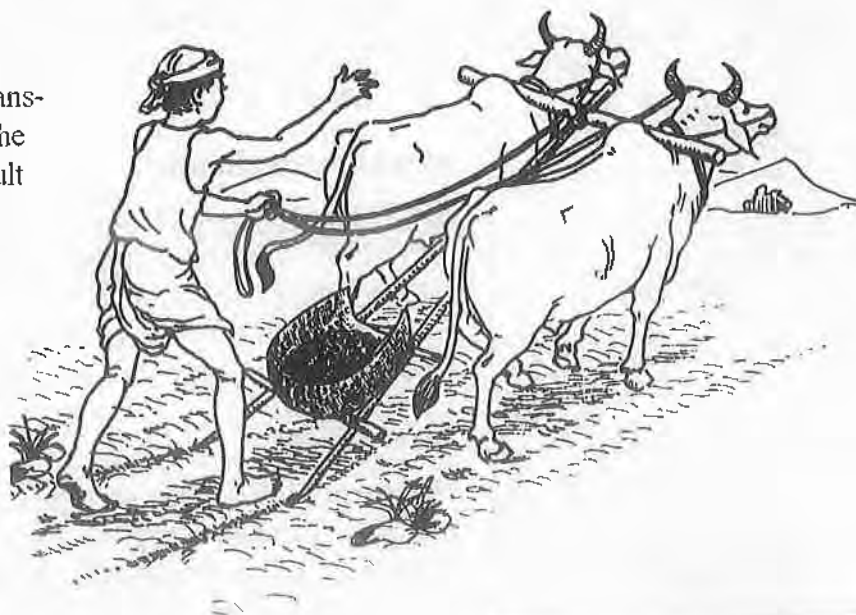
To sift out the grains, two sieves are generally used. The first sieve has bigger holes than the grain and lets the grain fall through the holes like straw. The second sieve has holes smaller than the grain and is used to remove small particles like sand.



Transportation

Garagasa

The *Garagasa* is used for transporting farmyard manure to the field when the terrain is difficult (hilly/uneven) and it is not possible to use a wheel cart. It consists of a bamboo basket placed on two wooden beams drawn by a pair of bullocks.



Contributor : Rajashekhhar

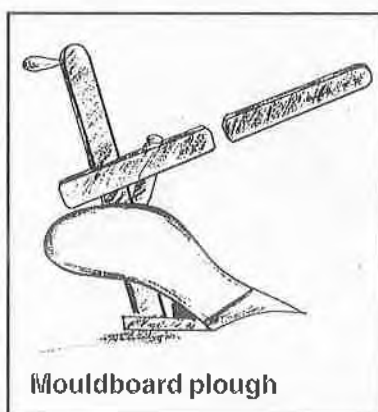
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Role and use of improved agricultural implements

Timeliness of farm operations is the key to achieve higher production and avoid post-harvest losses in rainfed agriculture.

Important farm operations for drylands

- Tillage and seed bed preparation
- Seeding and fertilising
- Weeding and intercultivation
- Plant protection
- Harvesting
- Threshing



Mouldboard plough



Disc harrow

Rain is the only source of water in the drylands. Its availability is uneven and scanty. The time available to carry-out field operations is limited and critical for higher production.

The working capacity of indigenous implements is often low, making it difficult to perform operations in time. In seeding and fertiliser placement, these implements lack the desired precision resulting in poor crop stand and inefficient utilisation of moisture and nutrients.

As timeliness of operations is the key to the success of crop production, improved implements are essential components of dryland crop production systems.

Improved implements/ equipment package

The package of improved implements/equipment suitable for drylands varies depending on the type of soil, rainfall, variation, crops and cropping systems and other agroclimatic conditions.

Tillage implements

The main objective of tillage is to assist the natural processes to obtain the most favourable soil conditions for the germination of seeds and the growth of plants. Implements are used to break and turn the soil, to bury weeds and vegetation and other matter in the soil to provide a good seed bed.

Mouldboard plough

Mouldboard plough cuts and inverts the soil and stubbles in the form of slices. Weeds and other crop residues are completely buried. Unlike the traditional wooden plough, it does not leave uncut soil between adjacent furrows. It covers an area of 0.05 ha/hr and can be pulled by medium-sized bullocks.

Disc harrow

Disc harrow is a riding type implement suitable for seed bed preparation. In lighter soils, two to three operations using this implement makes for good seed bed preparation. However, in hard soils, the disc harrow in its first operation does not penetrate easily. In such situations, the first operation by mouldboard plough followed by disc harrow saves time and labour for seed bed preparation by 15-20%.

Chisel plough

Chisel plough rips through the soil at a width of 40 mm and a depth of up to 300 mm with a narrow chisel. This implement helps in breaking the hard layer of soil just below the regular ploughing depth and allows the rainwater to infiltrate the soil. At 1 m interval, it can cover an area of 0.2 ha/hr.

Bund former

Bund former is an implement suitable for making bunds after sowing crops to check water in the fields. It forms bunds by gathering the upper layer of soil. The shape and size of the bundle can be controlled by changing the angle of wings which gather the soil.

Ridger

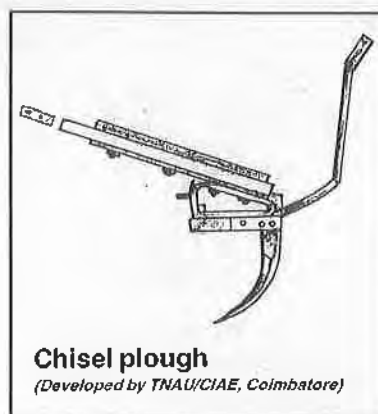
Ridger is an implement suitable for making drainage channels and border ridges. In two to three passes, it can make a ditch up to a depth of 30 cm.

Sowing and fertilizer equipment

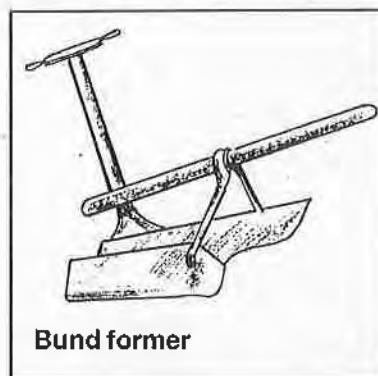
Sowing is one of the most important farm operations after seed bed preparation because sowing time and the way it is done decisively influence seed germination and later the growth of the seedling. This, in turn, affects the effectiveness of subsequent weeding and intercultivation operations and finally, crop yield.

Manually metered bullock drawn seed-cum-fertiliser drill

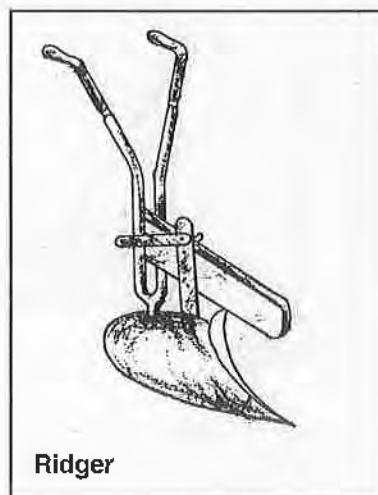
The seed cum-fertiliser drill is an improvement of the traditional seed drill. This implement covers three rows in one pass and drops seeds and fertilisers simultaneously at desired depths. Provision is made to drop fertilisers about 35 mm below and 35 mm by the side of the seed. This implement can do the work of two labourers who are otherwise required for dropping fertilisers behind a traditional seed drill. The drill can cover an area of about 0.6 to 0.9 ha in a day. This has a special advantage when labour availability is a constraint.



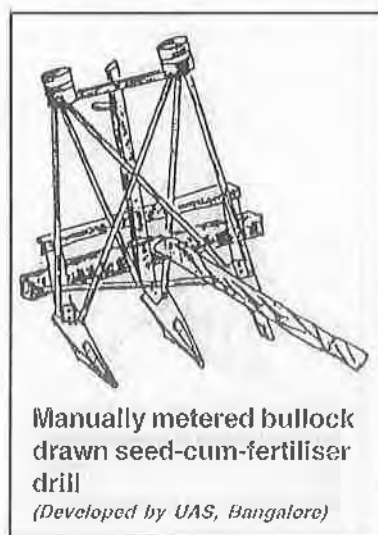
Chisel plough
(Developed by TNAU/CIAE, Coimbatore)



Bund former



Ridger



Manually metered bullock drawn seed-cum-fertiliser drill
(Developed by UAS, Bangalore)



Automatically-metered bullock drawn seed-cum-fertiliser drill

The automatically metered seed-cum-fertiliser drill covers three rows in a single pass and drops seeds and fertilisers simultaneously at desired depths, i.e., dropping the fertiliser 35 mm below and 35 mm by the side of the seed. This implement requires two persons — one to operate and the other to assist. The drill can cover an area of 0.8 to 1.0 ha in a day. For different seeds and plant-to-plant spacings, different seed plates are used in the metering unit.

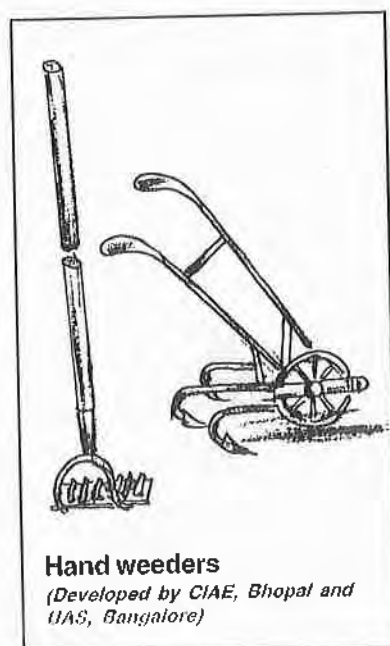
Use of the manually and automatically metered seed-cum-fertiliser drills can increase the yield by 10 to 15% due to better seed germination, optimum plant population and efficient utilisation of fertiliser.

Weeding and intercultivation implements

The main objectives of weeding and intercultivation are: removal of weeds, aeration of soil and ridging up of plants.

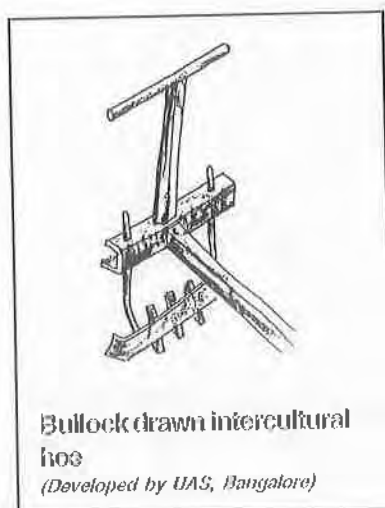
Weeding and intercultivation in broadcast and randomly planted crops are normally done with a *khurpi*. The operations are labour-intensive and time-consuming.

Crops planted in rows with sufficient wide space can be intercultivated with labour saving hand tools and animal-drawn implements efficiently and at a faster rate.



Hand weeders

The long-handled improved weeders are very efficient for intercultultural operations in row crops, particularly in sandy and loamy soils. These can be operated easily by one person. The fatigue in operating long-handled weeders is considerably low because the operator works in a standing posture. The field capacity of these weeders ranges from 0.2 to 0.3 ha/day.



Bullock-drawn intercultultural hoe

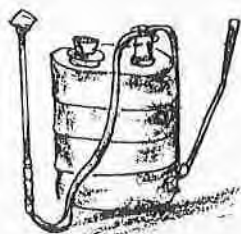
Bullock-drawn intercultultural hoe is an improvement of the traditional two-tynded hoe. It is a combination of blade fitted across the tynes. This combination helps loosen the top soil, uproot shallow rooted weeds by the projected tynes and form furrows and ridges by simultaneously throwing soil on either side in one operation. Two such implements can be tied to a pair of bullocks which can cover about 0.6 to 0.8 ha/day.

Plant protection equipment

Crops are attacked by insects, fungus and virus parasites as well as weeds. Weeds can be eradicated by effective cultivation but pests and diseases have to be kept under control. Sometimes (chemical) sprays and powders need to be used.

The most common types of plant protection equipment are manually-operated knapsack sprayer, compression sprayer, foot sprayer, rocker sprayer, power-operated knapsack sprayer and hand-operated duster. Depending upon the area to be covered, sprayers can be selected based on their output capacities.

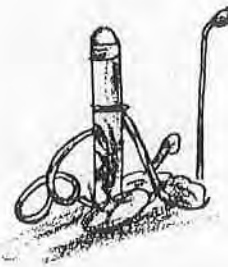
Spraying and dusting equipment



Knapsack sprayer



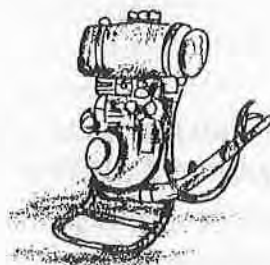
Compression sprayer



Foot sprayer



Rocker sprayer



Knapsack power sprayer



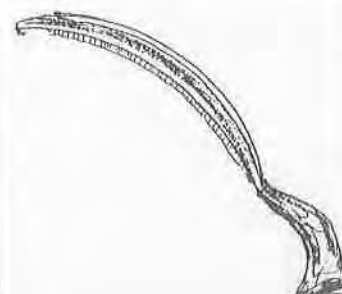
Hand rotary duster

Harvesting and threshing equipment

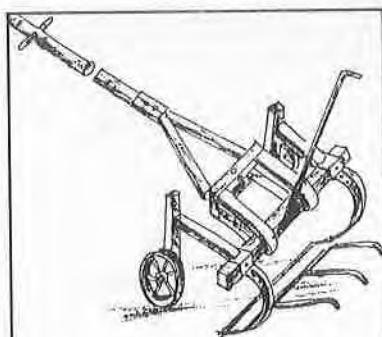
Timely harvesting and threshing operations are extremely important to minimise losses due to the vagaries of nature. Improved tools, implements and equipment help in performing these operations in time.

Improved sickle

The improved sickle is best suited for harvesting dryland crops like *ragi* (finger millet), wheat and paddy. It has a curved, wooden handle with a special hand grip to avoid injuries to the hand while harvesting. The sickle blade is made of high carbon steel or saw steel and the cutting edge is serrated. The curvature of cutting edge is narrow and requires less human energy to harvest compared with that required for the traditional sickle. The blade curvature also incorporates a self-sharpening characteristic. This is about 20-30 percent more efficient than the indigenous sickle. The time required to harvest one hectare of crop using this sickle is about 120-125 manhours.



Improved sickle
(Developed by CIAE, Bhopal)



Bullock drawn digger
(Developed by CIAE, Bhopal)

Bullock-drawn digger

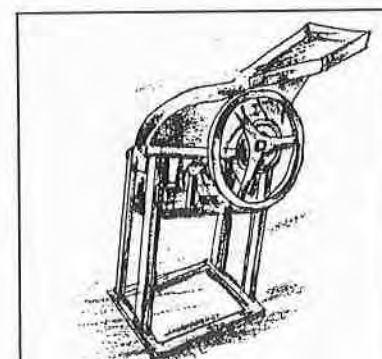
The bullock-drawn digger is an efficient implement for digging groundnut and potato. Transport-cum-depth gauge wheels are provided for easy transport and uniform depth of operation. Soil working depth is adjustable up to 20 cm and covers 32 - 45 cm width in a single pass depending upon blade size. Lift rods are provided behind the blade to facilitate separation of soil from groundnut or potato. This implement can dig about 0.4 ha of groundnut and 1.0 ha of potato per day.



Multi-purpose thresher

Multi-purpose thresher

Suitable for threshing cereals, pulses and oilseeds. The multi-purpose thresher can be operated by an electric motor. It has a threshing cylinder and a grain cleaning arrangement. Output capacity ranges from 1 to 5 q/hr of clean grain depending upon power source.



Maize sheller

Maize sheller

The maize sheller is a power-operated equipment suitable for removing grain from dehusked maize cobs. The output capacity ranges from 40 kg to 3 q/hr depending upon the power source.

Operational costs of farm implements and equipment (Rs/ha)

Mouldboard plough	165
Disc harrow	130
Chisel plough	75
Bund former	120
Ridger	120
Manually-metered bullock drawn seed-cum-fertiliser drill	200
Automatically-metered bullock drawn seed-cum-fertiliser drill	130
Hand weeder	200
Bullock-drawn intercultural hoe	150
Improved sickle	550
Bullock-drawn digger for groundnut	350
Bullock-drawn digger for potato	325

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Contributor: M. Chowde Gowda

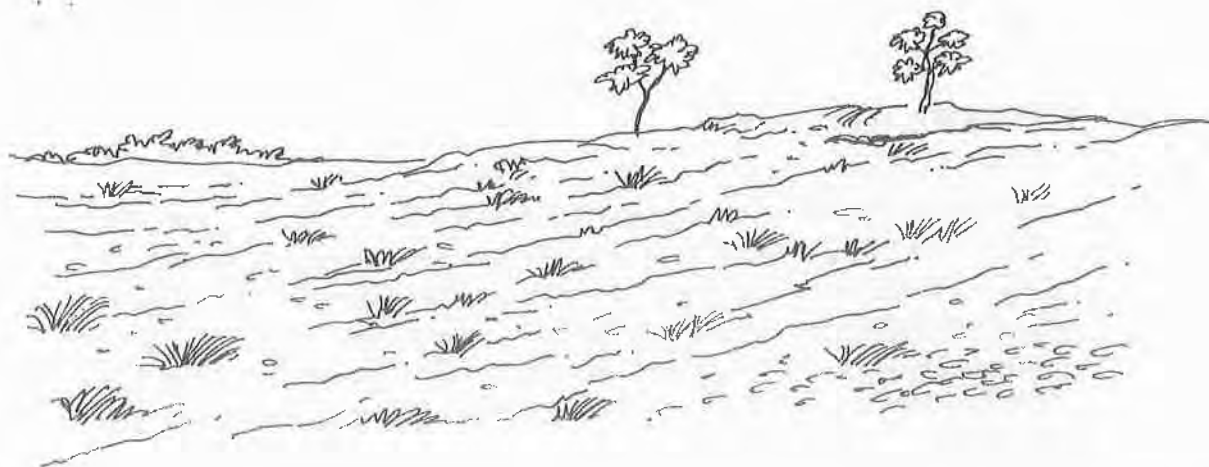
CRIDA: low cost, bullock-drawn equipment for dryland seeding

Timely seeding of crops is one of the most crucial operations in dryland farming. Majority of small and marginal farmers use indigenous country ploughs for seeding and fertilising. The operation is slow and depends heavily on farm workers and their skill. This delays the sowing beyond the optimum time period and crops generally face a terminal drought, causing an irreparable damage to their productivity. Timeliness in seeding operations is best achieved by using a low cost drill-plough and plough planter. These simple and low-cost implements also improve the precision in seeding operations.

A country plough is the principal implement available with the vast majority of dryland farmers in India. It is used for primary tillage, seeding and fertiliser application and interculture operations. When seeding and fertilising, a ploughman is followed by two farm workers who drop seed and fertiliser in the opened up furrow. Then the ploughman makes a dummy pass to cover the seed and fertiliser with soil. Since they are unable to regulate the soil mass cover, the result is unequal depth of seeding and deep seed placement resulting in poor germination, sub-optimal plant stands and overall low yields.

To improve sowing efficiency methods, the drill and plough planters were designed to be coupled with the country plough handle. Using this simple equipment, the farmer is able to save on the cost of two farm workers who follow the plough during sowing operations. It also eliminates the need for the dummy pass because both seed and fertiliser are covered in the same (single) operation. As a result, the farmer can cover twice the area per unit time minus the assistance of two farm workers.

This implement attaches directly to a plough and increases yield by allowing the seeds to be planted at a consistent depth and covered more uniformly with soil. It also reduces labour costs and planting time.



Comparative performance of country plough and drill plough obtained by a farmer from Tupuguda village for seeding and fertilising sorghum

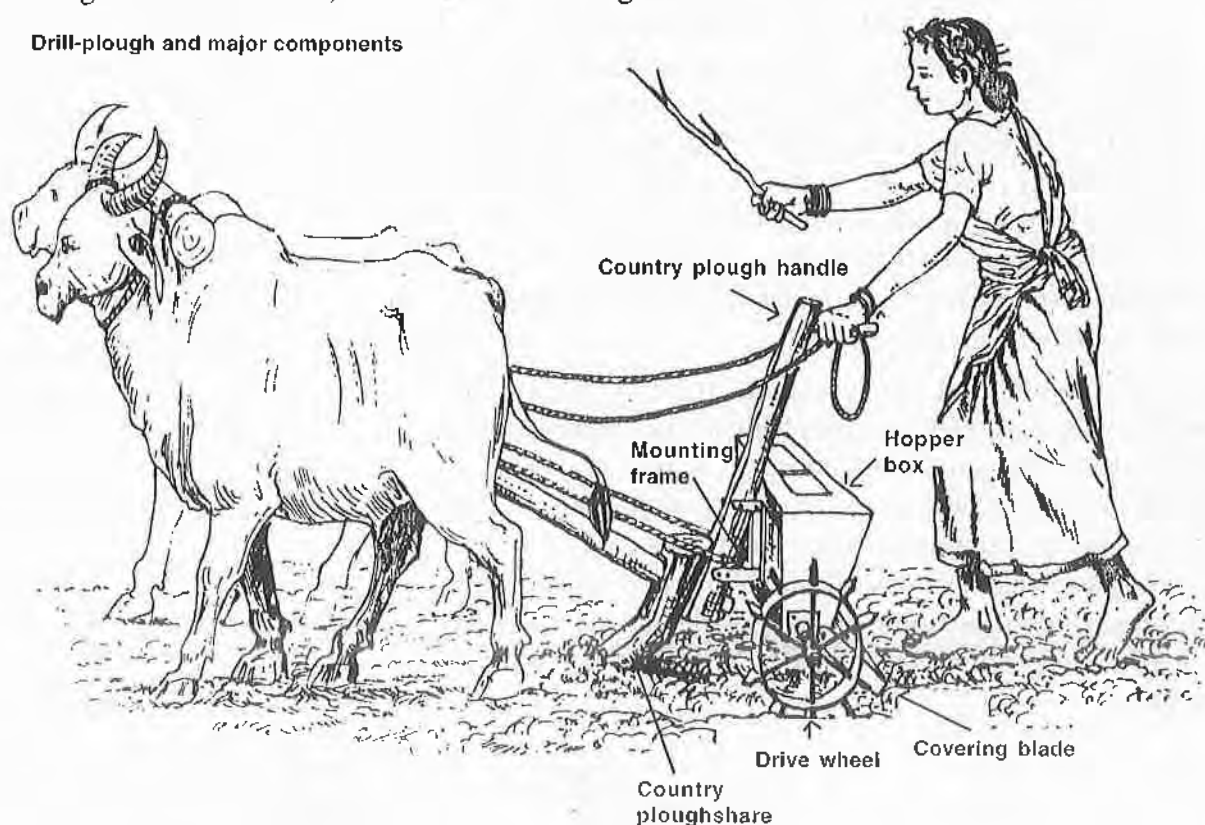
Parameter	Farmer's Practice	Drill Plough
Draft (kg)	35	40
Field coverage (ha/day)	0.42	0.80
Number of labourers required	3	1
Hours/ha	57	10
Bullock pair (hours/ha)	19	10
Cost of operation (Rs./ha)	275/-	88/-

Drill plough

A drill plough consists of:

- a hopper box;
- a shaft, with rubber agitator;
- a ground drive wheel;
- metering plates;
- a covering blade; and
- a mounting frame.

Drill-plough and major components



Operating principle

The rubber agitator fixed on the shaft is rotated by the drive wheel during operation. The pegs on the wheel partially sink into the soil serving to rotate the wheel. The seed and fertiliser are stored in the hopper compartments and are pushed through a pre-calibrated orifice by the rubber agitator. The seed and fertiliser are carried to the furrow opened by the country plough through tubes fixed below the hopper at an angle directed towards the furrow centre. The floating blade attached to the rear bottom of the hopper covers the seed with an even mass of soil.

Installation and operation

- The seed bed should be clod free, weed free and smooth — seeding machines are not a substitute to good seed bed preparation.
- Run the country plough for about 5 m in the prepared field. Match the drill mounting frame to country plough handle from the rear side. Press the drill unit down until the drive wheel pegs are 50% sunk. Mark the hole positions of mounting frame on handle and drill the holes. Bolt the drill on plough handle. Change the position of the mounting frame on plough handle for different bullock heights.
- Insert the metering plates for seed and fertiliser from the sides and lock in proper position by tightening the stopper nut. The small compartment is for the seed and large compartment is for the fertiliser. Centre exactly above the orifice centre the rubber agitator. For small seeds like pearl millet, the rubber agitator should just touch the metering plate; however, for large seeds, i.e., groundnut, there should be 2-3 mm gap between the metering plate and the agitator.
- Fill the hoppers to full capacity with seed and fertiliser. Pre-calibrate the seed and fertiliser rates for important crops based on the calibration chart. For better performance, maintain the seed/fertiliser level in the hopper at a minimum of one-third capacity.
- With steel pipes at the bottom, direct the seed and fertiliser to the centre of the furrow. Clip a 50 mm long rubber bicycle tube to the seed and fertiliser pipes to avoid blockage. The bicycle tube during turning stops soil from entering the pipe. After turning, the tube comes back to its normal position allowing for free flow of seed and fertiliser into the furrow.
- The floating covering blade is intended to push an even soil mass to the seed furrow. A cloddy soil blade-jump causes uneven soil covering. Adjust the stopper provided near the side pivot point to restrict jumping of the blade.
- When the drill-plough is ready for operation, run the first pass as straight as possible. Run the second pass parallel to the first pass. Refill the seed and fertiliser when it reaches the one-third level.
- For sowing different crops, select appropriate plates as listed in the calibration chart. Remove the earlier plate and fix the new plate in position.
- After completing the season's work, separate the drill from plough and clear of mud. Apply anti-rust compound and store it for use the next season. Before the sowing season, take out the drill, clean and check all moving components. Replace rubber agitators if necessary.

Plough-planter

Although the drill-plough promotes even crop stands, it does not maintain the desired inter-plant spacing within a row, which is crucial for crops like groundnut, castor, maize, etc. A plough-planter is similar to the drill-plough except that it is provided with precision seed metering obtained through an inclined plate mechanism.

Operating principles

The unit is supported by two wheels: the pegged wheel at the left and the plain wheel at the right. The metering plates are rotated by the power transmitted by the drive wheel through shaft and bevel gears. The cells in the metering plate are cast to match the seed size and shape. The number of seed cells per plate is designed to obtain desired seed spacing within a row. The seedbed should be free from clods and trash to ensure precision planting of crops like groundnut, maize, pigeonpea, castor, etc.



Field adjustments and operation

- Attach plough-planter to the country plough using the procedure similar to that outlined earlier for the drill-plough.
- Insert the fertiliser plate from the side and lock it with the stopper nut. The rubber agitator should be exactly above the orifice centre.
- Fix the seed metering plate on the bakelite base in a square shaft at the centre.
- Tighten the springnut. Avoid over tightening.
- Fix seed cut-off plate in the hopper box in a closed position.
- Fill the hopper with seed and fertiliser to full capacity.
- Move cut-off lever up to allow free seed flow into the plate chamber.
- Adjust the covering blade position for even soil mass cover and start the operation.
- Watch the seed and fertiliser level through the transparent lid of the hopper box and refill when it reaches one-third capacity.
- Make the first pass as straight as possible.
- Make the second pass parallel to the first pass
- Remember, row spacing can be adjusted for various crops.
- Operation saves human labour, bullock time and seed.
- Eliminates drudgery for farm workers.
- Can be constructed in a village workshop with locally-available materials.
- Makes the country plough more versatile.
- Costs are within the reach of small and marginal farmers.
(Drill-plough = Rs.500/-; Plough planter = Rs.1000/-)
- Initial investment can be recovered in just 2 ha of operation.
- Ensures optimum crop stand and increases the yield of dryland crops.

Contributors: V.M. Mayande, J.C. Katyal

Basic concepts in post-harvest storage technology

Estimated post-harvest losses per annum is approximately 10%

Grain losses are due to:

• Insects	2.55%
• Rodents	2.50%
• Disease and moisture	0.68%
• Birds	0.85%
• Threshing yard	0.15%
• Transportation and processing	1.68%
Total	8.41%

Grains are the most basic food. It is essential to produce, preserve and market grains by retaining their quality and reducing losses. Grains can be categorised into three kinds:

1. cereal grains: maize, wheat, sorghum, millet, etc;
2. pulses: pigeonpea, cowpea, grams, etc; and
3. oil seeds: soyabean, sunflower, groundnut, etc.

Compared to other foods, grains are unique because they can withstand transport and have long-term storage capacity, thus, retaining their quality. Because farmers are primarily responsible for quality control after harvest, grains should be maintained by storage using earthen pots, pits, granaries, sacks, storage bins, etc.

A grain storage is a man-made ecological system in which living organisms and their non-living environment interact with each other.

Popular storage systems practiced by farmers are:



Remember

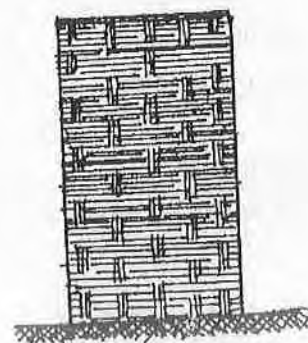
A grain saved is a grain produced.

Note

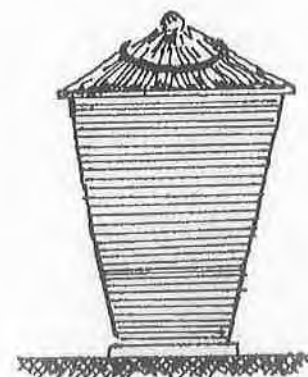
- A storage temperature greater than 15°C is ideal for good storage.
- Rate of respiration of grain increases with an increase in temperature.
- For every 5% decrease in storage temperature, longevity (of seed life) is doubled.

Above ground storage

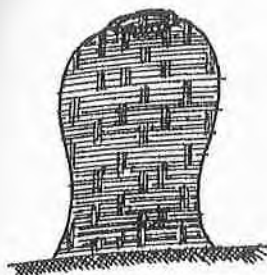
- **Room storage:** Grains are stored in a room, either in bulk or in gunny bags. This method is not rodent-and insect-proof, as most of the rural buildings are made of mud.
- **Gumme:** This is a bamboo structure with cowdung plastering. Capacity ranges from 3-5 quintals (qtls), it is not rodent-and insect-proof.
- **Pure:** This is made of paddy straw having a capacity of 10-20 qtls. This is kept in an open place exclusively to store paddy for a short duration. This is not rodent-proof.



Gumme



Pure

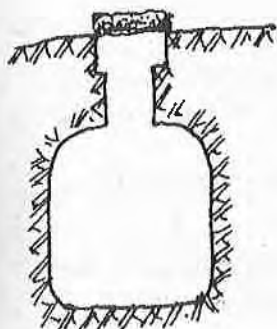


Galga

- **Gadhi:** This is a permanent structure made of mud with bamboo reinforcement along with roofing and a manhole of 600 x 600 mm. This has a capacity of 20 to 30 qtls.
- **Galga:** This is a bamboo structure with cowdung coating similar to that of Panaka having a capacity of 1 to 2 qtls.
- **Earthen pot:** This is a small capacity structure of 1 qtl maximum and is used to store grains for daily consumption. This is a rodent-proof structure.



Gadhi



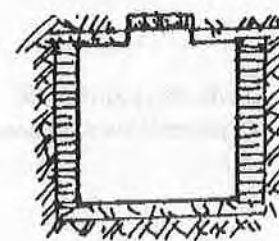
Hagevu

Underground structures

- **Hagevu:** This is a cylindrical pit dug mostly in red soils with an opening of about 700 mm diameter, at the top. No lining is done but the sides and the bottom are covered with paddy husk and straw. Removal of grain is somewhat difficult. The capacity ranges from 20 to 40 qtls and is used for long period storage. This can be practised where water table is very low. This is insect-proof.
- **Vadevu:** This is similar to hagevu. The walls are made of brick with mud plastering or stone slabs. Top is covered by stone slabs with a manhole of 600 mm diameter. Removal of grain is difficult. Capacity ranges from 20-40 qtls. The structure is rectangular and is meant for a long period storage.



Earthen pot



Vadevu

Remember before storage:

- Dry and clean the grain (10-13% mc). Bite a grain to test moisture content.
- A hard, smooth and crack-free floor is good for drying.
- Tarpaulins/plastic sheets can also be used.
- Clean and disinfect the storage structure.
- Remove broken grains from whole grains.

When stored, the important factors to be considered are temperature, moisture, oxygen (O_2), carbon dioxide (CO_2) concentration.

Important insect pests and nature of damage

Popular name (Scientific name)	Nature of damage
Rice weevil (<i>Sitophilus oryzae</i> Linn.)	The adult is dark brown in colour. The female lays eggs inside the grain by chewing a minute hole and seals the egg with gelatinous secretions. The grain becomes quite hollow and can float in water. Grains: wheat, sorghum, maize and other cereal crops
Lesser grain borer (<i>Rhizopertha dominica</i>)	The female lays eggs on the surface of grain. It feeds like the rice weevil inside the grain. Profuse powder production is characteristic of its damage. Crops: wheat, maize, sorghum, other cereals and pulses
Kapra beetle (<i>Trogoderma granarium</i>)	The female lays white eggs on the surface of the grain or in crevices. Under abnormal conditions, larvae can live without food for some years. Damaged grain is hot and contains a lot of larval skin. Grains: wheat, maize, rice, sorghum, oilseeds and pulses
Rust red flour beetle (<i>Tribolium castaneum</i>)	Eggs are laid in broken grain particles. Larval stage feeds for about four to five weeks. Found primarily attacking milled products, processed and packaged items. Grains: wheat, maize, sorghum, millets, rice, pulses, oilseeds, flour, rolled products
Sawtooth grain beetle (<i>Oryzaephilus surinamensis</i>)	Eggs are laid in floor crevices. Larval stage feeds on the grain of rice as well as flour. Grains: rice, processed cereals and oilcakes
Flat grain beetle (<i>Cryptolestes ferrugineus</i>)	Lays eggs in powdery materials. Grains: rice, bran, cake, oilseed and other cereal products
Angumois grain moth (<i>Sitotroga cerealia</i>)	Infestation starts in the maturing cereal crops in fields. Eggs are also laid in stored grain. The larvae enter into the grain through the husk. Damaged grain is lightweight and gives an unpleasant odour. Grains: paddy, wheat, maize, sorghum, bajra
Rice moth (<i>Corcyra cephalonica</i>)	Serious pest in neglected stores. Females lay eggs. Newly-hatched larvae start feeding on broken grains. The larva prepares a web within the grains. Grains: wheat, rice, maize, sorghum, millets, whole and broken pulses
Almond moth (<i>Cadra cautella</i>)	The moth lays white eggs scattered on the grain surface. The larvae start feeding on grain debris. Grains: wheat, maize, rice, sorghum, millets, pulses and oil seeds, processed foods

Popular name (Scientific name)	Nature of damage
Indian meal moth (<i>Plodia interpunctella</i>)	Grain is damaged by crawling caterpillars which can completely web over the surface of grain. Grains: groundnut, maize and other cereal products
Pulse beetle (<i>Callosobruchus maculatus</i>)	The infestation starts from maturing pods. Freshly laid eggs are of cream colour but become white after hatching. Larva directly enters the seed through the seed coat. Damaged pulse seeds are almost hollow and are not fit for consumption. Grains: pea, green gram, bengal gram, pigeonpea, cowpea

Sources of infestation

There are many ways by which stored products become infested:

- by placing clean products in infested storage;
- by placing infested products in clean storage;
- by mixing infested with uninfested materials;
- through second-hand infested container;
- through the use of infested transportation; and
- through rodents and nests of birds.

Pulse seed storage

- Clean and whitewash the store before storing new produce.
- Treat the seeds with non-edible oils such as neem, pongamia at the rate of 5 ml/kg of seeds.
- Mix seeds with dried eucalyptus leaf powder (at the rate of 5%) to prevent infestation.
- Dry the seeds up to a moisture content of 8% or below.
- Disinfect the seeds with any fumigant to remove initial infestations.
- The place of storage should have a temperature below 20°C and 60 to 70% relative humidity
- Dust the store with Malathion, 5% dust or spray malathion at the rate of 5 ml/litre water.

Seed quality does not improve in storage i.e., inferior quality seeds remain inferior.

Good quality seeds are those which:

- germinate well;
- are disease-free; and
- free from dirt and other plant materials.

Biogas is a good grain protectant

Biogas, introduced into a storage unit will replace oxygen inside the storage.

- Pulse beetles are killed.
- Seed quality is not affected
- Pulses can be stored safely for almost two years.

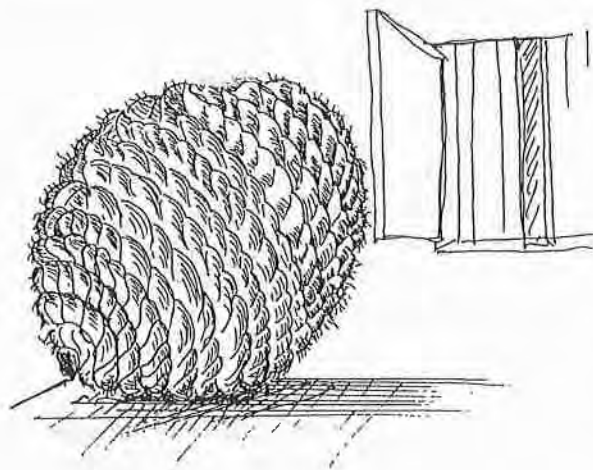
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Contributor: B. Ranganna

Traditional grain storage methods

Reduction in moisture is the key to longer shelf life of grain.

In rural areas, farmers store harvested grains for their personal use for the entire season. They adopt several methods to protect grain from rodents and insects during storage. Here are some cost effective methods adopted by farmers in the south-western part of Karnataka.



Dry straw cover

Grain is stored in a container made of straw ropes. This is generally suitable for storing pulses.

Ropes are prepared using dry paddy straw. These are passed through in a spiralling fashion through other ropes, so that they are held together. A ball-like container is created and simultaneously filled with pulses. After the entire quantity is put in, the mouth is closed. A rope is securely tied so that grains do not spill over. A coating of dung slurry is added to seal off any holes. This is easy to make and costs between Rs. 200 and Rs. 300.



Earthen container

This is a common practice. Earthen pots of varying sizes are made of local clay from 10 kg to 300 kg capacity. A small outlet is provided at the bottom for drawing small quantities of grains from time to time. Food grains are stored inside and the mouth closed with a thick paste of clay and dung. The container is kept on a raised platform to prevent losses due to moisture. In this method, grains can be stored for nearly two years. This may cost about Rs. 150 to Rs. 300, depending upon the storing capacity.

Underground storage chamber

Another method of storing grains is to create an underground chamber. The size is determined based on the needs. A pit of about 1.5 m depth with a diameter of about 1.2 m is dug. An opening of 0.6 m x 0.6 m is provided at the top. After digging, it is exposed for two days to dry up. The inside is then neatly plastered with a mix of clay and dung.

A layer of dry straw is placed at the bottom and on the sides. After filling the chamber with grains, the mouth is sealed with a stone slab and covered with a heap of mud.

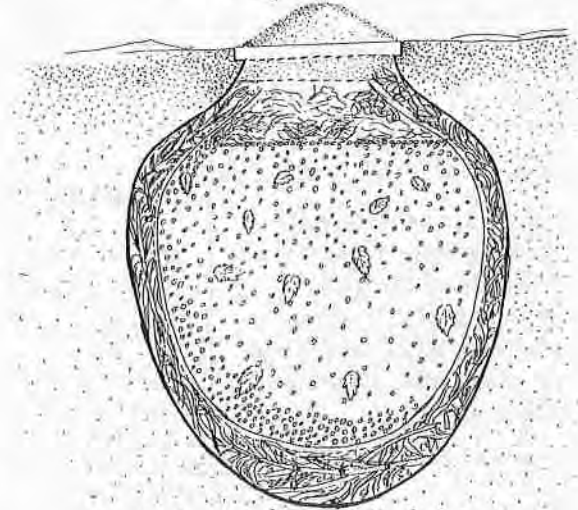
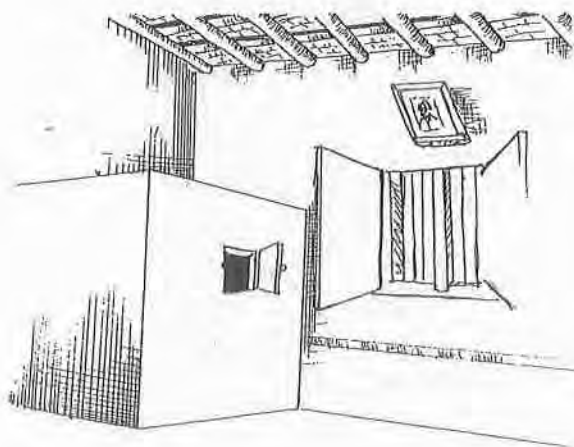
Grains can be stored this way for nearly 1.5 years. This may cost about Rs. 300 to Rs. 500.

With growing surface drainage systems and other reasons, this practice is rapidly losing favour among farmers.



Caution

While opening the underground store, wait for two hours before entering for air to go in. Alternatively, lower a lighted oil-lamp into the chamber. If the light continues to burn, it is safe to enter the chamber.



Overground tanks

This storage tank is made of bricks or mud along an existing wall in the room.

Depending on the requirement of storage capacity, build an oblong tank and neatly plaster with clay and dung slurry. After filling the tank, cover with wooden planks or slabs.

Depending on the size and material used, it may cost up to Rs. 2,000. Incidentally, the size of the storage tank is believed to be indicative of the prosperity of the family.



Bamboo bins

This is another traditional method of storing grains. A huge bin is prepared using locally-available bamboo or palm sticks. These bins can be big enough to store up to 5 qtls of grains. The walls of the bin are plastered with mud and dung mixture.

This may cost about Rs. 150 to Rs. 400. This is a durable device, if properly maintained.

Farmers have observed that *ragi* (finger millet) is free from all kinds of storage pests. The grain itself may repel insects and so other grains are stored along with *ragi*.

Gunny bags

Small quantities of grains may also be stored in a gunny or PVC bags in the house. These bags are generally stacked on a raised platform to protect loss from ground moisture. However, this is a costly method as gunny bags are expensive and cannot provide guaranteed protection from rodents, etc.

Traditional practices are still relevant and applicable. They can be encouraged and improved upon to ensure economic security of grain-producing farmers.

Precautions

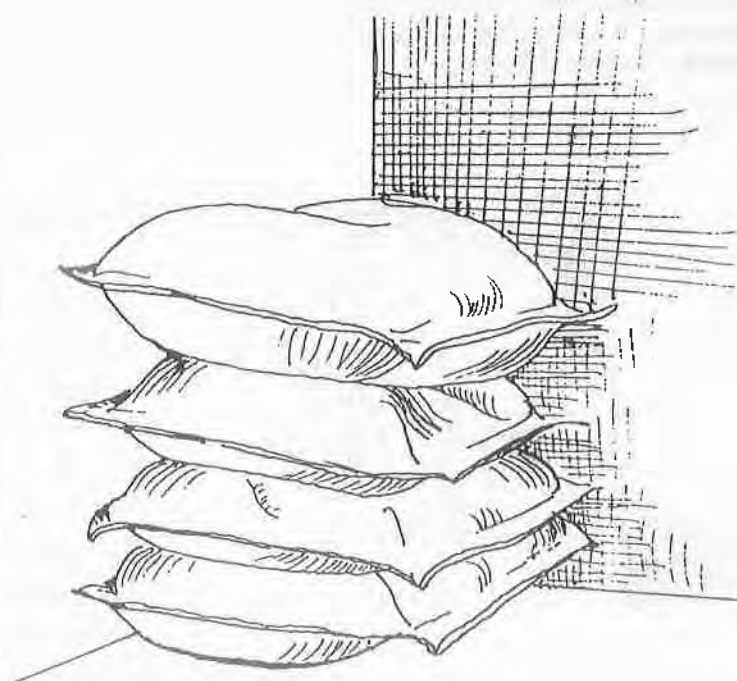
- Dry the grain properly before storing. Excess moisture will result in fungus infestation.
- No chemical insecticide need be applied in any of these storage methods.
- Neem leaves can be put on along with the grain.



Remember

Don't waste food grains. Behind every grain are many hours of hard work of the farmer.

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Contributor: Naganna

Marketing of dryland agricultural products

Agricultural marketing is a process starting with a decision to produce a saleable farm commodity and involves all aspects of market structure, both functional and institutional. Its effectiveness rests on technical and economic considerations and includes pre- and post-harvest operations, assembling, grading, storage, transportation and distribution. It also involves assessment of demand for farm inputs and their supply and policy aspects relating to marketing of products and inputs.

Agricultural marketing plays an important role not only in stimulating production, consumption and accelerating the pace of economic development. Orderly and efficient marketing of agricultural produce helps farmers enhance their income levels.

It is often felt that marketing arrangements for agricultural products continue to be sub-optimal. Under the traditional approach, emphasis has been given to technology transfer relating to production rather than to marketing. In the context of increasing sales and securing higher prices, scientific marketing of agricultural commodities has assumed greater importance.

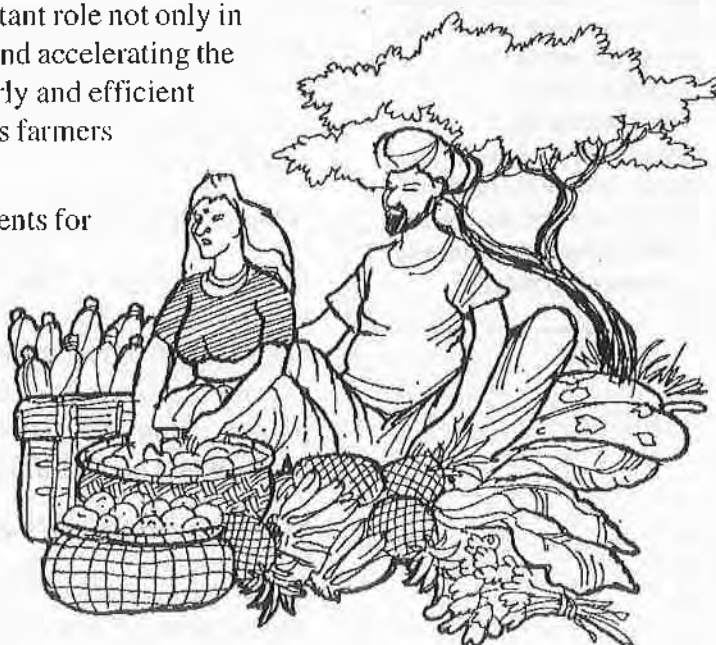
Dryland agricultural produce consists of coarse cereals, pulses and oilseed crops. Marketing is of considerable importance to producers since these crops constitute major portion of the farmers' diet as well as their primary source of income.

Demand for dryland agricultural produce

Dryland farm products are in-demand by consumers to satisfy their nutritional requirements, by cattle raisers to feed their livestock, by traders for sale and by manufacturers for refinement into processed foods or other goods.

Studies have shown that income elasticities of consumer demand for coarse cereals are low, implying that these crops are perceived as inferior to other foodgrains. Thus, as incomes rise, consumers prefer to consume grains such as rice and wheat in place of coarse cereals. This trend is

Agricultural marketing consists of both input and product marketing.



The National Commission on Agriculture has projected consumer demand for foodgrains at 205 million tonnes by 2000 AD. Of this, the supply of coarse cereals is projected at 65 million tonnes. Consequently, nearly 32% of the projected foodgrain supply has to be met from crops grown in dryland areas.

Price support for dryland farm products

The price support policy for foodgrains covers commodities produced in dryland areas. Although support prices of coarse cereals have increased at nearly the same rate as cereals, like rice and wheat, buffer stocks have not been built up and coarse cereals have not been included in the public distribution system. As a result, demand and market prices remained relatively low compared to the superior cereals. Nonetheless, the government has expressed its intent to build buffer stocks and stabilize prices if the coarse cereal market becomes too volatile.

particularly apparent in urban areas. Urban consumers also appear to be more sensitive to changes in cereal prices than rural consumers. As a result, if prices of coarse grains rise, urban consumers will reduce their demand to a greater extent than rural consumers. The implication of these tendencies (low income elasticities of demand combined with the high price elasticities of demand) could be very difficult to push the consumption of coarse cereals. Instead, it may be preferable to stimulate commercial demand through the promotion of coarse grains in industrial uses.

Effective marketing of dryland farm products

The tendency among farmers to market their produce has been increasing. The process of production is complete only when the product is marketed at a price remunerative to the farmer. Farmers can achieve increases in both price and sales volume if they adopt the following measures while marketing their products:

Always clean the produce before selling.

Produce brought by the farmers for sale in the market must be clean and free of dirt, sand, pebbles, etc. Impurities will lower the price offered by the trader/buyer in the market. Reduction in price is more than is warranted by the extent of the impurity present. Many buyers are interested in buying only clean produce and are willing to pay a higher price for it.

Sell the produce after grading.

It is always advantageous for farmers to market their produce after grading. It has been proven beyond doubt that sellers get a higher total income when they sell the produce after grading. The additional income generated through grading is more than the cost incurred in the process of grading.

Sell different varieties of products separately.

Different varieties should be marketed separately because of consumer preferences for specific varieties.

Use carry bags/packs of standard weights.

Farmers should weigh their produce and fill each bag with a fixed quantity so as to facilitate quick transactions and prevent malpractices in the market.

Avoid immediate post-harvest sales.

The historic behaviour of prices has indicated that they are lowest immediately after harvest. Farmers should remain aware of seasonal price movements to sell their produce at the optimal time.



Note

Farmers are often subjected to forced sales as a result of prior commitments to traders or moneylenders. To overcome this problem, farmers should seek the provision of credit through alternate institutions.

Make use of warehousing/pledge loan facilities.

To avoid forced sales due to money shortages, commodities should be kept in warehouses. Cash requirements can be met by pledging warehouse receipts at banks and cooperatives.

Sell produce in regulated markets.

It is advantageous for farmers to sell their produce in regulated markets rather than in villages or unregulated markets. Malpractices in regulated markets are comparatively low. Moreover, competition among buyers in these markets is fairly high, resulting in increased produce prices. It should be noted, however, that access to regulated markets may necessitate the formation of farmers' organizations.

Patronise collective marketing organizations.

Farmers can realise better prices by scale economies if they sell their produce collectively through cooperatives and associations.

Process the produce where appropriate.

Processing adds value. If farmers or their organizations can take up intermediate or final processing, they can reap the benefits of value addition by making the produce available in the desired form.

Get and use pertinent market information.

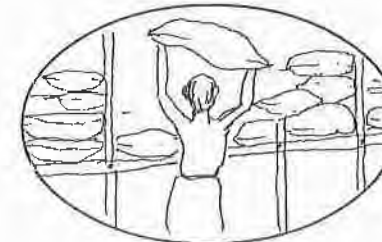
Farmers must keep abreast of market news to know market opportunities. Price information assists in making decisions about when and where to sell the produce to obtain the maximum price. Positioning the product in the appropriate market is crucial because shortages and surpluses are common in most product markets. Sources of market information include: government agencies, mass media and private organizations.

Conclusion

There are large financial gains that could be made by adopting a methodological approach to marketing farm produce. In this context, it is essential that extension programmes ensure transfer of both production and marketing technologies.

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Contributor: P. G. Chengappa



7 Participation, extension, linkages and institutional partnerships

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No sustainable resource use without democracy

This paper seeks to promote sustainable rainfed farming by dealing with the question of how support organisations promote concepts of empowerment.

Dryland development initiatives have often excluded questions of empowerment, focusing instead on several issues concerning sustainable management of natural resources in rainfed farming systems. Such initiatives serve to:

- optimise economic returns from resource use for all members of society (**growth and distribution**);
- promote technologies in harmony with nature's regeneration potential (**carrying capacity**); and
- create local institutions for the management and maintenance of resources and assets (**civil society building**).

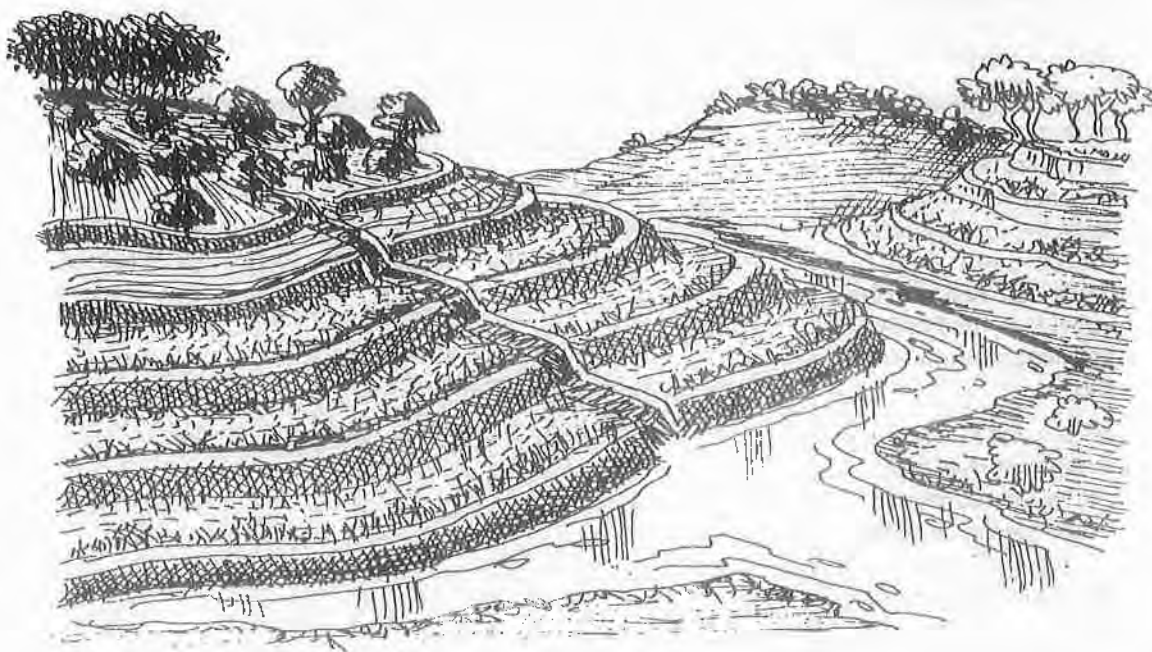
These key elements provide overall direction in drafting of development plans for rainfed area development. The assumption is that with external support through government schemes, private sector promotion, rural credit or extension programmes, trends in resource depletion and unsustainable resource utilization could be reversed.

Initiatives on the part of non-government organizations (NGOs), rural banks, research institutes and donor programmes seek to implement such a reversal.

The basic proposition is that effective empowerment of local organisations can never mean increased power over others. What is required is a set of democratic development ethics fit for truly enabling focus groups.

The first conclusion

Impacts of a advanced and scientifically-designed technology interventions backed with political will and financial resources are often nullified by the "human factor".



The second conclusion

For want of effective democratic systems and processes, many programmes are ineffective and do not reach their intended groups nor do they achieve their own objectives.

A common feature of these initiatives is the strengthening of self-reliance and empowerment of beneficiary groups. Unfortunately, the current practice of "technology delivery", of externally induced change is often unrelated to local reality. In addition, many well-intended schemes faced a range of non-technical factors such as unorganised local population and inefficient or even non-existent public administration. They are also exposed to multi-layered systems of bribery, corruption and clientelism, persisting feudal power structures in backward areas, manipulative political groups and authoritarian institutions. Politically-motivated subsidies, capital intensive programmes for infrastructure development with a variety of fund syphoning opportunities, badly timed local works and inappropriate wage rates are just some of the many mechanisms depriving people of effective participation in the above programmes.

It is not surprising that effects of such programmes, instead of enhancing people's autonomy, often perpetuate dependence and further erode the community's self-development potentials.

Elements of a development approach based on participatory principles

Why community organisation ?

A community working towards empowerment needs to:

- **be able to fulfill basic economic, social and political rights;**
- **participate in society as responsible members working toward a common objective and beyond the basic and immediate needs of the individual, the family or the village community; and**
- **acquire the local strength to deal with stress, pressures and challenges at all levels in a fair, just and equitable manner.**

Mobilising social forces: the need for community organisation

The "rural development sector" (grassroots NGOs, government departments, fertiliser companies and missionaries) needs a strong organisational component at the community level to arrive at choices of its own, grounded in local identity.

Local communities are the primary resource users in large parts of semi-arid India. Traditional land use systems, which remain essentially self-supporting and non-conflicting due to abundance of the resource base and low population density, have become rare and are found only in few tribal regions.

In most other parts, the dryland farming population is exposed to multiple pressures and has to find institutional solutions to enhance its leverage and negotiating capacity. To increase leverage and the level of local empowerment, communities must take into account why many schemes, promoted by support organisations, have failed, if the process of empowerment is to be successful.

The culture of support organisations (SOs)

- Development support organisations tend to design and plan their support initiatives well ahead of the first involvement of focus groups.
- Plans tend to set rigid targets; SOs commit their staff to work towards these targets — professional recognition and reward systems are contingent on the achievement of defined targets.
- There is a limited understanding of people's participation. Many perceive participation to be limited to needs surveys, consulting people's opinions about the SOs' plans and motivational work/project implementation.
- SOs emphasize their own agenda (prepare ground for private investments; fund placement; vote banks; model approach development, etc.).
- Blind replication of "thought-to-be" successful experiences and models.
- Extension systems based on "teaching the uneducated, the ignorant" beneficiaries.
- Caste and class-based behaviour and attitudes.

The internal management culture in many SOs — and that includes a large part of NGOs, as well as donor agencies or research establishments — is strongly hierarchical, single-leadership oriented or prescriptive and model-based. It is just natural that the above elements of SO-culture do not generate empowerment or result in genuine citizenship building among focus groups.

Support organisations must identify structural impediments within the organisations to effectively enhance roles in rainfed farming development. The following deal with some procedural methods to attain this goal.

The third conclusion

Authoritarian organisations are non-credible role models for newly-emerging community organisations.

The fourth conclusion

Rigidity in a support organisation's own agenda suffocates the very objective of empowerment and partnership building.

The fifth conclusion

Over-emphasis by the support organisation (SO) on truth finding, on searching for the right answer to a given problem, adversely affects the people's own creativity and potentials.

The sixth conclusion

Empowerment and emancipation of oneself within the SOs is a precondition for empowering others. Exercising authority or seniority, caste or class privileges, or being driven by career concerns, are detrimental to SO efforts to empower others.

Empowerment approaches beyond knowledge building

Some lessons can be drawn and applied from an analysis of the culture of SOs if these organisations want to enhance their effectiveness and impact in rainfed farming development: They need to:

- strengthen communities, groups or single resource users in their own responsibility to sustainably care for their resources;
- transform — as a matter of principle — resource development interventions into support actions for self-help initiatives;
- measure the success of development interventions in terms of indicators like growing self-control and reduce resource-user conflicts instead of the number of hectares treated or physical assets created;
- shift from a centrally-managed, performance-control based development thinking to decentralised, concern driven, transparent and locally negotiated ways of resource management; and
- stress two-way learning processes among stakeholders groups and avoid blind upscaling of technologies or approaches.

Underlying these requirements are enabling approaches summarised in **Chart 1**.

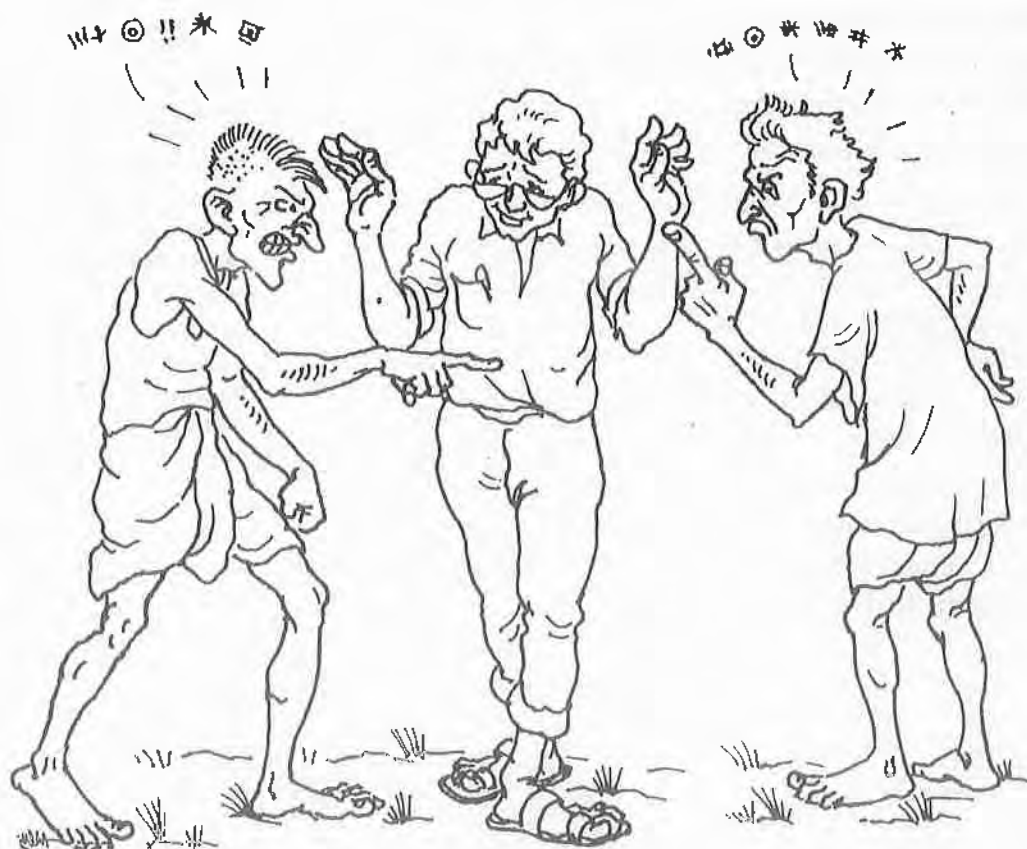
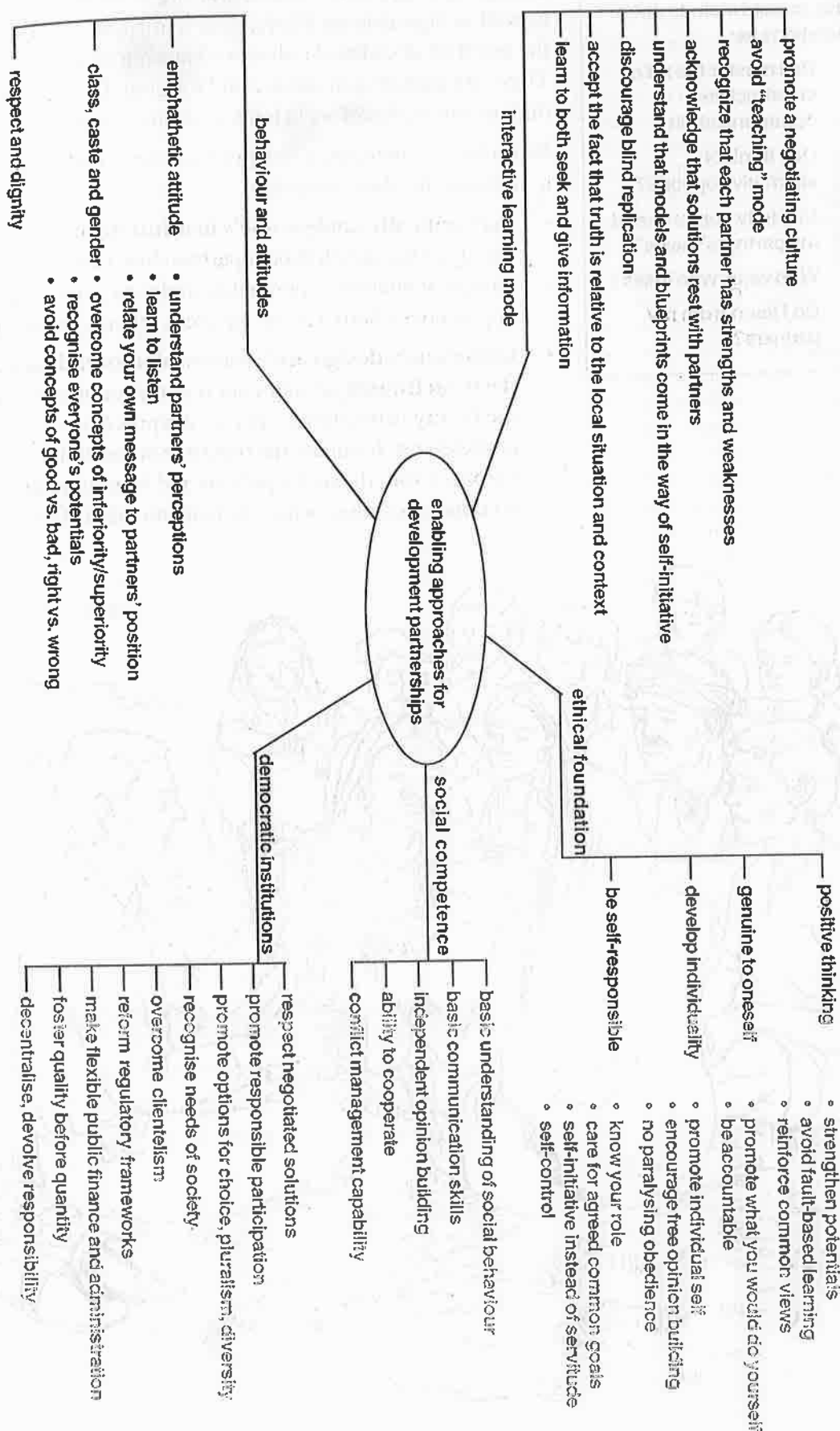


Chart 1: Enabling approaches for development partnerships



- Numerous ways can contribute to operationalise these approaches: self-reflection; critical analysis of the institution, professional training in social competence, organisational development initiatives, participatory work culture, systematic evaluation of one's own/partners learning, etc.
- Each SO and field level worker has to find one's own path of change. No models, manuals or recipes are available for this set of qualitative approaches.

Self critical analysis

This should include such questions as:

- Do I master the art of constructive communication ?
- Do I think of alternative options?
- Do I fully comprehend my partners' views?
- Who wins, who loses?
- Do I learn from my partners?

Operationalising the enabling approaches

Ethical value systems, behavioural and attitudinal expressions, as well as organisational behaviour in different societies, are the result of decades of collective learning (acculturation). These are anchored in culture and religion. Changing these dimensions is, therefore, a long-term endeavour.

Nevertheless, there are a few practical steps and tools available to move in the above direction.

- **Self-critically analyse one's institution**, the project, the family or the development partnership based on the five strings of enabling approaches and rank your own approaches relative to the different criteria listed in Chart 1.
- **Consciously design and practise democratic processes of decision finding** among your team, your organisation or in the family: workshops, open group processes, family conferences. Evaluate the outcome at the end through feedback rounds, seek opinions and learn to interpret such feedback including what lies beneath the surface.



- **Document contributions** from the team carefully.
- Identify those areas where you would like to **develop yourself professionally** and find appropriate capacity building programmes, be it in personality development, in negotiation skills, in democratic group moderation or in client-oriented planning and strategy building.
- Obtain, read and discuss relevant **literature**.
- Challenge your organisation with your own set of creative ideas and reflections.
- Reward self-initiative and **positively reinforce ideas emerging from partners**.

Enabling approaches depend largely on the awareness of one's own responsibilities, on the readiness to continuously learn and persuasion that our own preparedness for change will open avenues of change for our partners too. No standard set of tools or correct attitudes will be applicable but the quality of relationship established between each SO and its partner COs will determine the degree of empowerment achievable.

Role change in SOs

The responsibility for public goods, such as limited natural resources can no longer be comfortably "delegated" to anonymous public service departments. While governments will increasingly focus on enabling legal and regulatory frameworks but no longer implement resource development programmes directly, it is the Panchayat institutions, community self-help groups, farmers' federations or rural producer associations which will bear the task of resource management. SOs bound to facilitate such role change and effectively empower resource development actors.

Therefore, there is a need to redefine own vision, goals and strategies. This will require a change in the work culture of SOs. Broad-based organisational participation and an enhanced clarity as to how effective community empowerment (with subsequent withdrawal of support services) should be designed are important steps in achieving sustainability.

Future agenda for SOs

Future focus will be on social competence and capacity building in participative processes, in team management, personality development and relationship-building, in addition to traditional areas of technical and managerial expertise. A transparent and shared value system based on respect, empathy, concern and commitment is the foundation of successful support organisations. They will increasingly perceive their own role as a continuous learning organisation with and through their institutional partners. They will adopt methodologies of interactive adult learning such as active listening/ mirroring, cross-hierarchical group sessions, facilitation of change processes and conflict resolution, participative planning and evaluation, etc.

Promotion of democratic control over natural resources

Conflicts over limited natural resources such as land, water and forests are increasing. Access to these is determined either by ownership, poverty, lack of alternatives or by commercial interests. Regularising access by political or legal means to these resources to all segments of society has in practice not been successful. The issues are complex and touch on the basic human needs question.

Government may have to seek a combination of the following strategies:

- control land ownership and land trading in peri-urban areas. Based on sound land-use plans, assure adequate agricultural land for regional and national food security;
- encourage locally-controlled management of forest resources with incentives on usufruct and long-term economic benefits for the local communities;
- introduce and enforce water user taxes and charge basic energy rates for agricultural water use through local water user associations; allow for royalty to flow into the local area development programmes; and
- strengthen democratically elected civil society organisations which can resolve natural resource disputes at the lowest levels where these occur. Equip them with powers and authority.

Conducive policy environment

Progressive devolution of authority and powers over natural resources would also include:

- redefinition of rural development priorities towards the masses of medium and small farmers in rainfed areas;
- reduction of interventionism in agricultural and rural support services and pricing systems;
- revalidation of local market networks;
- reorientation of governments' human resource recruitment and staff development systems; introduction of rewards for self-initiative, accountability, participatory behaviour; self development through learning; and
- reformation of public financial and administrative structures and procedures; quality, flexibility and empowerment are favoured over target achievement and bureaucratic conformity.

Individual and collective responsibility is a critical dimension of sustainable resource use. This however can hardly be achieved if we do not provide the necessary democratic framework for it.

Contributor: Martin Sommer

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Farmer-centred extension strategy for dryland agriculture

Dryland agriculture is complex and diverse and is mostly practised on problem soils. Farmers in the dryland areas do not have access to modern sources of information. Low quantities of external inputs are used. Yields of agricultural commodities are low and dependent on the use of resource-conserving technologies, i.e., harnessing natural resources like soil, water, forest, animal wealth, etc.

Technology transfer in rainfed areas needs special attention because of problems unique to such areas. First, a limited range of technologies is available from extension agencies for rainfed areas. Second, these agencies need to initiate group action and mobilize communities to adopt rainfed farming technologies and manage natural resources.

Assured farmer participation in technology development and dissemination is the key to success in dryland extension efforts because farmers have experience and local insight. Search for such an initiative converges on a "farmer-centred extension (FCE)" approach where farmers act as principal agents of change.

Two approaches

Two approaches in extension are involved: technology-centred and farmer-centred.

While technology-centred extension focuses on disseminating technology, farmer-centred approach promotes the welfare of farmers by using technology as a vehicle for development.

Why FCE?

The farmer-centred extension approach is more effective as it:

- facilitates access to remote areas not easily served by extension agents;
- establishes quick and better rapport with the farming community;
- can operate on a low budget; and
- can provide timely as well as efficient and effective extension services.

Main issues in rainfed farming

- Soil and water conservation
- Agroforestry
- Animal husbandry
- Crop management
- Human resource development

Free communication among farmers is the soul of FCE.

Farmer-extensionist's responsibilities

- Plans, monitors and evaluates progress for farm improvement.
- Organises training, study tours and farmer visits.
- Conducts or leads farming experiments especially on-farm and adaptive trials.
- Liaises between the community and external agri- development institutions.
- Encourages the formation of community level groups or farmer associations.
- Supports community leadership.

The farmer-centred approach is participatory in nature, promotes the concept of human rights and gives power to disadvantaged groups. It ensures high motivation and active involvement of farmers, who then develop confidence, pride and a sense of responsibility.

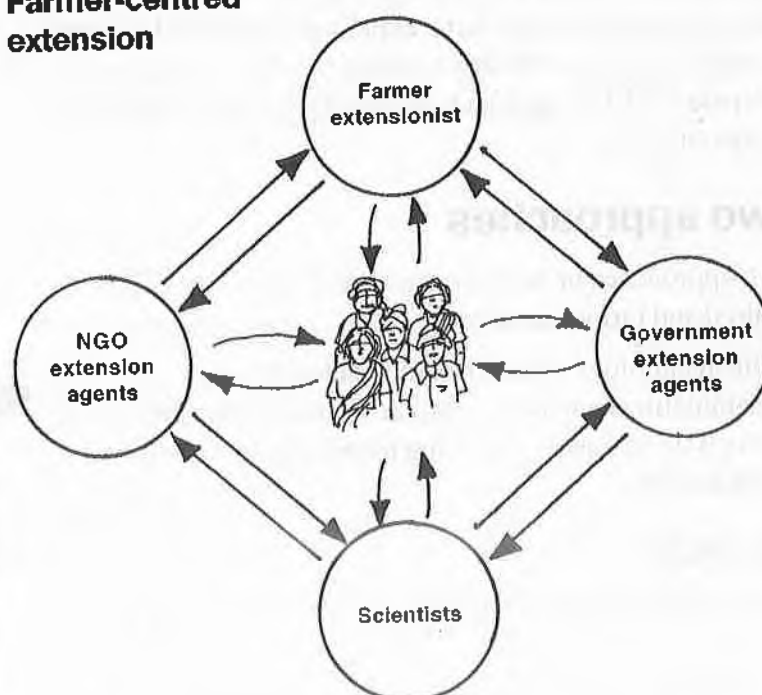
Farmers

Farmers are the focus of all extension efforts. They help extensionists appraise local situations and identify and prioritise problems. They possess indigenous knowledge which helps provide local solutions. Training programmes, local field demonstrations and on-farm trials are designed with their assistance.

Farmer extensionist

A farmer-extensionist works closely with fellow farmers and extension agencies. The farmer identifies problems and interprets technical information.

Farmer-centred extension



Government extension agents

Government development agencies operate through grassroot level extension agents. They provide information to farmers on specific technical subjects and arrange for agricultural inputs. NGO extension agents, farmer groups and government extension agents can form a tripartite alliance to help scientists in technology development.

Farmer groups

Because natural resources are community assets, individual action (in dryland areas) may not bear fruit. The difficult agro-economic situation calls for community action. Local groups can participate in natural resource management by taking responsibility for soil and water conservation structures and tanks in a watershed. Farmer groups can help research institutions become more responsive to local farming problems.

Local groups need to widen their sphere to ensure success. Small groups can pool their resources and knowledge and join other groups. The bigger groups can influence policies at higher levels.

Research and training institutions

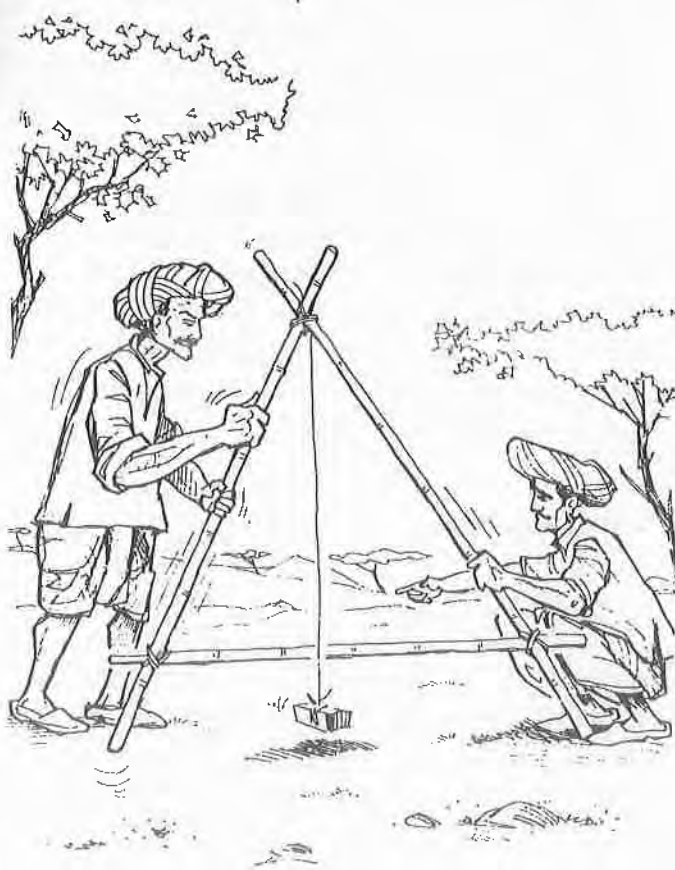
Research institutions helping to develop useful technologies for dryland areas should work closely with farmers. Linking research with extension is important to make it participatory.

Training is an important component of farmer-centred extension. It helps farmers keep abreast with the new skills needed in farming. Participatory training methods are more effective as they fully involve farmers in the learning process.

Training institutions like the *Krishi Vigyan Kendras* (KVK) and Farmer Training Centres have to provide programmes suited to the training needs of farmers in dryland areas.

Strategies for FCE

- **Formation of self-reliant groups:** The process of establishing self-reliant groups at the local level must be voluntary and organic. Farmers are normally organised in informal groups. Extension agents should facilitate the formation of such community organisations.



NGO extension agents

Dedicated extension agents belonging to NGOs reorient government extension activities to be more farmer-responsive. They help communities analyse and prioritise their problems and suggest remedial measures. NGO extension workers serve as a feedback channel for farmers and influence the process of conveying farmers' priority-based needs to government functions.

The best educators of farmers are farmers themselves.



- **Begin with informal organisation:** Begin by focusing on a particular problem and bring a small group together to solve it. It is not necessary to organise first, choose leaders and start work. Initial meetings of farmers may help but are not a must. It is better to start with small problems and groups. Informal groups will automatically give way to the formation of formal groups.

The extension agent may act as a catalyst in forming common interest groups (like landless pastoralist groups, women's groups, youth *mandals* etc). These groups may converge into various other working groups for technology assessment and refinement, community resource management (use and maintenance), credit management, etc. and need not be exclusively independent of each other.

- **Identification of farmer extensionist:** The farmer extensionist should be chosen by a group not by election but by consensus. The extension agent should explain the role of the farmer extensionist to the group that s/he should be a progressive farmer; be able to communicate with people, has access to sources of information and of course, a professional approach to farming.

- **Equipping the farmer extensionist:** To facilitate FCE, the farmer extensionist should be trained to motivate people, handle group work, identify problems and assess needs besides having a technology-based training and excellent interpersonal skills.

- **Formation of Farmers' Professional Association:** Smaller groups of adjoining villages can form a larger organisation by getting together without losing the individual identity of the groups. This will help them gain a greater political say in the affairs of the state. This group can serve as a platform to disseminate technologies further over a wider geographical area through the participation of farmers.

Contributor: P. N. Mathur

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Participatory learning methods: Some uses for planning in drylands

Participation is a mechanism where people express themselves and act with mutual responsibility to promote a mutual set of interests.

In the context of rural development, participation must consciously aim at promoting equity and sustainability.

Participatory Rural Appraisal (PRA) techniques are useful ways of initiating the process of participation.

PRA techniques are comprised of a range of semi-structured tools that can be used to learn, relatively quickly, with the rural people about their situations, problems and opportunities. **This way of learning requires the cultivation of crucial attitudes to support a free expression of facts, ideas, opinions and aspirations.**

PRA Techniques

Some PRA techniques that can initiate the process of participation in dryland programmes are discussed below:

Timeline

Older people in the village can be asked to recall what the environmental and farming conditions were like in the "olden days", how things have changed, and what — in their opinion — were the factors responsible for such changes. This can yield a useful historical perspective for planning.

Mapping

People can easily be involved in making a map of their own village.

A **village map** plots all the streets, houses (locating each family by name, so that no house is left out) and other village landmarks. This map can be used to generate all kinds of information: how many people in each house, how many adults and children are employed in agricultural activities in each household, how much wet and drylands are owned/cultivated by each household, and so on. Sticks, stones, seeds, coloured powders and other such locally-available materials can be used to represent each type of information on the map.

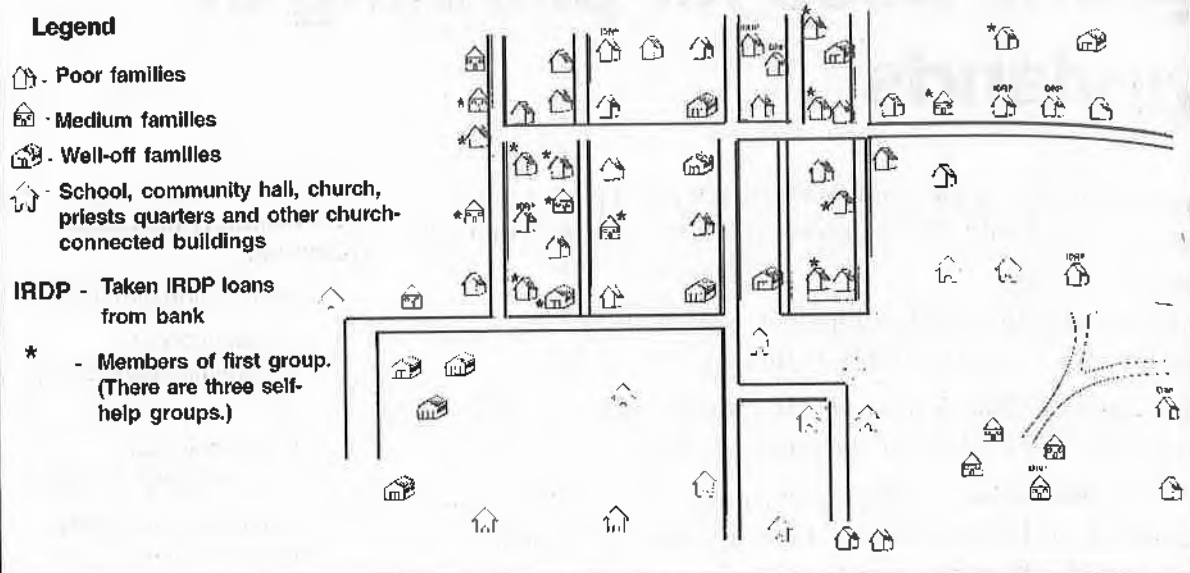
Participatory processes include:

- information generation;
- analysis of the information generated;
- planning (including budgeting and responsibility-sharing);
- implementation of the actions planned; and
- management of the initiated activities on an ongoing basis.



Map of Chinnapparapalya, H. D. Kote Taluk, Mysore District

Chinnapparapalya is a village of Christian settlers migrated from Tamilnadu. This map was drawn on August 1990.



A **resource map** plots all the resources in and around the village that have a bearing on the livelihoods of the people: private lands, common lands, trees, wells, streams, ponds, etc. The ownership, present status and current use of each resources can be easily ascertained and indicated on the map. A watershed map plots each micro-watershed in full.

Mapping is a versatile tool and can be adapted for use in a variety of other situations as well. Maps are useful for planning and locating each type of intervention as well as monitoring the changes over time.

Modeling can also be used as a three-dimensional version of mapping.

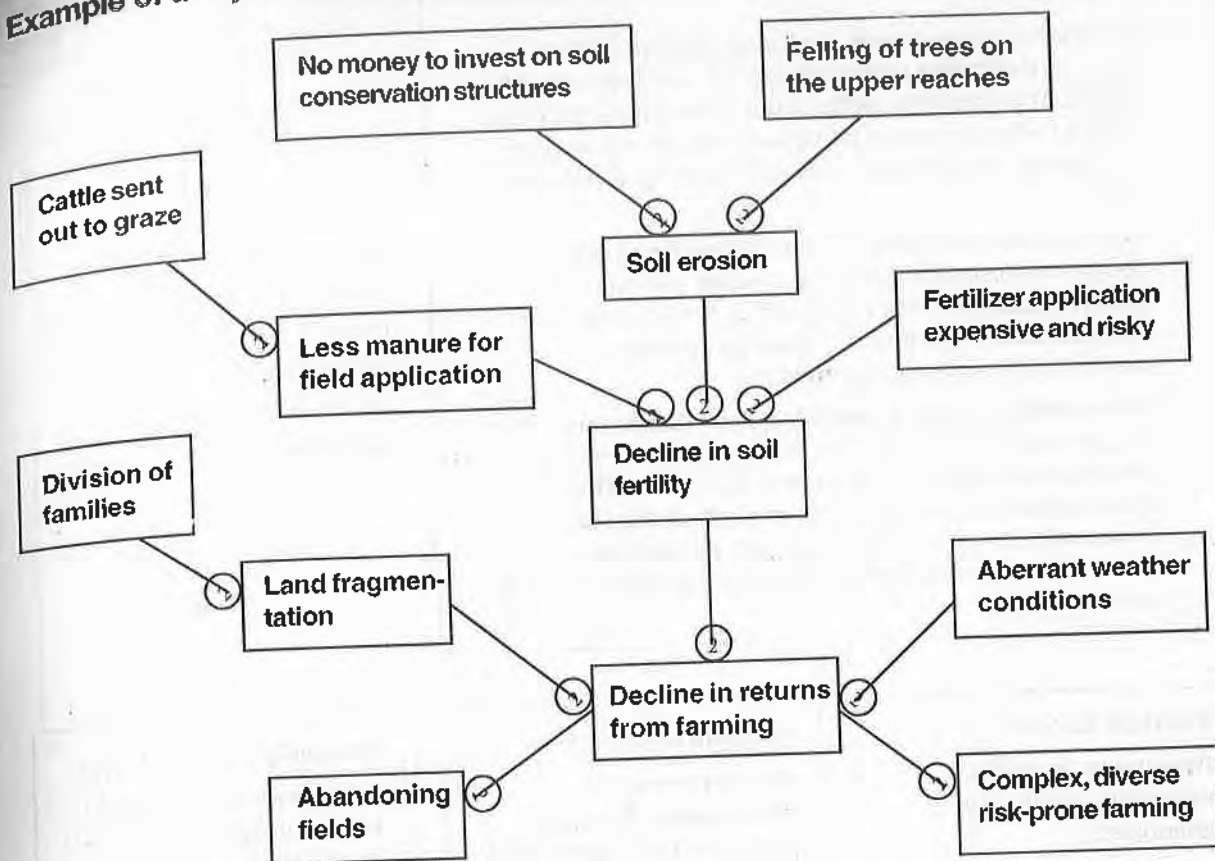
Charts and diagrams

Sticks of different lengths, stones and seeds can be used by the people to make seasonality diagrams, indicating different months, rainfall received in each month, seasonal labour availability, periods of income, expenditure and credit need, etc.

Various kinds of flow diagrams can depict resources flowing into the village, resources flowing out of the village, how agricultural information flows into the village, whom it reaches, and so on.

Relationship diagrams can plot relationships between the people and other institutions like local government offices, bank branches, private institutions, etc. Trend diagrams can be made to show how practices pertaining to specific agricultural/resource management practices have changed over time. Other variations of diagramming can also be tried out.

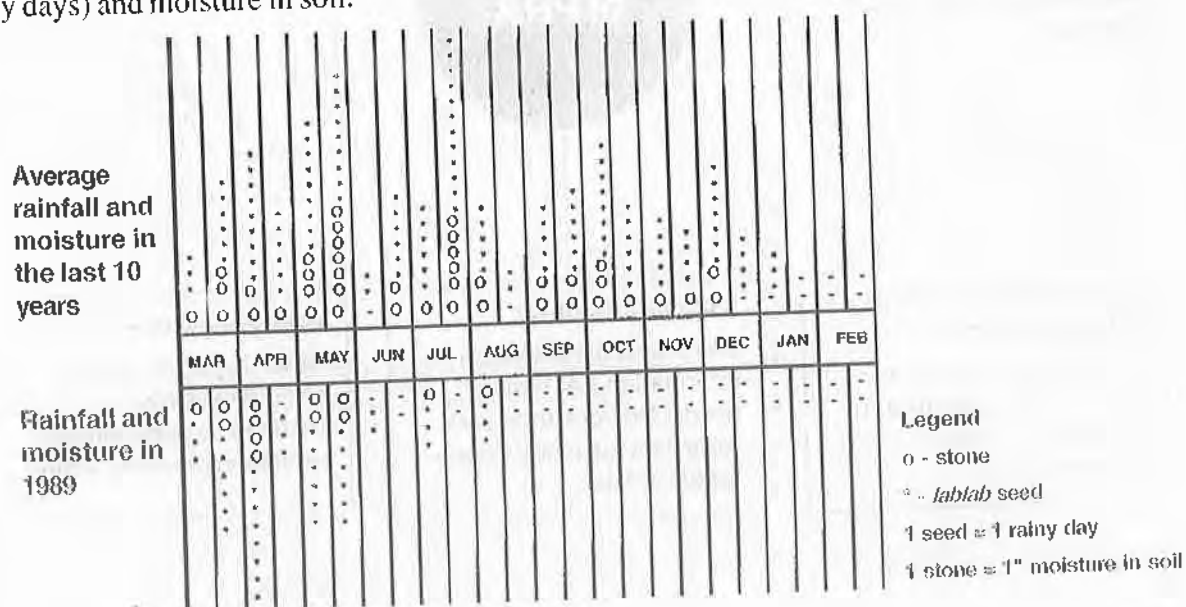
Example of a dryland farming problem flow chart



Maps, charts, diagrams, etc. can first be made on the ground in any open place where many people can move around and contribute to the information pool. Corrections can easily be made on the ground and the final output can be copied onto paper for future use.

Seasonality diagramming of rainfall in Neegu village

This graph was copied from the original graph made by a group of villagers. Interestingly, this group of farmers was particular to make a distinction between quantum of rain (i.e., no. of rainy days) and moisture in soil.



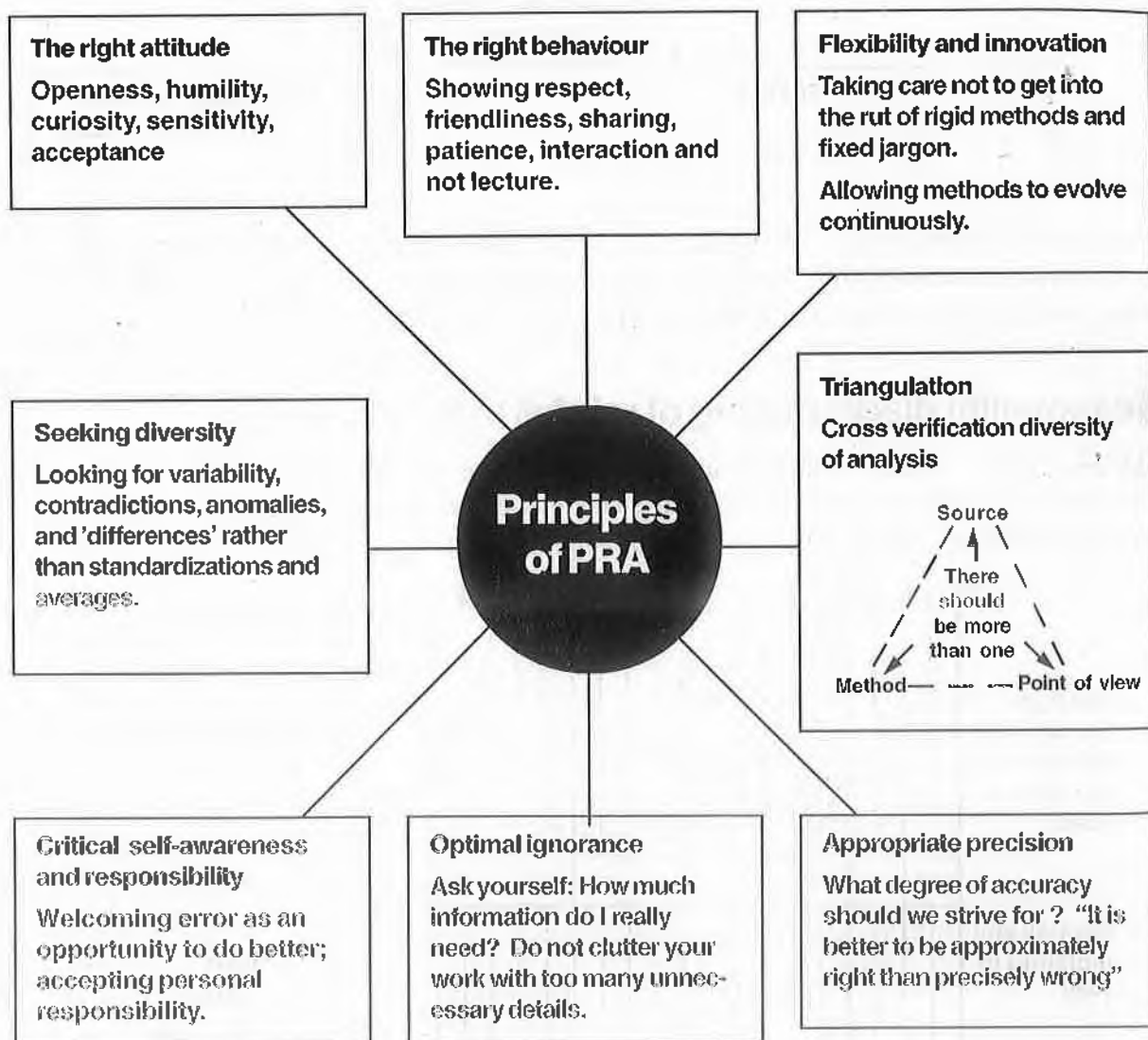


Remember

- The sticks, stones, seeds, coloured powders and paper cut-outs that form a part of many PRA exercises are only aids that can facilitate participation. The crucial element in PRA is the element of participation itself, which goes beyond the manipulation (manual handling) of the aids used.
- PRA methods definitely facilitate the involvement of people in information sharing, analysis and planning. However, they are not a substitute for the development process itself, as is often expected by planners, particularly from the government.
- PRA methods, though relatively quick in assessing situations, are by no means a short-cut to achieving programme objectives. Therefore, the use of PRA over other methods is guided not by the time factor but because it accords respect to people and solicits (actively) their involvement in data-giving, data-analysing and planning.

Transects

Cross-county walks with the farmers, preferably from "ridge to valley" will give a clear idea of the topography and terrain. Discussions with farmers and those met enroute will indicate how and why resources are being managed. Transects can also take specific routes, e.g. along a "nullah" to study problems and opportunities.



Source: Robert Chambers

Example of a matrix scoring exercise

Qualities	Cotton seed varieties				
	Varalakshmi	DCH	LRA	LCH	MC-5
Yield	••••• (very good)	•••••	••	••	••
Market value	•••••	•••••	••	••	•
Disease resistance	• (very disease prone)	•	•••••	•••••	•••••
Cost of cultivation	• (expensive)	•	•••••	•••••	•••••
Duration	more or less same for all				
Drought resistance	more or less same for all				
Seed availability	• (very difficult)	•••••	•••••	•••••	•••••

Exercise done on ground using stones. More stones indicate more farmer-satisfaction.

Care in the use of PRA tools

- A tool (any tool) is only as good as its user. Much of the validity of PRA outputs depends on its users' creativity, integrity and the situational appropriateness of the method selected.
- The user must clearly distinguish between facts, perceptions, opinions and hearsay in analysing and planning.
- Select informants with care. Everybody does not know everything neither does everybody hold a view on all subjects.
- Views expressed by a few cannot be taken to mean the views held by all.
- Cross-verification of data is a necessary part of a complete PRA exercise.
- Documentation poses several difficulties due to the wealth of information generated and the need to keep track of both process and output in ways understandable to all parties involved.
- PRA exercises can result in raising expectations and therefore, have to be carefully initiated with proper explanations.



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Contributor: Vidya Ramachandran

KRIBHCO's participatory planning approach to farming system development

This paper presents the participatory planning process developed and used by KRIBHCO project.

Farming systems development

This refers to an integrated approach to enhance farming techniques. In most villages, this typically involves the introduction of improved crops and crop varieties, soil and water conservation, joint forest management, agroforestry and minor irrigation.

Indicators of achievement

- have identified and overcome any suspicions held about the project
- all villagers have met with the project staff and have had an opportunity to discuss the project
- village leaders agree to help arrange the PRA

The Krishak Bharati Cooperative Limited (KRIBHCO) Indo British Rainfed Farming Project is a participatory and poverty-focused farming system development project located in three districts of three neighbouring states, Panchamahals (Gujarat), Jhabua (M.P.), and Banswara (Rajasthan). The project aims to improve the long-term livelihoods of poor farmers in the region, most of whom are tribal people from the Bhil community.

Cluster selection

Clusters are chosen where most villages satisfy the following criteria:

- no basic amenities and infrastructure facilities available within the 5-km radius (such as hospitals, schools, transportation);
- scheduled castes and tribes constitute over 90% of the population; and
- degraded forests.

Village entry/rapport building

- Establish identity and purpose of the project.
- Stress the project's interest in natural resource development, poverty reduction and the aim of working with women and men of local communities in identifying problems and priorities.
- Discuss development possibilities, understand the local issues and recent development experiences.
- Learn about local patterns and leadership style.

Tips for rapport building

- Discuss with men and women in meetings and individual contacts. Establish friendly relations with people from all sections of the community.
- Participate in village events, take interest in ongoing activities and learn from, understand and respect tribal culture.

General/Planning PRA

Objectives

- Promote rapport building.
- Demonstrate the respect of the project for the knowledge and views of the villagers.
- Identify, together with the villagers, local problems and areas of concern.
- Collect baseline information on social organisation and farming systems in the village.

Several exercises could be used to meet these objectives:

- collection of village agroecological information — **natural resource map**;
- collection of village socio-economic information — **social map**;
- collection of information on village historical events — **time line**; and
- information on cropping system, trees and livestock — **farming system diagram/calendar**.

Note

In undertaking CPA, the project may use a variety of methods such as group discussions, role plays and other PRA techniques.

Group identification

- Identify existing groups.
- Mobilise people for collective action.
- Develop guidelines for establishing rules and norms.
- Strengthen groups through exposure visits and trainings.
- Start regular meetings and small savings, identify Jankars (volunteers).

Community problem analysis (CPA)

CPA is an extension of the PRA method that can be used for in-depth analysis of local problems by the people, for the people, with the people.

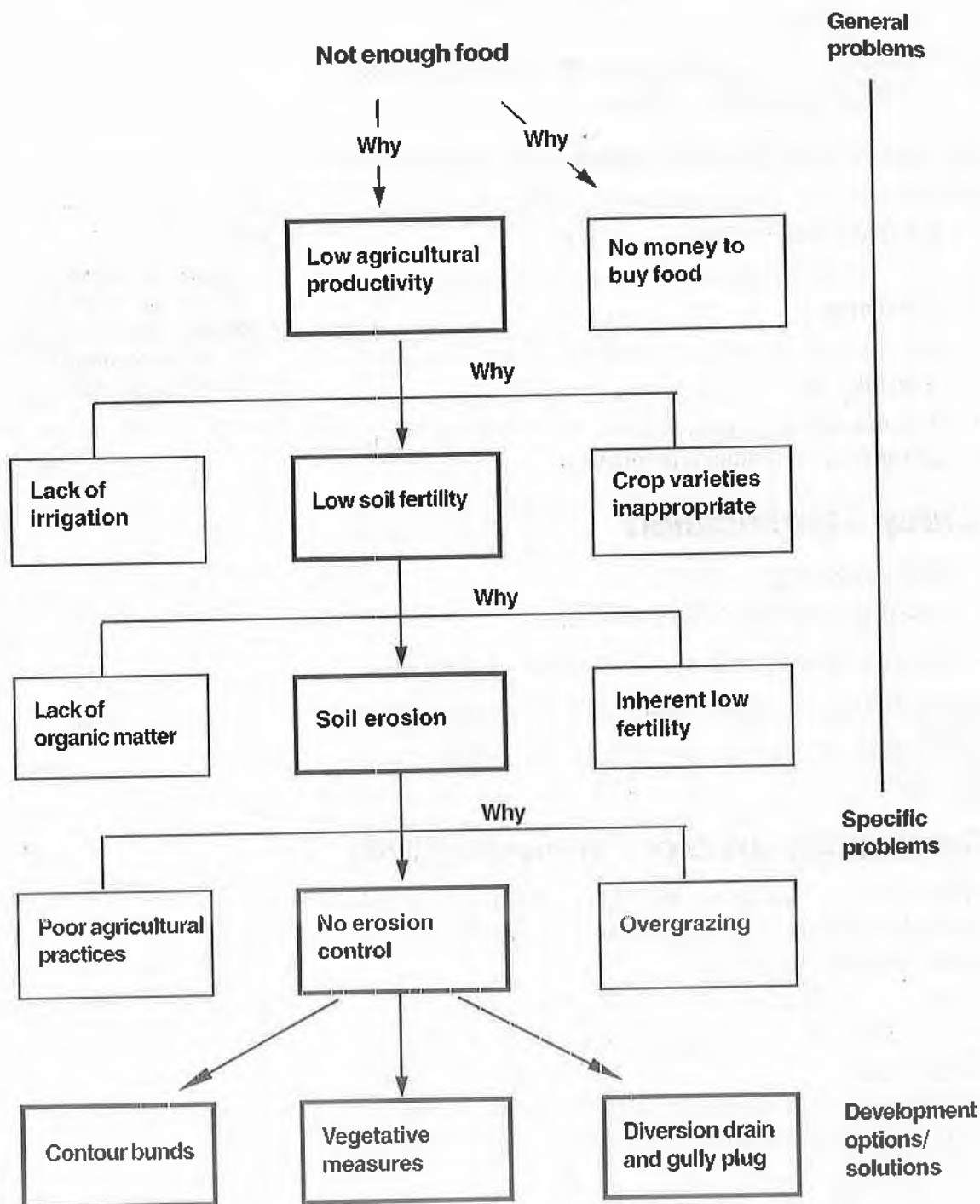
It follows sequences of “why” in order to reach a critical “why”. It also shows the **cause** and **effect** relationship of local problems. CPA is used to analyse complex and inter-related problems of farming systems development using inputs from men and women from different groups in order to:

- better understand the inter-related nature of these problems and identify their root causes; and
- enhance the skills and levels of understanding of the local community so they can be active participants in planning.

CPA Methodology

CPA leads to the identification of development options for different social groups.

Example of a CPA process



Grouping the main problems

Simple problems can immediately be tackled and will only involve the following:

- low cost, involving little or no financial input from the project;
- activities with short term benefits and involve low or no risks.
- Encourage collective action as well as involving women.

Identification and prioritisation of development options

Prioritisation may be easier in relatively homogenous communities in terms of wealth status, access to resources, etc. Homogeneity prioritisation differs in less homogenous areas. CPA seeks to reconcile potential differences to ensure that all groups gain from the process of village development. For example, before developing an irrigation project, prioritisation is required to reconcile the needs of people with access to water and those without. Those without access may decide to opt for a Joint Forest Management scheme to gain the same kinds of potential benefits that irrigated water might bring to those with access to water. This way, village priorities may be different but the equitable distribution of the benefits from village development is ensured.

Prioritisation may involve issue-focused PRAs on topics such as:

Well-being ranking and livelihood analysis

The livelihoods of different socio-economic groups, especially the poor and their constraints and development priorities.

Women's knowledge and perspectives

Women's roles in farming systems, the distinctive needs and priorities of women, assessment of ways to overcome constraints to their participation in the project.

Farming systems

Constraints and potential of the present farming system need to be identified and discussed together with the local communities.

Note

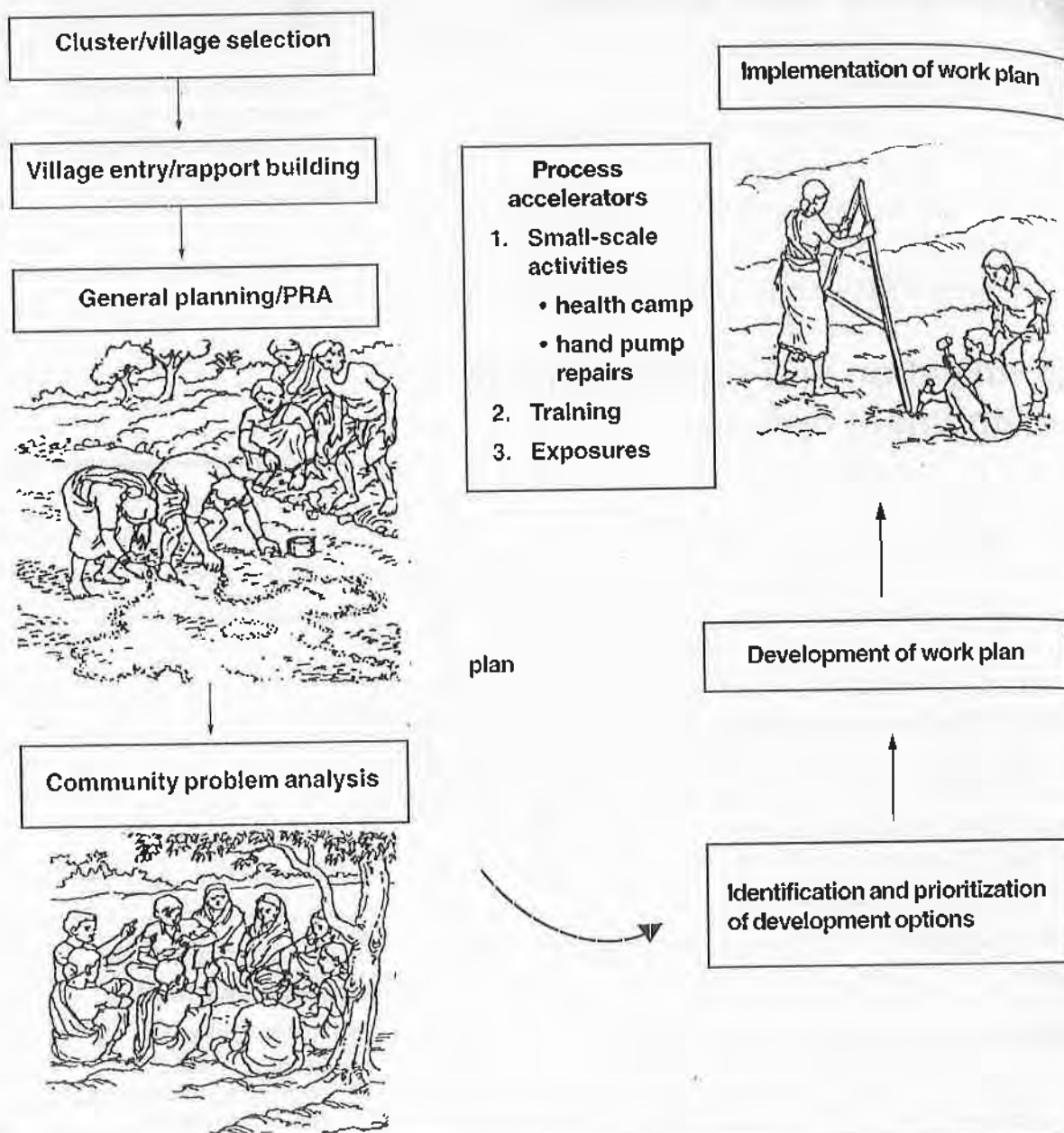
There is no one standard way of organising a PRA. Carrying out a PRA will vary from village to village, situation to situation.

The prioritisation of projects will be reviewed in village groups/meetings.

Development of village work plan

The work plan is a calendar of activities intended to be undertaken during a set period. It is to be developed jointly with the community and the project. The Village Work Plan highlights resource planning and responsibility sharing.

The KRIBHCO participatory planning approach



Unique combination

Self-help groups

More than 169 square hectares involving 1,900 households and over 3,600 women and men as members.

Jankars are trained volunteers with specific skills intended to enhance the planning process.

Information kit produced by MYRADA and the International Institute of Rural Reconstruction

A three-pronged approach

- Participatory planning process
- Local institution — self-help groups
- Local capacity — Jankar system

Jankar system

More than 665 Jankars, both women and men, identified and trained in the areas

Contributors: P. Sodhi, S. Jones, D. Mosse, T. E. Kande, U. Moitra, A. Joshi, Meera Shahi and Gayatri Bhowmik

Family-level micro planning for sustainable agriculture

The importance of family-level planning is often unrecognised. Farm-family level planning complements watershed-based plans. Such plans can be used to monitor progress on a farm over a period of time. The plans should consider the current resource base, family labour and family aspirations and expectations. Micro-planning recognizes current practice and builds upon it.

Objectives

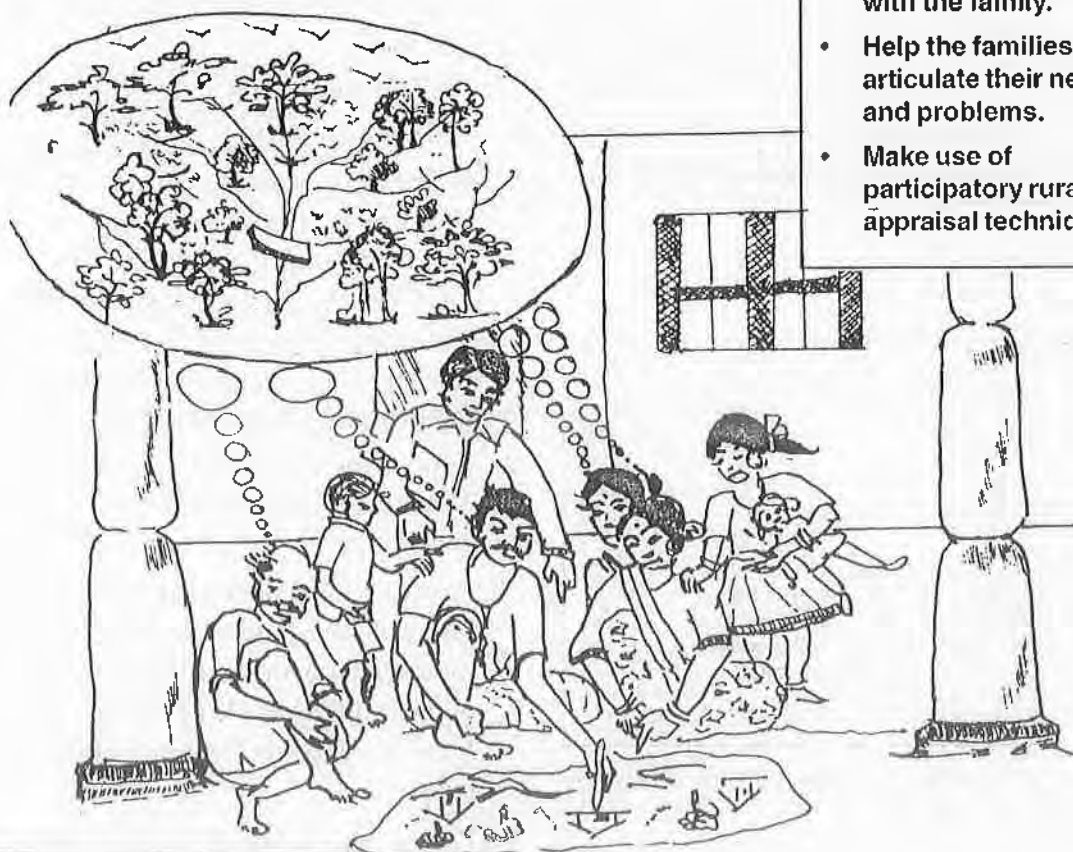
- To improve awareness and understand the asset base.
- To recognise the development needs.
- To ensure complete participation.
- To ensure commitment towards successful implementation of the plan.
- To ensure that the targeted group benefits.

Areas of decision-making

- Identification of problem
- Formulation
- Implementation
- Evaluation
- Cost/benefit sharing

Tips

- Spend sufficient time to understand the aspirations and capacities of the family.
- Engage in frequent informal interaction with the family.
- Help the families articulate their needs and problems.
- Make use of participatory rural appraisal techniques.

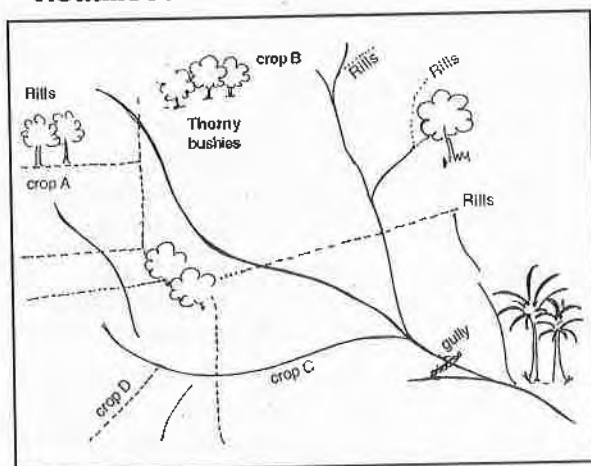


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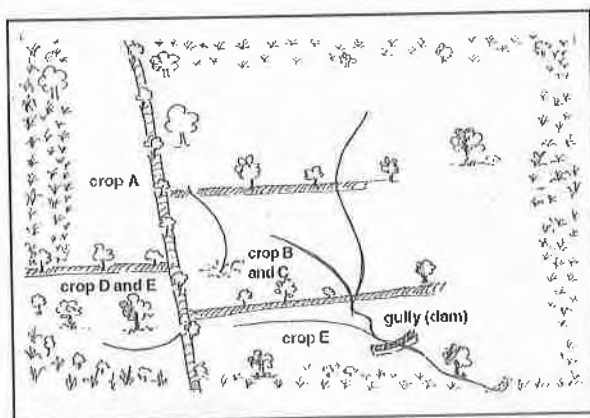
Interventions in current farming should meet the following criteria:

- social acceptability;
- technical feasibility;
- economic viability; and
- environmental soundness.

Sketching a family holding: actual and as potentially visualised



Sketch of the family holding indicating the physical features and the current cropping system.



Sketch of the land status and cropping system as visualised by the family.

Steps

1. Establish good rapport with the families involved.
2. Involve all the family members.
3. Walk through the fields and understand the current cropping patterns. **Current cropping pattern should be analysed keeping in mind the fact that these practices have evolved over a period of time.**
4. Prepare a sketch of the family holding indicating the physical features and the current cropping pattern.
5. Find out the assets in terms of livestock. The new design should meet the family's requirements in terms of food, fodder and firewood. It should lead to an increased food production and income.
6. Introduce new systems in harmony with the strengths of the existing system. New systems can put pressure on the family in terms of utilisation of family labour, finance, technical skill and exposure to new risks.
7. Explain the amount and cost of material and labour inputs.
8. Based on these interactions, draw another sketch of the landscape incorporating all the projections. It should show how the families visualise their farmland after five years. The role of an extension worker is only to educate and help the families realise their potential.
9. Explain the provisions available and the participatory role needed for successful completion.
10. Prepare a third sketch indicating the interventions undertaken from time to time, enabling monitoring and evaluation of the progress made by the family. Incorporate corrections in the original plan.
11. Prepare a schedule of activity and break it down into monthly and annual plans. This helps update the project plans and prepare annual family farm plans.

Contributor: G. N. S. Reddy and Vanaja

Application of participatory technology development and dissemination

For rainfed agriculture improvement in semi-arid tropics

Despite the existence of a rich knowledge base and numerous research and development organizations, farmers are slow to adopt technologies designed to improve dryland agriculture. Conventional agriculture research and extension systems have worked well in "high potential" ecosystems with easy access to inputs and services and where technological packages fit well into homogenous resource-rich conditions. However, in diverse, complex and resource-poor environments found in many dryland areas, conventional research and development efforts have proven to be less effective.

What is participatory technology development?

Participatory technology development (PTD) is a process that combines the knowledge and research capacities of local communities and that of research and development organisations in an interactive learning process. It involves identifying, generating, testing and adapting new techniques and practices to help solve local problems. The ultimate aim is to strengthen the experimental and technology management capacities of local people and communities, thus, farmers play a key role in the entire process.

PTD is a purposeful and creative interaction between local communities and outside facilitators which involves: gaining a joint understanding of the main characteristics and changes of a particular ecosystem; defining priority problems of farmers and farming communities; experimenting locally with a variety of options derived both from farmers (indigenous knowledge and other farmer experiences) and from formal science; and enhancing farmers' experimental capacities and farmer-to-farmer communication.

PTD in agriculture is not a substitute for station-based research or scientist-managed on-farm trials. It is a complementary process which involves linking the power and capacities of agricultural science to the priorities and capacities of farming communities to develop productive and sustainable farming systems.

This technology development approach is closely linked with a process of general community development. Activities involved in PTD — critical analysis of community-managed changes in the agroecological system, identification and use of indigenous technical knowledge, reconstruction of successful local innovations, self-organization and self-implementation of systematic experiments with selected options — all foster the awareness, self-respect and self-confidence, as well as the diagnostic and experimenting skills of the farmers involved.

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Key actors in the PTDD process

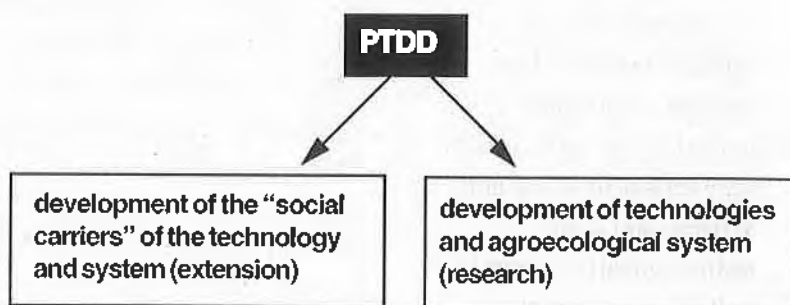
- Farmers and local community members
- Farmer organizations
- Official research and development (R and D) institutions (usually government or academic)
- non-government organizations (NGOs)
- artisans and traders
- private enterprise (inputs, markets, etc.)

PTD approaches also try to foster development of a network of village organizations, to intensify communication on local experimentation and improve linkages with supporting organizations and institutions. Development of village groups and independent relations of exchange encourages the maintenance and further spread of good local practices and enhances the prospects for on-going experimentation, improved resource management and self-sustained agricultural exchange.

PTD not only enables the generation of technologies to local environments, but also develops the local capacities, sociocultural structures and organizational linkages necessary to sustain the process. (*Entire section adapted from: ILEIA, 1992. Resources for the future.*)

PTD Application:

Key features of the PTDD



Following the slow adoption of technologies designed to improve dryland agriculture by farmers, MYRADA and IIRR with support from the Ford Foundation initiated a research project in partnership with farmers in selected villages of Kolar District, Karnataka State, India, to develop and promote dryland technologies to address problems of low soil fertility, fodder and fuelwood shortage and augment farmer's income. The project started in 1991 and ended in 1994.

A Case Study on MYRADA-IIRR Collaborative Project

Project location

The project sites were located in Kamasamudram, Bangarpet, Kolar District, South India, two hours by road from the state capital of Bangalore.

The project area is part of the Polar basin, covering an area of 28067.5 hectares bounded in between the Lat. 12° 46' to 12° 58' F and Long. 78° 05' to 78° 16' F. Hills, ridges, mounds, pediments, pediplain and shallow valleys are the characteristics physiographic features of the area. The terrain has a slope range of 0 to 35% and is located about 700 to 1096 m above sea level. The average rainfall is 700 mm annually, with the number of rainy days per year averaging 47 mm.

Project implementation strategies

Key elements of the project strategy

- Restoration, regeneration and recycling were encouraged.
- Farmers played the central role, technician played a limited but critical support role.
- The micro-watershed was used as the unit for project planning and implementation.
- Functional groups in the micro-watershed were established to encourage more participation and sustainability of the project initiatives.
- An emphasis was placed on using information generated through PRAs.
- Village meetings were held to develop treatment plans based on PRA results.
- Cross-visits were encouraged to promote learning across watersheds.
- A basket of technology was collected from four sources: research institution, government agency, NGO and farmers.

Basket of technologies

Technology	Technology source
<i>Improving farm income</i>	
• Traditional intercropping using improved cultivars	Farmers/Department of Agriculture (DA)
• Planting of fruit trees on rock on the wasteland or unbunded fields	Farmers
• Agro-horticulture combination (dryland and mother orchards)	University of Agricultural Science (UAS), Bangalore
<i>Improving the on-farm microclimate and increasing biomass and fodder production</i>	
• Planting of 2m cutting of <i>Gliricidia erythrina</i> , establishment of <i>Cassia siamea</i> on the farm bunds, planting of <i>Sesbania grandiflora</i> , planting of <i>Stylosanthes hamata</i> and <i>Stylosanthes scraba</i> , establishment of community mini forest and protected fodder bank	MYRADA/IIRR
<i>Increasing soil fertility</i>	
• Composting	UAS/Farmers/MYRADA
• Green leaf manuring, return of crop residues	MYRADA/IIRR
• Crop rotation	Farmers/UAS
• Application of farmyard manure, mulching, silt application	Farmers
<i>Conservation of soil and water</i>	
• Boulder bunds, earthen bunds, gully checks, diversion drains, check dams, silt traps, rockwalls	DA/MYRADA
• Small farm reservoirs	IIRR/MYRADA
• Vegetative barrier (vetiver grass)	UAS
• Dead furrows	IIRR/UAS
• Planting of agave	Farmers

Functional groups in the micro-watershed

The functional groups used in the project operate under the Watershed Development Association (WDA). These groups comprised of Credit Management Group (CMG), Watershed Development Committee (WDC), Watershed Promoters (WP), Farmer Cooperators (FC), and Farmer Instructors (FI). Each group has varying functions in the project. The WDC supervised physical work done in the watershed. The CMG handles financial matters. The WP carries out awareness programs. The FIs were in-charge of informal extension and training, including supervision of technology testing and documentation. The FC owned or cultivated the program site and the land was targeted for project implementation.

The basket-of-technologies approach has allowed farmers to choose from a range of available options and to adapt and refine these approaches to suit their situations.

- On-farm microclimate is improved through the planting of farm boundaries (as opposed to alley cropping which is normally recommended by researchers) with non-browsable trees identified by farmers.
- Farmers are encouraged to practice green-leaf manuring to improve organic matter status. Compost pits were built on the farm lot itself and not near the households which was the prevailing local practice. This change was done because the source of organic matter was mostly tree leaves and prunings. Transportation of compost was minimized.
- Community fodder banks (with emphasis on indigenous tree fodder species identified in PRAs) have been established on degraded common properties, to supplement the limited fodder supplies available on farms.

Technology adoption

A self-evaluation of the three microwatershed project sites conducted (in 1994 and 1995) using "farmer-identified" indicators showed that the number of cooperating households adopting various technologies increased significantly after joining the project.

As a result, farmers in the project areas increased their cropping intensity, food, fodder and biomass production.

Percentage adoption of technologies

Technologies*	Micro-watersheds					
	Srinivasnagar		Lakennahalli		Balamande	
	Before	After	Before	After	Before	After
Fuelwood and fodder production improvement	0	100	0	72.5	2.5	75
Soil and water conservation	18	65	5	29	4	26
Farm income improvement	21	75	28	40	23	15
Soil fertility improvement	14	75	23	49	27	53
Average	13.25	78.75	14	47.62	14.12	42.25

*See basket of technologies.

Project impact

Impact on biomass production

The result of the evaluation showed that from the third year of the project, farmers in Srinivasanagar have been harvesting (annually) fuelwood enough to serve two to eight months per family from their 0.70 ha. In Lakennahalli and Balamande villages, the amount of on-farm biomass obtained for fuelwood can serve between half to three months (on average) per household.

Impact of on-farm fodder production

The project impact of on-farm fodder production in all micro-watersheds has led to increases in the number of farmers keeping animals and the total animal numbers. Increases were also seen in the amount of fodder available to maintain these animals. For instance, the number of cows owned by the farmers increased from one (before the project in 1990) to three in 1995 (an average of the three sites). Similarly, the number of months the on-farm fodder was served to cows and the other farm animals increased from two months in 1992 to four months in 1995 (on the average).

Impact of on-farm biomass production

Watersheds	Project years					
	1993		1994		1995	
	Amount of on-farm fuelwood obtained. *(kg)	No. of days served for cooking	Amount of on-farm fuelwood obtained. (kg)	No. of days served for cooking	Amount of on-farm fuelwood obtained. (kg)	No. of days served for cooking
Srinivasanagara	185.5	65.4	471.4	140.4	604.7	241.4
Lakennahalli	65	18	115	52.5	69.5	34.8
Balamande	90	nd	130	74	39	84
Average	113.5		238.8	89	237.73	120.07

* Farmers estimated the fuelwood collected based on cartload. Cartload is equivalent to 200 kg of fuelwood (wet).

Note: The increases in quantity of fuelwood do not necessarily translate to equivalent increases in number of days served for cooking. This information is based on farmer's recall. However, the differences or inconsistency of trends could be attributed to several factors like farmer's trading their fuelwood for other needs, efficiency of stoves, family size, etc.

Other project impacts

There are indicators of positive effects on the farm-ecological condition as indicated by an improved microclimate, reduced soil erosion, increased soil fertility and the degree of tree diversity.

Soil improvement was shown in the increase of organic matter content. In Srinivasanagar project watershed village, soil organic matter content increased from 0.37 to 2.32% after the end of the project. In like manner, the soil organic matter content in Balamande project village increased from 0.35 to 2.27%.

Project impact on soil organic matter content

Watersheds	Organic matter content inside project watershed (%)	Organic matter content outside project watershed (%)
Srinivasanagara	0.37 (5)	2.32% (5)
Balamande	0.35 (2)	2.27% (5)

Numbers in parenthesis refers to the number of samples taken.

Extent of food security among households before and after the project

Watersheds	Number of months of food shortage				
	Before project implementation	1992	1993	1994	1995
Srinivasanagara	10.4	6.6	5.4	4.5	4.8
Lakennahalli	3.1	3.2	1.9	2	1.6
Balamande	4	3	2	1	1
Average	5.83	4.27	3.1	2.5	2.47

Note: Food security in this study is defined as amount of food farmers obtained from their farm to meet the family food consumptions.

Crop yields increased due to soil improvement and moisture retention. In Srinivasanagar and Lakennahalli, the average crop yield increased by as much as 45% and 27%, respectively. The rocky and barren lands that characterised the project site in the beginning were transformed and now valued at \$300.00 per acre, according to the farmers. It is expected that the project impact on the household economy will continue to increase.

Increases in crop yield and diversification have reduced the number of months of food shortage among participating households after joining the project. Thus, enhancing household food security (defined as the amount of food farmers obtained from their farm to meet the family food consumptions). In Srinivasanagar, the number of months of food shortage was reduced from ten to five months after the project. In Lakennahalli, the number of months of food shortage was two months against three months when the project started.



Conclusion

In the course of the period (1991-1994), the project has demonstrated that the three-tier approach — micro-watershed, basket of technology and farmer centered approaches using the knowledge utilization strategy — has encouraged farmers to participate in technology testing and refinement and allowed them the option to adapt technologies suitable to their specific environmental conditions. Thus, the project has helped farm families increase their food and biomass production, and income; modify the microclimate by the increased biodiversity, reduced soil erosion and improved soil fertility. The level of optimism and cooperation among the farmers had also increased.

The project impact evaluation presented here was supported by the International Institute for Environment and Development (IIED) in 1994 and Ford Foundation in 1995. The main text of the case study was presented in IIED-sponsored participatory watershed management workshop in India and will be published in IIED's New Horizons.

Contributors: Kennedy N. Igholwe, Neelkant Pandhare, Ramachandrapappa and Shreeshail Doni

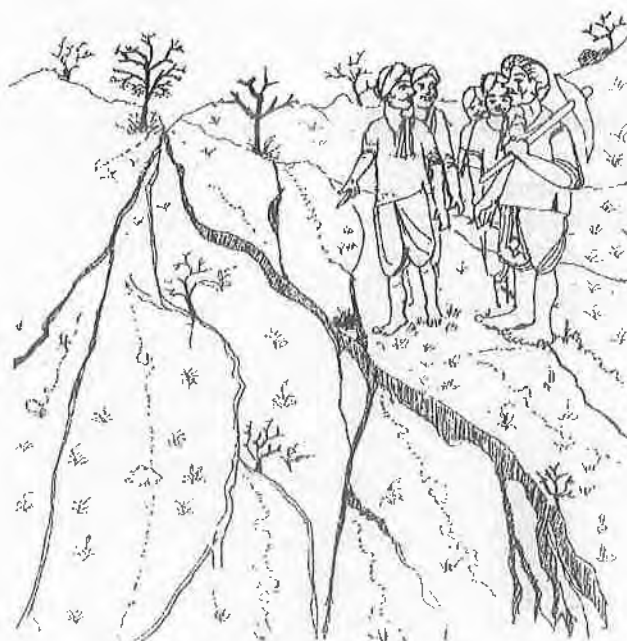
People's participation in dryland watershed management

Environmental degradation in drylands and the food insecurity it brings embraces a complex set of factors. Experience increasingly shows that the watershed approach adapted to local conditions offers the most viable solution to the issue of dryland management. But to facilitate the participatory management of watersheds on a sustainable and integrated basis is itself a complex task. An analysis of MYRADA's experiences has shown that: (a) people have to be appropriately motivated and organised so that they see themselves as stakeholders in the programme; (b) the task where returns are perceivably more immediate - eg. erosion control have to be taken up first; (c) work on private lands should precede work on common properties; and (d) not only should at least a part of the investment costs be locally mobilised, people should also perceive that they own financial assistance and technical services and have to be responsibly managed.

This article recounts experiences in Kollegal Taluk, one of the least developed in Mysore District. Their efforts to manage the soil and reverse environmental degradation have had impressive results. The information presented in this paper was gathered using PRA techniques focusing on the MYRADA Hutur project which is concerned with soil and water conservation and watershed management. This paper outlines the strategies in the development of watershed initiatives.

Problems identified in the initial stage

- Lack of organisation
- Lack of finance
- Low adoption of dryland technologies
- Low motivation
- Dependency and high expectation from others
- Insufficient technological knowledge
- Absence of sound CPR management system
- Lack of government involvement
- Lack of cooperation among farmers
- Lack of involvement of women
- Lack of involvement of landless



Impact of the programme

The following chart illustrates the types of SWC initiatives and the resultant benefits.

Visual indicators	Effects
Soil and water harvesting structures	• Gully stabilised • Erosion minimised
Vegetative cover	• High degree of regeneration • Agro-horticulture in good condition
Water storage in checkdams throughout the year	• Recharge of ground water • Increase in water table • Protective irrigation for crops
Change in cropping pattern	• Diversification of crops • Productivity increased
Fodder, fuel, biomass and horticulture	• Fallen leaves used as manure • Wood for fuel • Fodder for animals during lean season
Irrigation systems	• Irrigation from nalas (canals) • Intensive cultivation • Employment generation
Extension of areas with soil and water conservation structures outside the project boundaries	• Adoption by other local farmers and other projects; spread/multiplier effects
Fuel-efficient technologies	• Promotion of biogas and smokeless chulahs • Less fuel consumption • Better hygiene • Less weeding

Support of the Self Help Groups (SHG)

Poor farmers organised as SHGs assisted in management activities providing timely support and initial capital needs.

Developmental approach

People were informed of the differences in welfare and developmental approaches to project management. Rather than giving the money indiscriminately to the community (welfare), it was placed in a Watershed Development Association (WDA) as a developmental loan.

The collected money was called a "People's Watershed Corpus Fund" and was intended to be used for the future needs of the community.

Watershed Management Committee (WMC)

A Watershed Management Committee was selected from each WDA. The WMC provided supervisory services and ensured that people were trained with the necessary skills and that the process of disbursement and recovery of money was democratic.

Loan repayment

Programme funds were transferred to the WDA Bank Account to be advanced by the WDA to its members for treatment of individual lands. The WDA advanced 70% of the estimated investment cost, with the balance coming in as farmers' contributions.

The 70% advanced was a loan repayable over five years, with recoveries augmenting the WDA Common Fund for future use.

Ownership of the Corpus Fund

All the members of the WDA are owners of the total collected money. They are restricted in obtaining loans in the WDA's Corpus Fund. An individual seeking a loan must present his/her request to the WDA which makes a decision regarding the request through a democratic process.

Transparency and accountability

Accounts are kept and maintained by the WMC and are checked periodically by the WDA members. Thus, there is a lower chance of mismanagement if it is ensured that the financing process is transparent at all levels.

Mutual respect and sharing

There is vast scope for mutual sharing of skills and labour in the programme. People should be equitably treated, regardless of their landholdings, caste or gender.

Social pressure

Farmers are influenced by their peer to join the WDA. Those who are reluctant may be pressured into doing so, using the argument that the watershed is in fact an *area development approach*.





The MYRADA Huthur Project is proof of a sustainable development process resulting in people's empowerment through the management of their own watershed.

Although the programme's activities focus mainly on treating land, it also fosters a charitable spirit in the community. WDA members may advance a poor farmer a loan from the SHG at a reduced or zero interest rate. This might lead them to joining the WDA, where inability to contribute financially may be the reason why the farmer is hesitant to join the programme.

Direct benefits of people's management

People benefit from watershed management in a variety of ways, some of which are listed below:

Empowerment

People are given opportunities to exert power and control over their lives.

Adoption of manageable techniques

Soil erosion is controlled by establishing tried and tested structures which are a mixture indigenous and modern methods. In this way, in the absence of MYRADA, people can systematically manage the watershed.

Realisation of collective responsibilities

With the provision of information surrounding watershed management, people are becoming more self-reliant. They realise the importance of collective responsibility in all sorts of work pertaining to watershed management such as desilting the tank, drainage maintenance and tree planting.

Increase of water table/water points

People understand that water can be collected and used systematically on their own land with the use of various structures. This results in the increased levels of the water table and water points.

Conclusion

The watershed programme is becoming more dynamic. It provides a forum where people can address issues surrounding community development. This has influenced them to think not only of soil and water conservation, but also the basic needs of the village as a whole. As people are endowed with their own functional institutions, government agencies are now coming forward, with a willingness to support the peoples' institutions.

*Information kit produced by
MYRADA and the International
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Contributor: Sridhar

Women's participation in watershed development



Visibility of women comes from identifying of categories of resource users by season and gender.

Benefit-sharing will give women: drinking water, food security, improved nutrition and health, socio-economic empowerment, fuel and fodder.

Gender-bias in watershed management

The technical field in watershed development is almost completely male dominated. From engineers to field technicians, implementors are all men. Watershed training for communities is largely male-farmer oriented. These farmers and landowners invariably have political and social control over resources and thereby play a major role. Apart from excluding the women, the training components do not address the landless and other members of the community indirectly engaged in agriculture.

In fact, women's participation is judged only by the number of women working in construction sites, or at the most, their attendance at meetings. This is evident even though women are the primary users of resources and are responsible for accessing them from the environment.

Issues related to resource use and sharing of resources between various groups in the community hardly receive much attention. Women are landless, do not control finances, have no access to credit and having very little control over resources and they are left out of the planning process.

A watershed community consists of landowners, the landless, graziers and artisans — all of whom should benefit from watershed development. It is crucial to involve both men and women from the community in watershed development and management programme. Men and women from the same community are equally aware of the needs and problems they face, but their priorities are quite diverse. Attempts to understand these differences would help focus on gender-related issues throughout the project period.

The role and contribution of women can be perceived in every aspect and stage of implementation of a watershed development programme:

Stage/activity	Role	
	Present	Perceived
Planning and decision-making		
• Formation of watershed committees.	Limited representation on committees	Equal representation on committees
• Preparing project proposal		
- Survey	Nil	Assisting in survey; sharing of knowledge and experience
- Identification of soil conservation structures	Nil	
- Identification of water conservation structures	Nil	Sharing of knowledge and experience
• Contributing land for selected sites	Nil	Assisting in decision-making related to contribution of land
• Preparing budgets	Nil	Participating in decisions related to labour and other costs
Implementation		
• Construction of conservation structures	Providing labour	Supervising, maintaining ledgers, musters, making payments
• Maintenance of conservation structures	Providing labour	Initiating decisions related to maintenance, supervision, maintaining ledgers, etc.
• Development of agriculture	Labour and limited decision-making on family lands	Receive training inputs, contribute to decision-making at the community level
• Forestry and tree plantation	Labour and limited decision regarding selection of species, maintaining nurseries	Equal participation in decision-making regarding selection of species and areas for plantation, technical inputs, supervision on plantation sites
• Fodder and grazing lands	Nil	Equal participation in decisions related to development of grasslands, rotational grazing, stall feeding
• Horticulture	Labour	Selection of fruit, processing, marketing
• Dairy, animal husbandry	Labour	Technical inputs, processing of milk, marketing
Management and delivery systems	Nil	Equal participation in decision-making, technical inputs, sharing of knowledge and information, ensuring just distribution of resources
Social and welfare aspects	Limited access to health and education	Identifying community needs, ensuring availability of welfare
Alternate energy programmes	Labour	Identifying alternate resources for energy; planning and implementation

Gender specified roles in the implementation of watershed development projects

Watershed development activities involve the use of specific knowledge, experience and training. Access to this knowledge and training would make participation in watershed development activities more meaningful.

Training programmes in watershed development are male-farmer oriented, thus, isolating women from survey methods and technical know-how on the construction of structures. If training is offered to women they are only informed on how to develop nurseries for tree plantations, etc. Women are not given the choice to have technical training and deprived of holding a supervisory position, thus, failing to participate actively in decision-making. If women have access to technology and training, and prefers not to perform technical tasks, then it becomes solely her choice not to do so.

Additionally, women working as hired labour on land development sites are subjected to further injustice. Men claim higher wages because they strongly believe that their work is more strenuous.

Rural women have always been working to provide additional income for their families. Yet, their income is looked upon only as secondary income even if they are the only "bread winner" in the family.

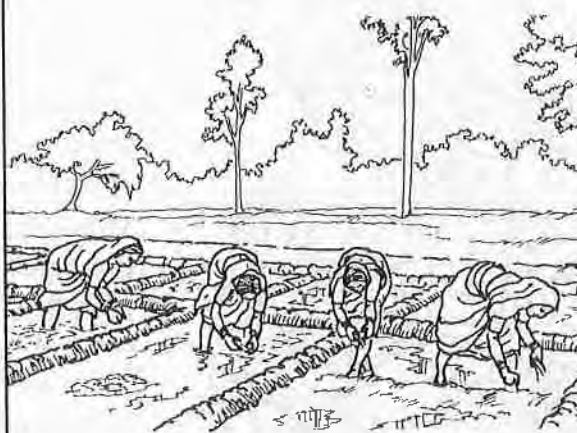
Introducing gender perspectives in the management and sharing of resources

Watershed development areas are a combination of private, common and government lands. No watershed area can be developed in isolation. Therefore, resources developed in watersheds "belong" to all the community members.

Triple work burden



Domestic work



Agricultural labour



Voluntary labour in community activities (Shramdan)

For effective management and sharing of resources, it is important to identify who the users are and the requirements for them to become legitimate users of the resources developed in the watershed.

Women are more aware of household needs — fuel, water, food and fodder requirement. Hence, the information and experience they have are valuable in the planning and management of resources. But mere availability of resources is no guarantee to lessen women's drudgery at work. It is access to these resources that is a crucial factor. Resources controlled by a dominant caste or class group cannot give equal access, even perhaps no access at all, to women from other groups. There should be a balanced representation in the Management Committee to ensure equitable access to resources.

Strategies for gender sensitisation and facilitating participation of women



Decisions taken in male-dominated watershed committee meetings do not reduce the drudgery of women!

Facilitating women's participation begins with understanding the community in which the watershed activity will be undertaken. It is important to create awareness and understanding among the men, so an atmosphere of acceptance can be created in the village whereby women can take an active part in community activities.

- Women are equal members of the community. They perform almost every task in agriculture other than ploughing. They are significant contributors to the village economy. They have traditional knowledge about natural resources.
- For women with children, freedom from her household responsibility while participating in community activities, means sensitising family members and neighbours to partially take care of the children's needs, etc.
- Support groups of women, such as Mahila Mandals, Savings Groups and Credit Groups should be organised.
- "Tokenism" should not be the reason why women are made committee members. They should be members in their own right.
- It is essential to call for meetings at a time when women can attend.
- During the meetings, women invariably find it difficult to express their views when men dominate. So, it is advisable to hold separate meetings for women to provide a venue to voice their ideas freely and independently.

It is important to understand each individual/ community before any attempts can be made to diffuse social and cultural barriers for the benefit of the watershed development project.

Contributor: Vasudha Lokur

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Pani panchayat movement

Since the beginning of civilisation, humans preferred living near a water source because it is essential for all forms of life.

Although both land and water are equally necessary for agriculture, it is recognised that without water, land cannot be cultivated.

Water is a common property resource which should be available to every member of the community irrespective of land holdings.

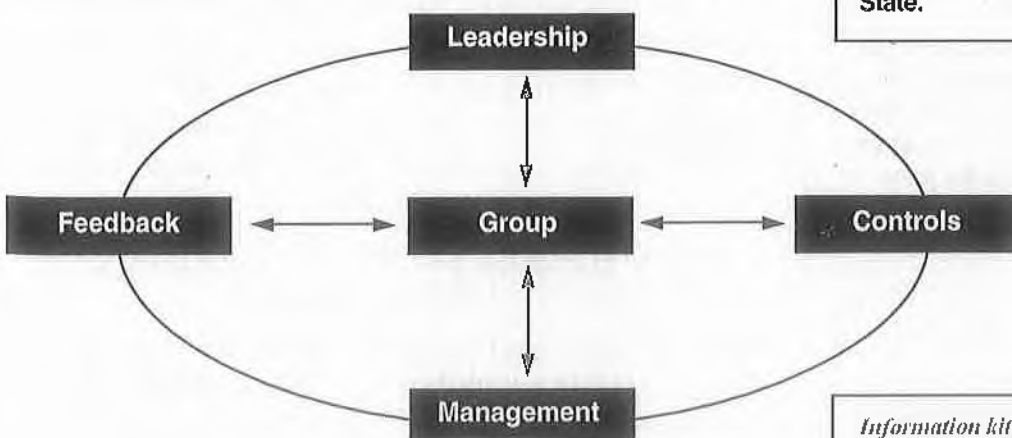
Water availability based on land holdings tends to further stratify society resulting in greater inequalities; hence, the need for an equitable allocation of water, particularly when the resource is limited.

Availability of food provides much needed security to the family. Therefore, every family will give high priority to food production from its fields.

While water for cultivation may be adequate under irrigation projects, the availability is critical in uplands and rainfed areas. The problem becomes more acute when rain fails. Any programme to harvest water in such areas assumes significance.

In such situations, collective efforts of villagers can work wonders. The villagers themselves pool their resources, make decisions through consensus and share the benefits equitably. This is what the Pani panchayat movement promotes.

Group management of Pani panchayat schemes



Pani panchayat is a voluntary activity of a group of farmers engaged in the collective management of distributing water equitably among themselves in order to improve their economic condition.

Pani panchayat is the name first given to a movement for motivating farmers of Naigaon village of the drought-prone Purandhar taluk of Maharashtra State. In 1973, a social worker Vilasrao Salunkhe and his wife Kalpana Tai, motivated the people of the village to pool their efforts to harness their meagre water resources for a common good and as a means to break social barriers and economic inequalities.

A five-member panchayat of the villagers was formed to manage the project.

This was the beginning of the Pani panchayat movement which is now successfully implemented in a number of villages in the State.

Information kit produced by MYRADA and the International Institute of Rural Reconstruction

Principles

- Small lift irrigation schemes are built by joint efforts of farmers for common benefit.
- Members of the community, including landless, are entitled to membership. Landless members can utilise the water for share cropping.
- Members have to contribute equally, either in cash or kind, the beneficiaries' share of 20% of the total cost of the project.
- Water lifted is shared by members based on family size and not on land holding.
- Every member family is allotted water for cultivation at the rate of half an acre per head subject to a maximum of 2.5 acres per family.
- Cropping patterns are decided by mutual consultation in the group.
- No water intensive crops can be grown. Sugar cane is not to be grown.
- Water rights are not attached to land rights. They cannot be alienated.
- The construction and management of the project and distribution of water and monitoring of crops is the joint responsibility of the members.



The concept, first implemented in a small village Naigaon of Purandhar taluk of Maharashtra, has gained wide acceptance and several villages have implemented it during the last 15 years. Depending on the source of water, there can be more than one Pani panchayat in each village.

Naigaon is a village with a population of 1,600 in 300 households with a total area of 1,537 hectares. Rainfall fluctuates between 250 and 500 mm. A small stream runs next to the village.

The Gram Gourav Pratishthan, a voluntary organisation engaged in rural reconstruction, provided the needed lead to bring the villagers together and take up the project. The Pratishthan has extended the scheme to cover 10,000 people. An area of 3,000 acres was brought under cultivation at a capital cost of Rs. 70 lakhs.

The state government, at that time, contributed half the cost as subsidy while the villagers contributed 20% in cash or kind. The remaining amount was provided by the Pratishthan as an interest-free loan. The Pani panchayats of several villages have repaid a large part of the loans from the Pratishthan.

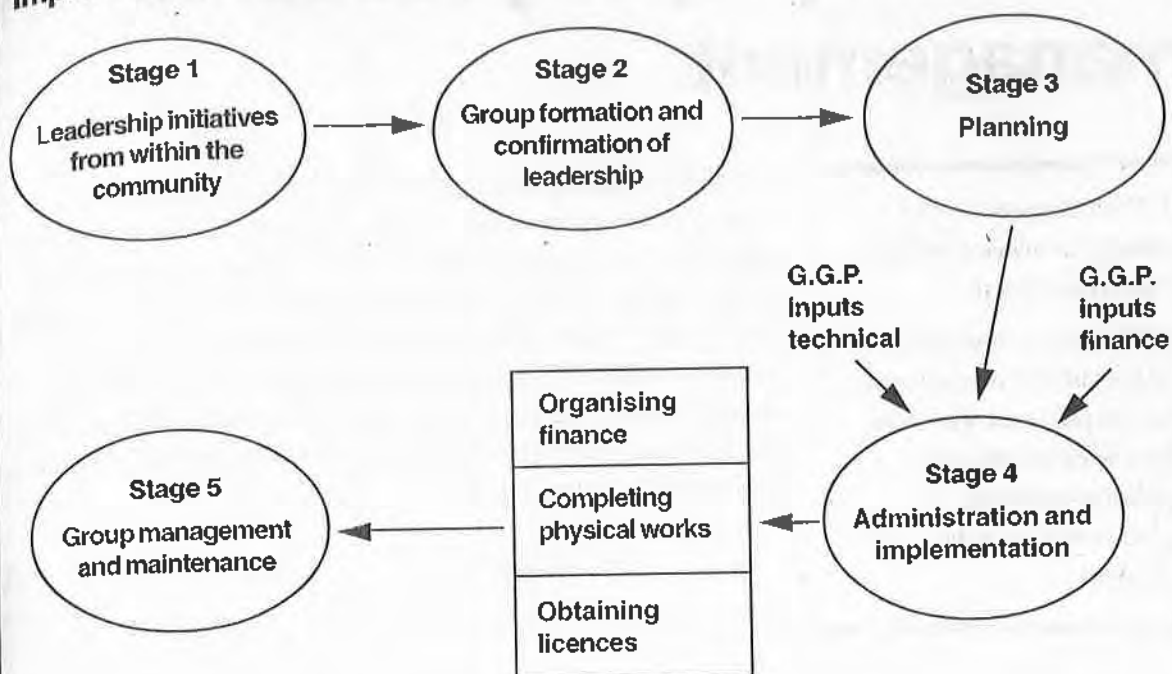
However, due to political changes the subsidy was withdrawn in 1981 and the entire cost was borne by the villagers, including a 70% interest-free loan from the Gram Gourav Prathisthan.

The farmers are growing a variety of crops, using minimum water quantity to maximise their incomes. The recent addition to the crops is the lucrative floriculture, where income goes up to Rs. 123,548 per hectare.

Each member pays Rs. 1,235.48 per year per hectare towards water charges and distribution expenses.

If schemes under the Pani panchayat movement are linked to other schemes in a watershed management programme, it will be more beneficial to the communities in rainfed areas and will also further promote equitable use of other resources.

Implementation of lift irrigation schemes through people's participation



G.G.P = Gram Gourav Pratishthan

What motivates the farmers

- combined struggle to survive in a hostile environment
- common benefit
- equal partners in effort and benefits
- equitable benefit – sharing breaks social barriers
- throws up local leadership
- empowerment of under-privileged sections
- decisions reached by consensus rather than imposed ones
- involvement of Gram Gourav Pratishthan in the beginning for technical and training inputs and financial assistance

Contributors: Vilasrao Salunkhe, Vasudha Lokur and Ganesh Pangare

Achievements

- Extensive agriculture by lifting water in uplands. These lands cannot normally get water for cultivation. Villages are displaced due to submergence by projects and relocated upstream.
- Self-imposed common tight control ensures optimum utilisation of scarce water resource.
- Only crops which do not require perennial irrigation are permitted.
- Emphasis on food crops ensures food security.
- Some farmers have taken up floriculture which has a very good market in nearby Pune. Flowers like tube roses, which do not need large quantities of water, are grown. The income of the beneficiaries has increased and the net profit ranges between Rs. 12,000 and Rs. 50,000, depending upon the crops they grow.
- Social tensions reduced due to participatory management of community resources.
- Some city migrants have returned to their villages to go back to farming.

Limitations

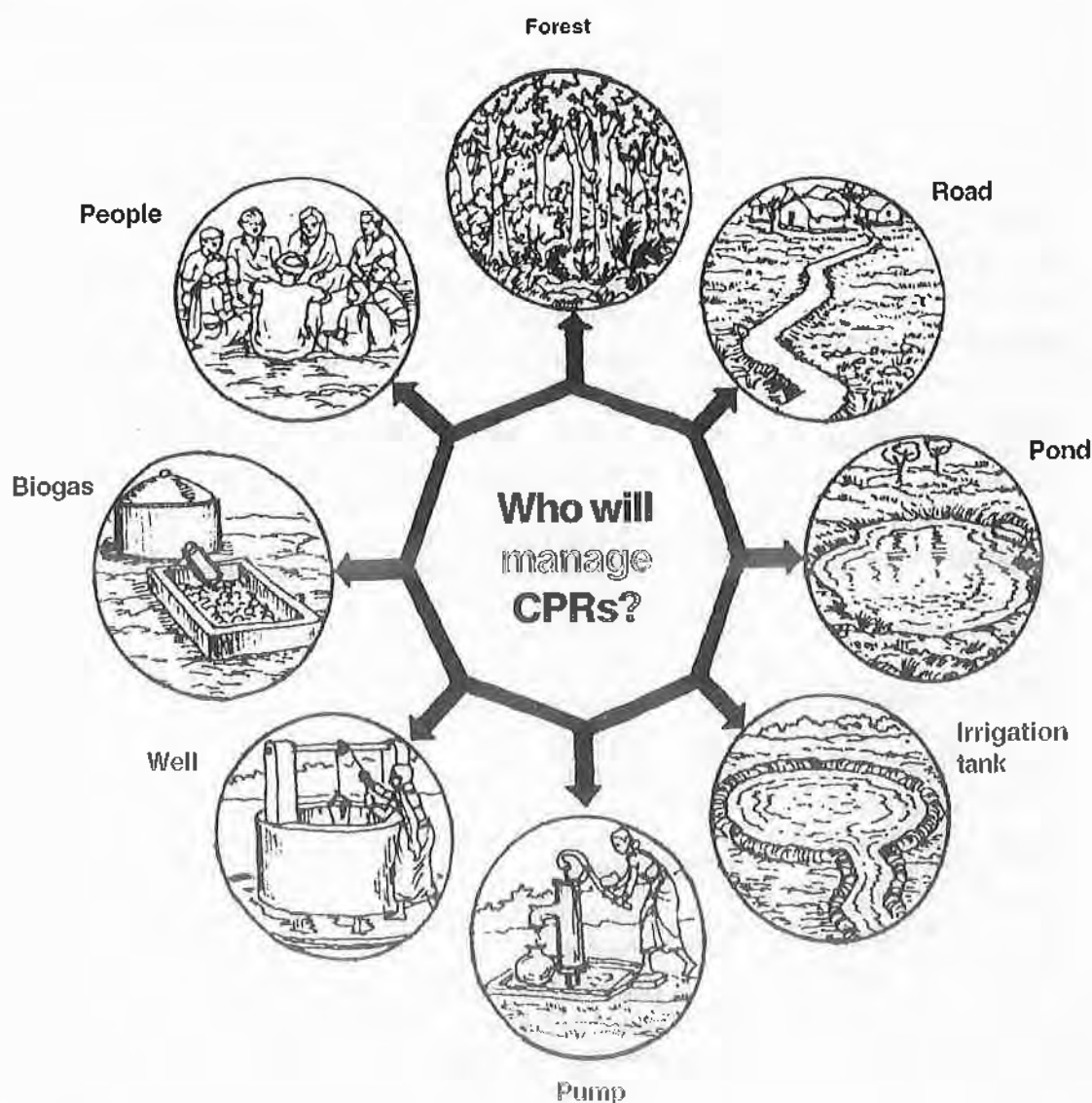
- Lack of political will to subsidise community lift irrigation schemes.
- Delay and irregular supply of electricity by the electricity board. Alternate sources of energy like solar or wind power can be tapped to cater to the situation.

Common property resource management

CPR management is an attempt to revive a tradition that once existed.

CPRs form an integral part of the survival mechanisms for the poor and, therefore, their accessibility and protection to these resources have to be ensured.

Common property resources (CPRs) is broadly defined as natural resources in which a group of people have common user rights (not necessarily ownership rights). These include natural forests, village lands, grazing lands, streams, rivers, groundwater and oceans. These may also include man-made resources like irrigation tanks, community wells and village roads. The poor depend upon CPRs for a variety of requirements including water for domestic consumption, irrigation, food, minor forest produce, fuelwood, fodder and timber.



Why participatory management?

- CPRs are community life-lines and almost all people have a stake in their well-being.
- CPRs that could once sustain local communities can no longer do so because they are over-stressed and mismanaged.
- There is a need to raise public consciousness and involve people in CPR management.
- Joint management currently appears to be the best way to ensure that they are managed responsibly, particularly when the State, as a single agency, cannot afford to do so on its own.
- It is not desirable that an external agency take control of resources that essentially belong to the community.

Why are people indifferent to CPR management?

- Facilities created may not meet the users' needs.
- Lack of appropriate knowledge and skills.
- Individuals are reluctant to take responsibility for maintaining a system which is used by the community as a whole.
- Inequitable use and allocation of resources.

How do you make CPR management effective?

- Organise people for collective action.
- Involve the entire community in planning and development as they are the stakeholders.
- Develop clear guidelines on user rights and responsibilities of each person in maintaining and managing the CPR.

Forests

Forests in many places are in a degraded condition. With a view to develop forest resources effectively for the benefit of the landless and other dependents, a concept of Joint Forest Management (JFM) has evolved in recent years.

This concept visualizes people's participation in the protection and regeneration of forests for their own as well as for the community's benefit. JFM involves organising forest protection committees comprised of villagers and forest officials to jointly plan and develop forests in their areas.

Strategies for effective management

- Ensure equitable distribution of benefits among all users.
- Institutionalise people centered management programmes.

Guidelines for forest equity

People should have their share of the benefits from forests, including access to timber, fuel, fodder and other resources. There must be unambiguous guidelines on issues relating to the rights to cut trees for timber or to use crop yields from horticulture trees, either for self-use or for sale to earn an income. Guidelines on the community's duties and responsibilities to develop, maintain and manage the forests are needed. These can be formulated in cooperation with forest officials. If these guidelines are adhered to, management initiatives will be successful.

JFM must also adapt to local situations, with a view to benefit the poor, especially the women, landless and tribals. These people should be given an effective role in decision-making, in respect to species selection for fodder, fuelwood, fruits and other usufructs sharing, their collection and sale.

Drinking water/irrigation sources

Panchayat wells, bore wells with hand pumps, community wells, tanks and ponds are other CPRs in need of proper management, to remain efficient and sustainable. This is another sector that has been accorded a considerable amount of attention and provided with adequate funds, and yet suffers from the lack of appropriate maintenance resulting to operational shortcomings. Due to neglect, a large majority becomes dysfunctional. Severe neglect can lead to health hazards caused by pollution or lack of proper drainage, especially in rural areas.

Users need to be trained properly to develop appropriate skills to operate, maintain and manage infrastructure facilities in ways that would provide equal benefits to all. If these efforts consider indigenous knowledge and practices, they will have a better chance of adoption by the people. Shortcomings and inefficiencies in traditional practices can, and need, to be supplemented with modern knowledge so as to benefit the users. This strategy will inspire confidence among the people and motivate them to respond more readily.

Protection of grazing lands

All new plantations and grasslands have to be protected from animals, especially if the biomass to be grown is browsable. But because all common lands are used intensively, attempts to enclose a patch of degraded land will be strongly resented by the people. This may be the case even if the land is considered unproductive. People may fear the loss of grazing land and sources of firewood. Such attempts may be opposed by the poor, unless they are fully assured that the biomass grown inside those enclosures will continue to meet their needs on a prioritised and equitable basis.

Grazing lands

Continuous grazing suppresses the regeneration of all grasses, shrubs and fodder trees and reduces the productivity and quality of grasslands. This is why vast tracts of the country have come to be called wastelands.

The use of the word "wasteland" (by the government) to describe degraded lands has conjured up an image of vast tracts of land lying, totally-unused, barren or misused. In other words, all wastelands have intense users, therefore becoming degraded. On the contrary, no piece of land in India can lie barren for a long time. India's ecology would automatically turn it into a forest, but for the fact that it is consistently overused or misused.

If people's support does not exist, then either the survival rates of plantations will be extremely poor or non-browsable plants like eucalyptus will continue to be planted; a technical fix to a social problem which is not an appropriate solution. The same will happen to any major programme to dig ponds and tanks unless villagers protect their catchments. They will soon silt up and new programmes will be needed to dig them up again. We should learn the valuable lesson that ecologically vital but fragile rural resources cannot be created and maintained effectively by any bureaucracy. It can be done only by the rural people.

Common lands should be retained as commons and should be managed by village communities to develop CPRs as a community enterprise. This is ecologically and socially the best option. However, this is difficult to implement without concerted and collaborative efforts. The entire community must be involved in the protection of CPRs under its control. The experiences of voluntary groups across the country showed that given the right leadership and a suitable legal framework for community action, villagers will come together to protect and manage their common property resources.

All members of a group will protect a common resource only if they will benefit from the resource equally.

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Institutional innovations and mechanisms in CPR management

Dimensions of CPRs

- CPRs contribute substantially to the life supporting systems of economically weaker stakeholders under high risk, low productivity and fragile situations.
- CPRs protected under religious sanctions are rich sources of bio-diversity.
- Under the neo-economical system, dependence of the rich community on CPRs were reduced.
- Overall shrinkage and demographic pressure is over-stretching the use of CPRs.

The role of common property, common use and open access resources in rural development is being rediscovered. This system used to play a significant role in village communities. However, the free-riding behaviour and attitudes of a few privileged people resulted in the dismantling of the institution of Common Property Rights (CPR). Alternative strategies and institutional innovations for participatory management are now being considered and applied. The concept of sustainable integrated watershed development puts emphasis on marginalised resources. Other examples include the village bulls (used for insemination), common threshing grounds and water resources.

Common or joint interventions

There are many activities which are not effective when attempted at an individual field or farm level but which call for simultaneous area treatment or action such as:

- ground water recharge;
- drainage of high ground water table area;
- flood moderation and enhancement of natural water flows;
- reclamation of saline soils;
- eco-restoration of ravines; and
- soil conservation.

Institutional innovations/mechanisms

- High pay-off common resources like irrigated lands, fishing water bodies, etc. are being leased on a seasonal or yearly basis through open auctions. This revenue is spent on common needs like the settling of village loans, construction of public utility buildings and the like. This arrangement generally constitutes costed transactions.
- Some registered user groups or voluntary agencies are trying to discourage overuse of CPRs by imposing financial restrictions (for example, they levy Rs.100-150 per year or per sickle per year for cutting grass; some of them charge one rupee per head load of fuelwood, Rs.10 to 15 per hour use of harvested, water, etc.). Funds raised in this manner are used in the maintenance and protection of resources.

Ways of managing CPRs

Traditional patterns of organization to manage CPRs have been in existence for centuries. Some continue to work efficiently up to now but most have disappeared under various pressures.

Several planning and development agencies are now making a conscious attempt to revive public interest and responsibility in managing CPRs.

Planning and developmental agencies

1. Watershed Management Societies and Watershed Developmental Associations (Guidelines: Ministry of Rural Development)
2. State Departments — Watershed, Soil Conservation, Minor Irrigation, Fisheries, Horticulture, Agriculture etc.
3. NGOs and private consultants

Funding and management

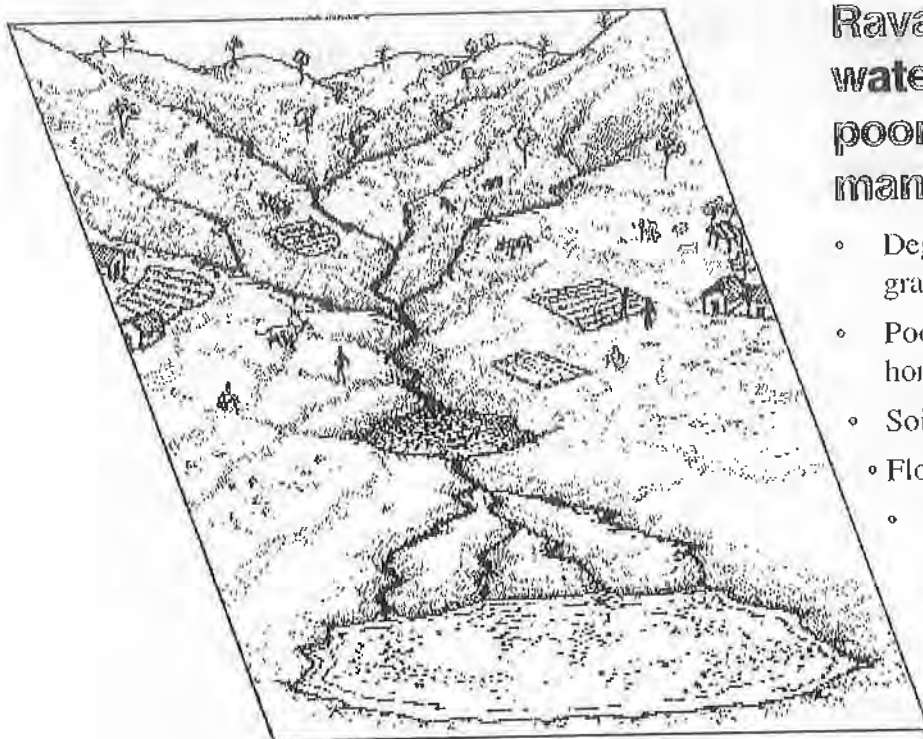
1. Village common resources — government-managed works such as water resource development (surface and ground), drainage, village forest, milk collection centres, etc. Thus, developed resources may be managed by a registered village resource management society. Beneficiaries would pay for using resources and the income generated would be used for community welfare.
2. Resources managed by a group of people, particularly landless labourers, can be funded through loans, equity and/or subsidies for activities like sericulture, poultry, pig-rearing, cottage industry and the like. Profit from this would go to members. Wastelands allotted to the landless could be used without the involvement of the rich farmers. This would help reduce the risk monopoly in the CPR system.
3. Village institutions, like the tree growers' society, are another institutional arrangement for reforestation.

Tree Growers Cooperative Society

Corporatisation through the establishment of public limited cooperative societies (with a share price of Rs.100 each) has encouraged the involvement of the masses in managing wastelands. Wastelands are leased on a long-term basis. The local community gets actively involved in growing fodder, fuel, timber and medicinal plants by raising their own nurseries. Transactions of these societies are normally costed and some of them also give dividends. Wastelands are now being regenerated naturally and economically through the principles of social fencing and the use of local skills, techniques and materials.

Support agencies

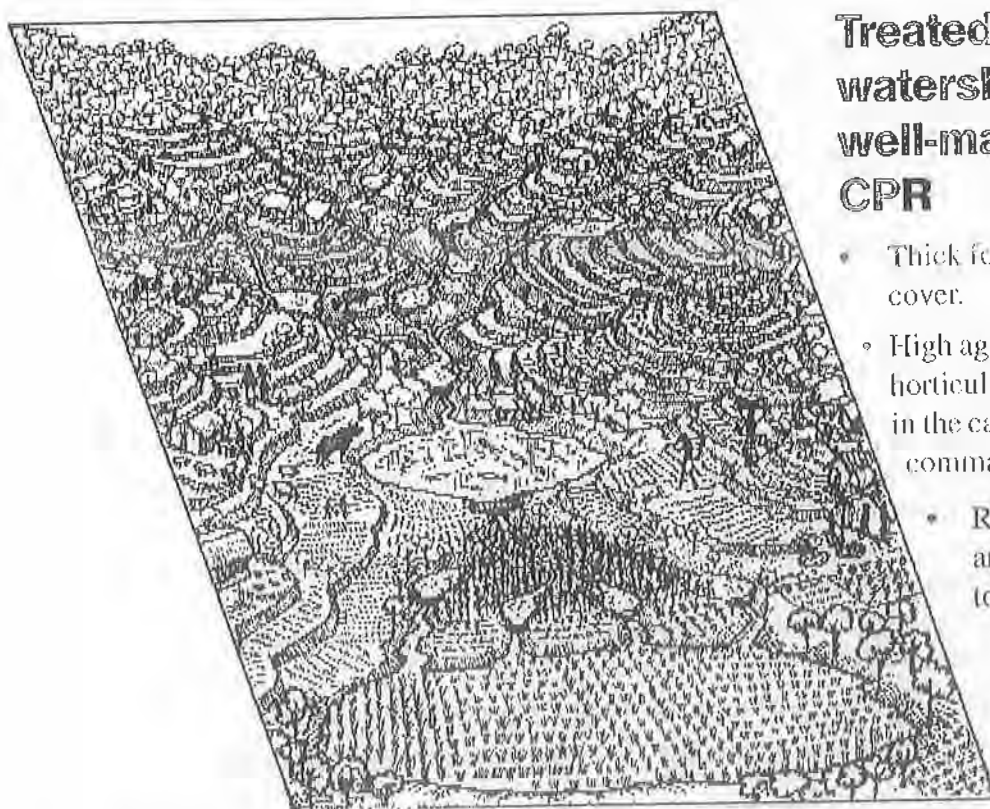
- Central Ministries — Rural Development & Panchayat Raj, Rural Employment, Agriculture, Environment, Wastelands, etc.
- State Departments — Soil Conservation, Agriculture, Animal Husbandry, Fisheries, Sericulture, Cottage Industries, etc.
- Developmental Schemes — Nehru Rojgar Yojana, Food for Work, Rural Health Drinking Water & Sanitation, DWACRA, etc.
- Banks — NABARD, Nationalised Banks, Agricultural Finance Corporation, etc.
- International Agencies — World Bank, East European Countries (EEC), Bilateral donors



Ravaged watershed and poor or no CPR management

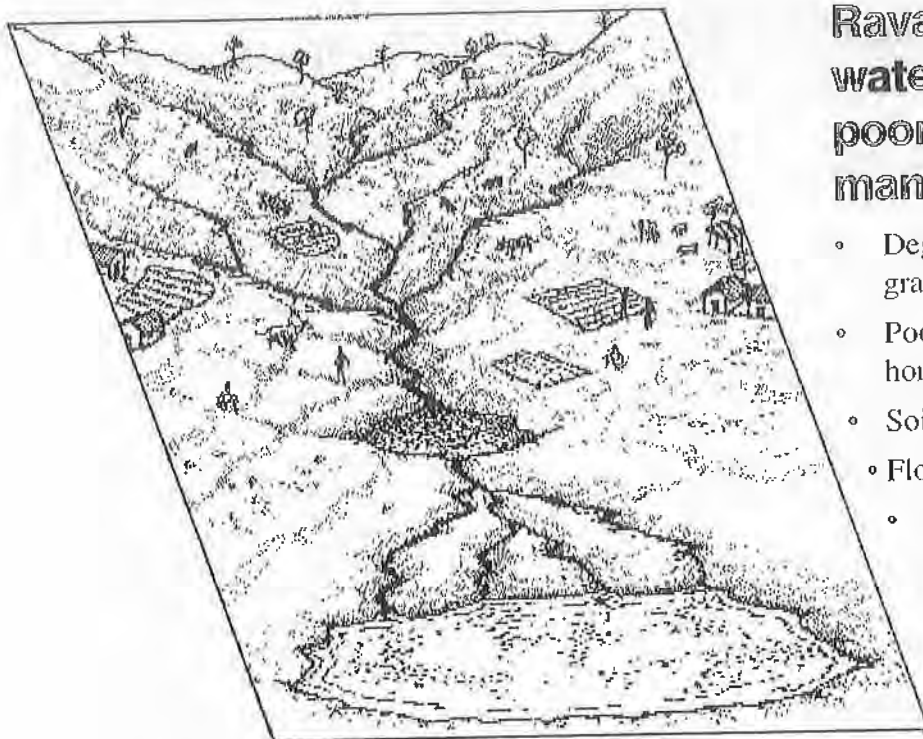
- Degraded forests and grasslands
- Poor agriculture and horticulture
- Soil erosion
- Flooding
 - Reservoir siltation

PRA



Treated watershed and well-managed CPR

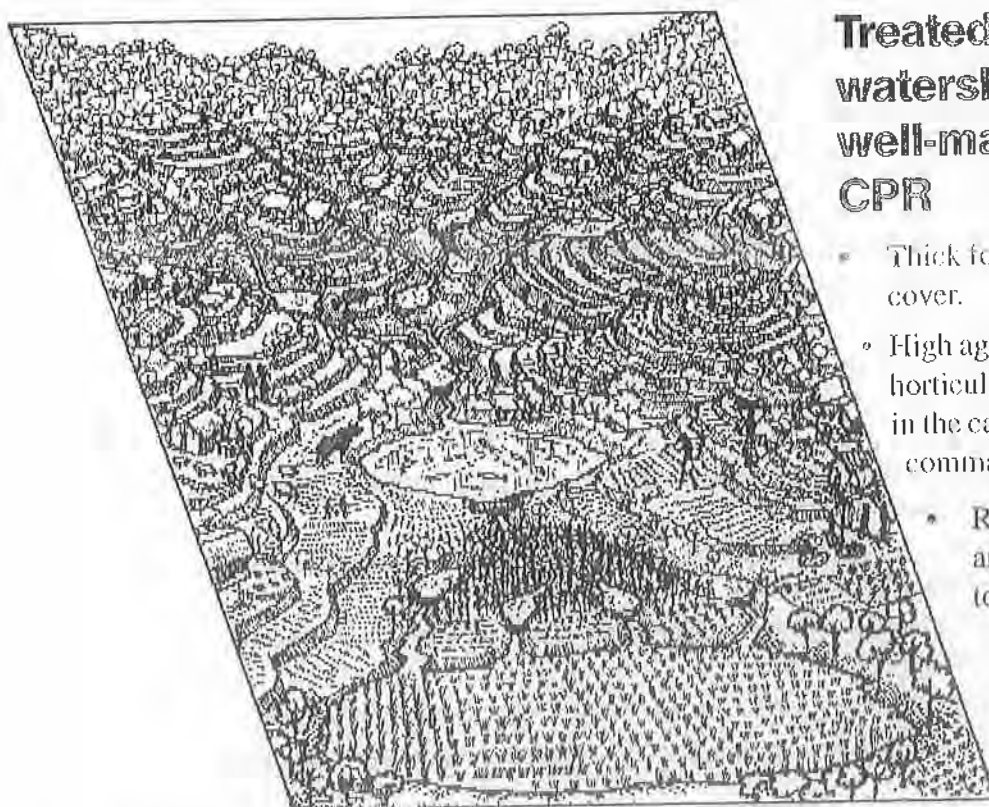
- Thick forests and grass cover.
- High agricultural and horticultural production in the catchment and command areas.
- Reduced erosion and problems due to flooding.



Ravaged watershed and poor or no CPR management

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PRA



Treated watershed and well-managed CPR

- Thick forests and grass cover.
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Diversification of usufruct rights

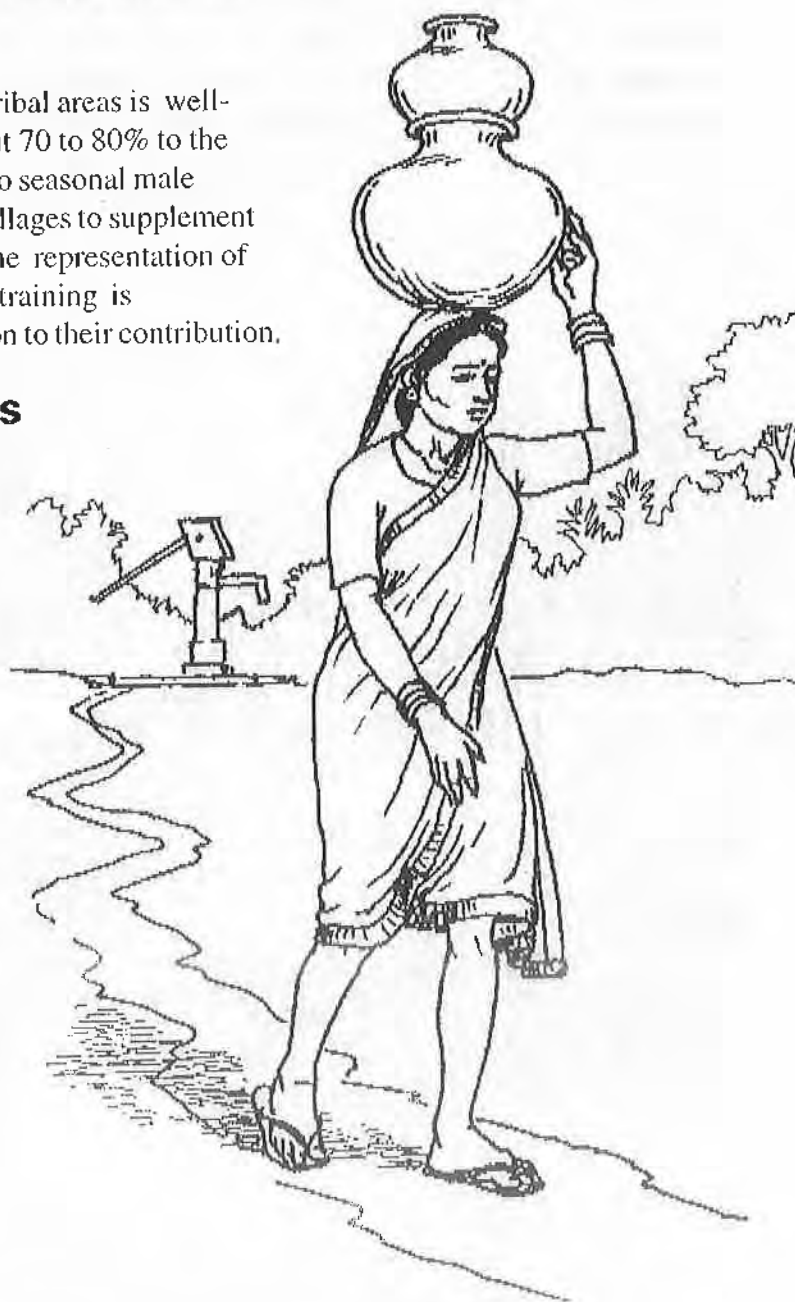
Most of the so-called reserve forests are over-exploited and require regeneration through incentive-based social fencing. Many forests are endowed with natural foods like wild fruits that can be improved through budding, grafting and top working. The local community may be trained and allowed to perform this activity in the reserve forests by giving them the rights to pick and market these fruits. This economic attraction will influence people to protect forests with the added benefit of regenerating the natural vegetation.

Gender issues

The positive role of women in tribal areas is well-known. Women contribute about 70 to 80% to the family labour in hilly areas due to seasonal male migration (the men leave their villages to supplement the family income). However, the representation of women in local institutions and training is disproportionately low in relation to their contribution.

Resolution of conflicts

Conflicts occur even in highly successful institutions of CPR management. It is relatively easy to resolve them in a homogenous group like a single caste. The acceptance of leadership across castes, communities, religions and economic strata is a much more difficult proposition. Local institution building should, therefore, be organised while keeping this in mind. A conflict resolution mechanism like a social counselling group of committed and experienced people may be necessary.



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Contributors: J.S. Samra and S.P. Shardwaj

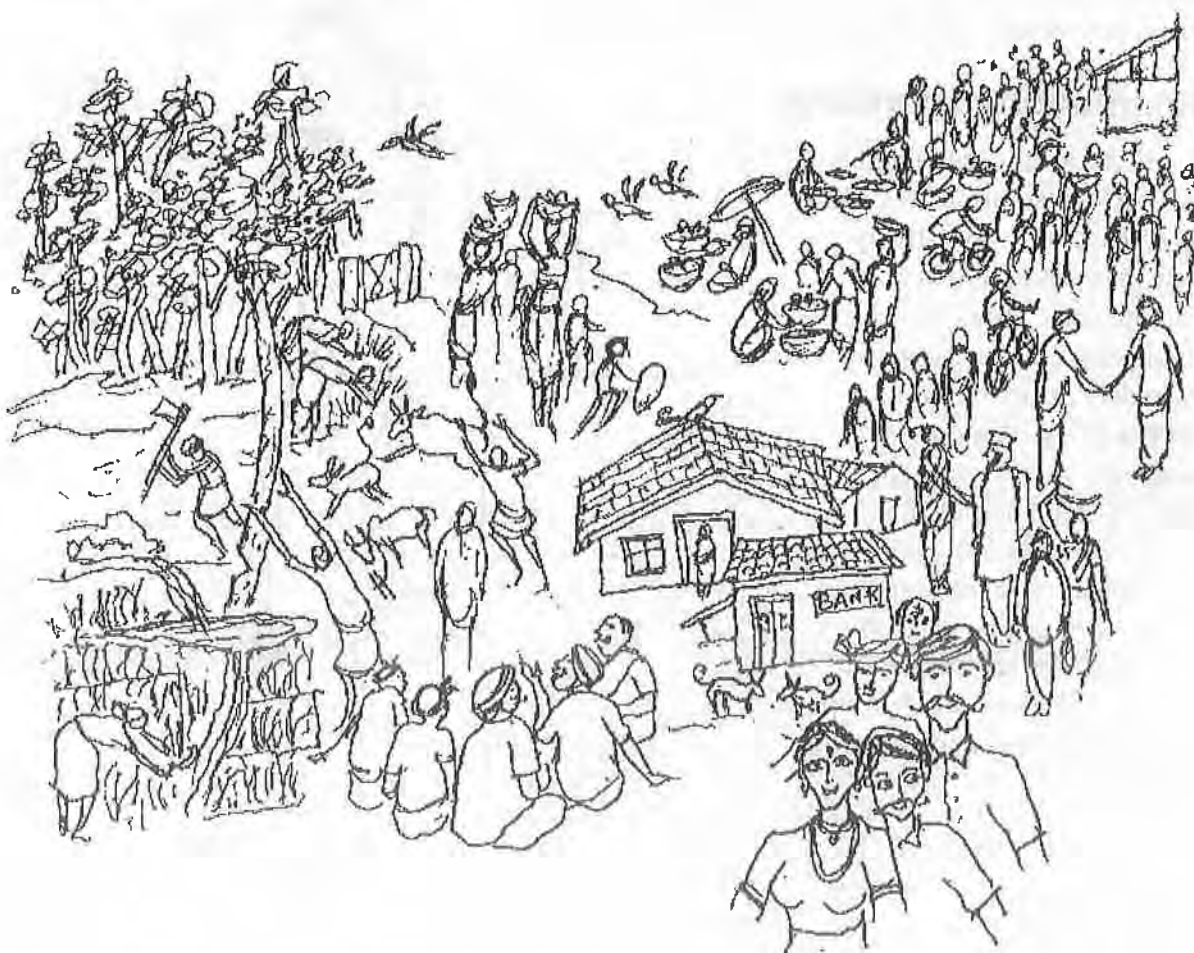
Social fencing in resource development programmes

The Six "Es"

Social fencing takes care of six Es namely:

1. ecology;
2. energy;
3. employment;
4. economics;
5. ethics; and
6. equity.

It is ironic that while there is an awakening in the consciousness and sensitivity of people on natural resources and degradation, there is also an increasing trend in degradation. There is a need to blend different approaches to include people-centred development with area-development. People must be involved at every stage of development to protect resources from degradation. This calls for an approach like social fencing, an understanding among people living in a geographical area (village/watershed) to unitedly protect the developed CPRs and equitably share the benefits generated.



Successful village with social fencing approach — Sukhamajri and Chinnatekur Watershed

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Focal points for social fencing



Social awakening through meetings — creating an awareness on natural resources and effects of its degradation.



Social reward system-recognition given to workers.



Linker group-individuals (four to six) who have the ability to settle differences among the people and are accessible to the developmental agencies.



Self-help group (like minded people) join together to start income-generating activities through financial assistance from external sources or their own.

Development programmes aimed at economic growth and sustainable development must:

- ensure that land users themselves are involved from the start in analysing problems and finding solutions;
- identify causes for land degradation before giving solutions;
- use techniques that provide short and long-term economic benefits; and
- promote systems that provide permanent vegetative cover to protect the soil, increase fertility, optimise water penetration and meet the demands of society.

Social fencing against degradation

Resource conservation over large areas can be achieved at a reasonable cost through the activities of land users themselves. Conservation programmes should create conditions that encourage land users at farm level to adopt land use systems and management strategies that will lead to conservation.

A commitment to resource conservation is the essence of social fencing.

Contributors: M. Padmaiah and M.S. Rama Mohan Rao

Community-managed food security

Precursors to Community Grain Fund

Eco-employment: helped over 3000 women to increase the productivity of their degraded lands through bunding, trenching and top soil addition and provided over half a million womendays of employment in eight years.

Land Lease: added extra food to the family basket and enhanced the status and bargaining power of Dalit women in their community.

Eco-insurance: stopped non-sustainable toxic, chemical farming systems harmful to drylands.

Deccan Development Society, an NGO in Medak District of Andhra Pradesh, India, works with rural Sanghams (associations) of *Dalit* women, women from the lowest social caste group.

DDS believes that empowerment of these rural communities through transfer of resources can ensure food security for dryland regions.

This case study illustrates a four-pronged effort at food security.

Four steps to food security

- Marginal farmers develop their own marginalised lands and thereby increase food availability for their families through eco-employment programmes. This activity adds up to 100-300 kg of additional grain per year into their family food basket besides increasing their stake in their own lands.
- Women's groups lease in marginalised farm lands at a competitive price, cultivate it as a group, produce food crops and share it for consumption with their families.
- A Community Grain Fund programme, through reclamation of 1000 ha of cultivable fallows or extremely marginalised lands, produces 800,000 kg of grains in 30 villages.
- A Community Gene Fund, with 300 women-farmers, reclaims lost landraces as well as restores control over seeds with women.



Community Grain Fund

The Public Distribution System (PDS) in India is exclusively based on two grains: rice and wheat, both produced in resource-rich irrigated belts. Consequently, rainfed crops like sorghum, pearl millet and finger millet face a serious setback. People in dryland areas suffer cultural, agricultural and nutritional crises. These also accelerate fallow-formation in dryland regions.

The Community Grain Fund (CGF) project was designed in response to this problem. It attempts to establish a food security net aimed towards coarse grain producers and managed by women.

The first step that the (CGF) project took was to start reclamation activity on 1000 ha of cultivable fallows spread over 30 villages. Degraded lands were cleared and ploughed deep by tractors — for the first time in many years. Farmyard manure was bought and applied on these lands. Sowing and weeding took place on time, something poor people never were able to afford earlier.

The next step was to identify around 100 poor households in each village for grain distribution and issue them a sorghum card. This was done by the *dalit* women *sanghams* in each village through a wealth-ranking process. The card entitles the family to 25 kg of sorghum per month at a subsidised price for six months a year during the rainy season. This is when the poor cannot find work and food is scarce. Consequently, they face acute hunger. The PDS sorghum fills this critical gap.

Proceeds from grain sales are deposited in a bank as the Community Grain Fund. The money could be used year after year to reclaim more fallows in their village. The food security net could be cast wider and wider.

This complex task is being managed by groups of *dalit* women, who are poor, illiterate and marginalised.

Gains (Made in 30 villages)

• Fallows reclaimed	1000 ha
• Extra sorghum produced	800,000 kg
• Extra meals produced	3,000,000 kg
• Extra wages produced	75,000 rupees
• Extra fodder produced for	6,000 heads of cattle
• Extra meals per family	1,000

This meant that, along with more grain production, purchasing capacity of the poor also went up with increased wage opportunities.

Investment (per hectare — in Rs.) (over 3 years)

Ploughing	1750
Manuring	1875
Transport	375
Sowing	750
Weeding	1750

Total	6500
-------	------

Contribution to CGF (per hectare — in qtls)

Year 1	3.75
Year 2	5.00
Year 3	5.00
Year 4	3.75
Year 5	3.75
Total	21.25

Tale of two PDS

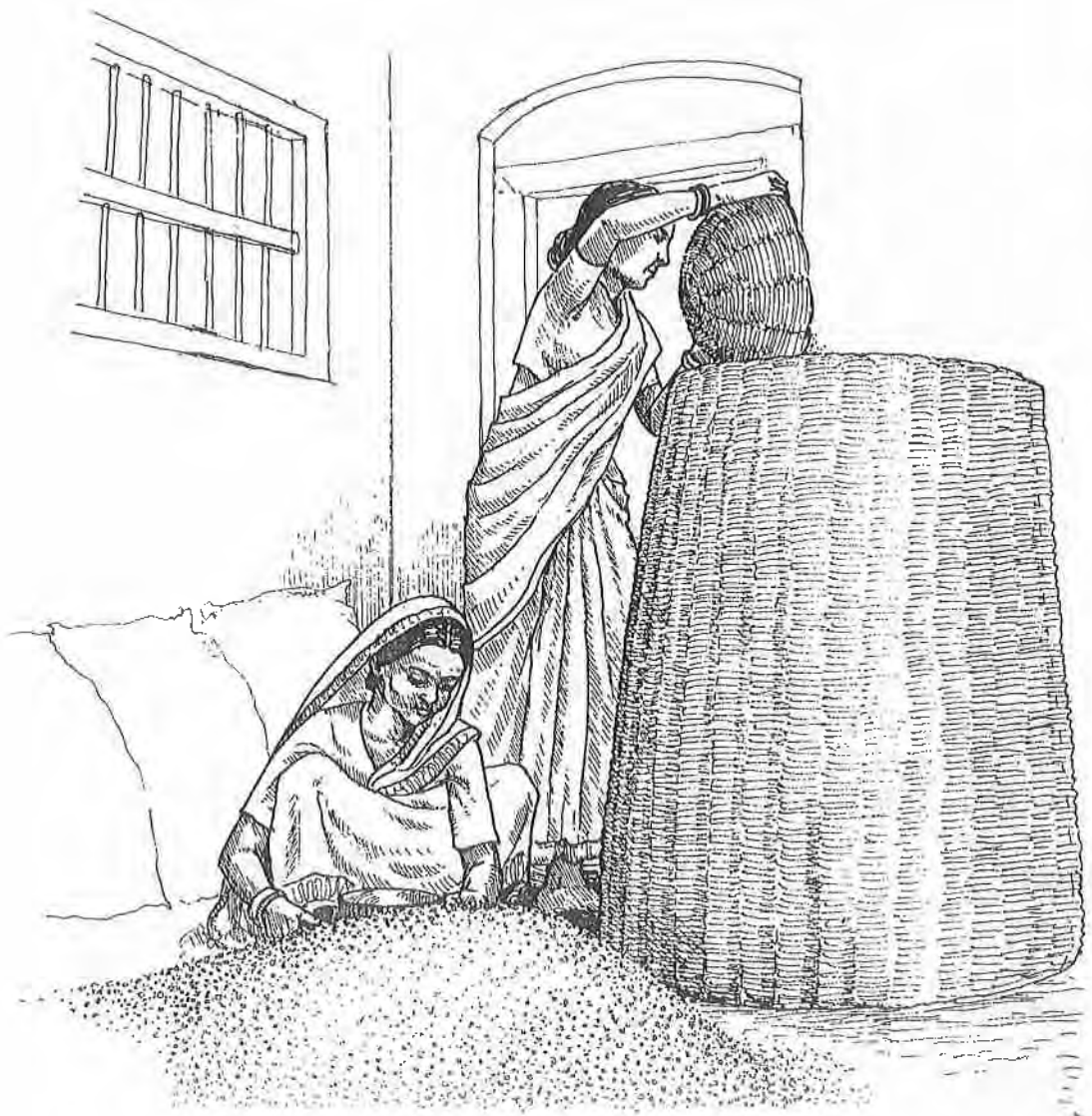
Mainstream PDS

- Highly centralised
- Based on only two cereals — rice and wheat
- Beneficial to irrigated resource-rich areas
- Women and local communities are marginalised

Alternative PDS

- Totally decentralised
- Based on local grains
- Supports rainfed, resource-poor areas
- Women and local communities are central to it

If their experiment succeed, the women of the Deccan Development Society will establish the first decentralised Public Distribution System in the country. One with a local production, local storage and local distribution model suited to the local dryland conditions.



Community Gene Fund

Designed to conserve the local landraces, the Community Gene Fund (CGF) programme attempts to restore the traditional control over genetic resources which women traditionally enjoyed.

Women belonging to poorer sections of the rural society and the *dalits* are basically subsistence farmers. For them, traditional crop varieties are very important because these crops have harmonised over a long period of time with the environment and hence, are easier to grow. Likewise, these varieties demand less resources and, therefore, fall within their management capabilities.

Investment (per hectare—in Rs)	
• Ploughing	750
• Manuring	3,000
• Transport	1,500
• Weeding	1,000
Total	6,250

In this project 12 ha of land per village were identified to raise traditional crops for seed purposes. The lands were selected by the village *sanghams* based on the following criteria:

- the poverty of the woman who owns the land and her commitment to grow the traditional crop; and
- the suitability of the land to grow the traditional crop as seed.

A one time investment of Rs. 6,250 per hectare is made and recovered in the form of seeds. Recovered seeds are stored in the village to serve as an *in-situ* gene bank to help other farmers grow traditional crops.

A total of 600 women whose farm sizes are between 0.2 ha and 0.4 ha directly participated in the programme. The secondary and tertiary groups of beneficiaries were about 1,500 women and 20,000 women, respectively.

Expected results

The Community Gene Bank project visualizes the following:

- secure crop biodiversity in the area and ensure a safety net for women who are dependent on subsistence farming;
- empower the women to reclaim their unproductive lands;
- create an *in-situ* gene bank;
- enable the women's groups to develop the skills and management capacities to grow local landraces as seed crop and establish village level seed banks;
- develop a seed distribution network for the local crop varieties and ensure large-scale re-emergence of these varieties; and
- empower the women to develop into seed entrepreneurs and to enter agribusiness on their own strength.

Outcomes

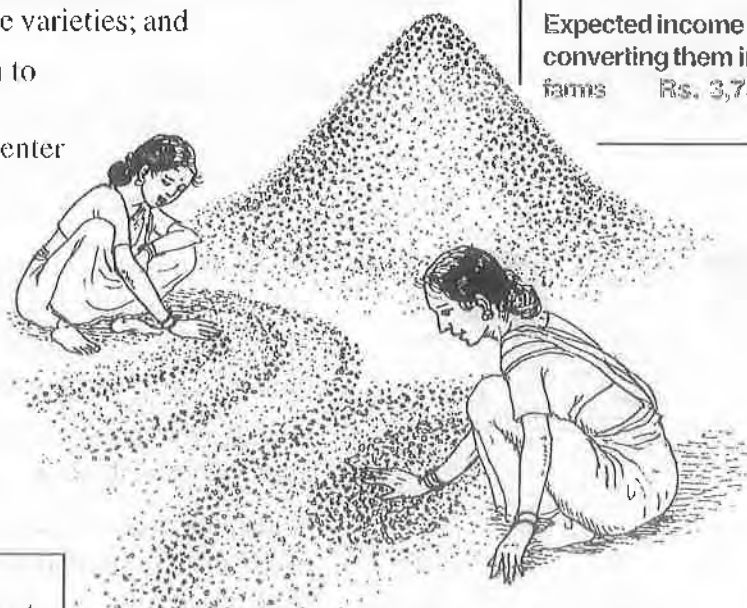
- Creation of a fallback system for women outside the mainstream market which has always acted hostile to them.
- Creation and operation of their own markets, thereby, entering into the agri-business as entrepreneurs and increase their agri-incomes.
- Conversion of lands into seed-farms, to help women earn one and a half times the normal income (the present practice in the region is that if someone borrows a kilogram of seed s/he returns 1½ to 2 kg during the next season).

Benefits

Present income from their lands **Rs.375-500**

Income by making lands productive **Rs. 2,250-5,000**

Expected income from converting them into seed farms **Rs. 3,750-7,500**



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Contributor: R. V. Saiheesh

An alternative approach to financing dryland development

Majority of people in dryland areas have limited physical and capital resources. This limitation deters them from investing in new technologies or adopt new approaches to farming and other income-generating activities even if they recognise the benefits of making such a change. One of the primary constraints is the inability to access sufficient credit in a timely manner that prevent them to take advantage of opportunities to improve dryland agricultural production and consequently their welfare. Several approaches have been taken by institutions in an attempt to provide credit to farmers for the purpose of adopting appropriate technologies. The traditional approach favored loans to individual farmers whereas the proposed system concentrates on extending credit to self-help groups.

The traditional approach to financing dryland development

This approach focused either on crop loans or term loans to individual farmers. Credit dispensation for dryland development has concentrated on commercial crops such as groundnut, cotton, tobacco and chili that high-scale financing compared to cereal and pulse crops.

Investment credit was influenced by commercialisation, emphasising viability and repayment. Models based on alternative land uses that combine horti-silvi-pasture and livestock husbandry systems were widely accepted by dryland farmers.

Despite the positive efforts taken by financial institutions, credit flow for dryland agriculture was relatively low. This can be attributed to problems relating to both demand and supply side constraints which arose as a result of:



- low bank investment due to a wide variation in yield levels and the uncertain nature of production in dryland farming, resulting in low returns and unsatisfactory repayment performance;
- lack of awareness and knowledge about appropriate technologies; and
- inadequate administrative and institutional mechanism to support dryland farming and its related issues.

The traditional financing approach as applied to watershed development

Treatment of dryland areas on a watershed basis has become popular for development of rainfed agriculture. A watershed is an area with a common drainage point, meaning all rainfall falling within the watershed flows through one or more natural courses converging at a common point.

Watershed activities and investments

Initial activities are related to soil and water conservation measures like bunding, planting of trees and vegetative measures, treatment of drainage through gully plugs, earthen and concrete bunds, check dams, etc. These activities are taken up on public as well as private lands. Financial support for these activities has not normally been available from institutional sources except perhaps in the form of government grants or development capital from non-government organisations (NGOs).

Positive features

- A 70% increase in cropping area plus increases in cropping intensity.
- Increase in cereal and pulse production levels and better employment opportunities generated at both micro and macro level.
- Better crop husbandry supplemented by scientific dairy activities have generated additional income, employment and improved the nutrient standard of the watershed community.
- Over-all economic viability of dryland development investments with the financial rate of return of over 40%.

Limitations

- Poor physical and financial progress of dryland development programmes in general.
- Lack of coordination among different partners.
- Inappropriate choice of technologies.
- Inadequate and untimely disbursement of loans, input supplies and training facilities.
- Poor recovery performance of bank loans.
- Inadequate and unmotivated bank staff.
- Poor sustainability of promoted informal groups and watershed communities.
- High risk and uncertainty in expected productivity and profitability.

Technological and administrative elements of watershed projects

Conservation and effective utilisation of water through components involving:

- treatment of arable and non-arable lands including wastelands within the watershed and drainage channels;
- preparation and adoption of a scientific cropping plan based on land capability to minimise soil erosion and loss of moisture;
- adoption of a full package of agronomic practices and alternative land use technologies;
- timely and adequate supply of inputs;
- a project approach with time bound objectives for development of the entire watershed; and
- adoption of an integrated multi-disciplinary approach covering all components of dry land technology.

Role of NABARD

- Provision of 100% refinance of credit directed at watershed based dryland projects.
- Provision of concessions for financing of defaulters falling within watershed projects.
- A training module has been developed and is being run for imparting training about dryland farming to bankers.
- Implementing grant based watershed programmes

Self help group (SHG)

This is a group of people voluntarily formed on the basis of affinity for the purpose of achieving a common objective through mutual support. *(See the paper on Institutional Credit for Small and Marginal Dryland Cultivators: the Self-help Group Approach.)*

Given the shortcomings of the traditional approach, the need to increase participation of NGOs and community members was identified. As a result, a new emphasis was placed on developing self help groups and the strengthening of linkages between NGOs, financial institutions and government bodies. Based on this, a new approach has evolved.

A suggested approach for financing watershed development

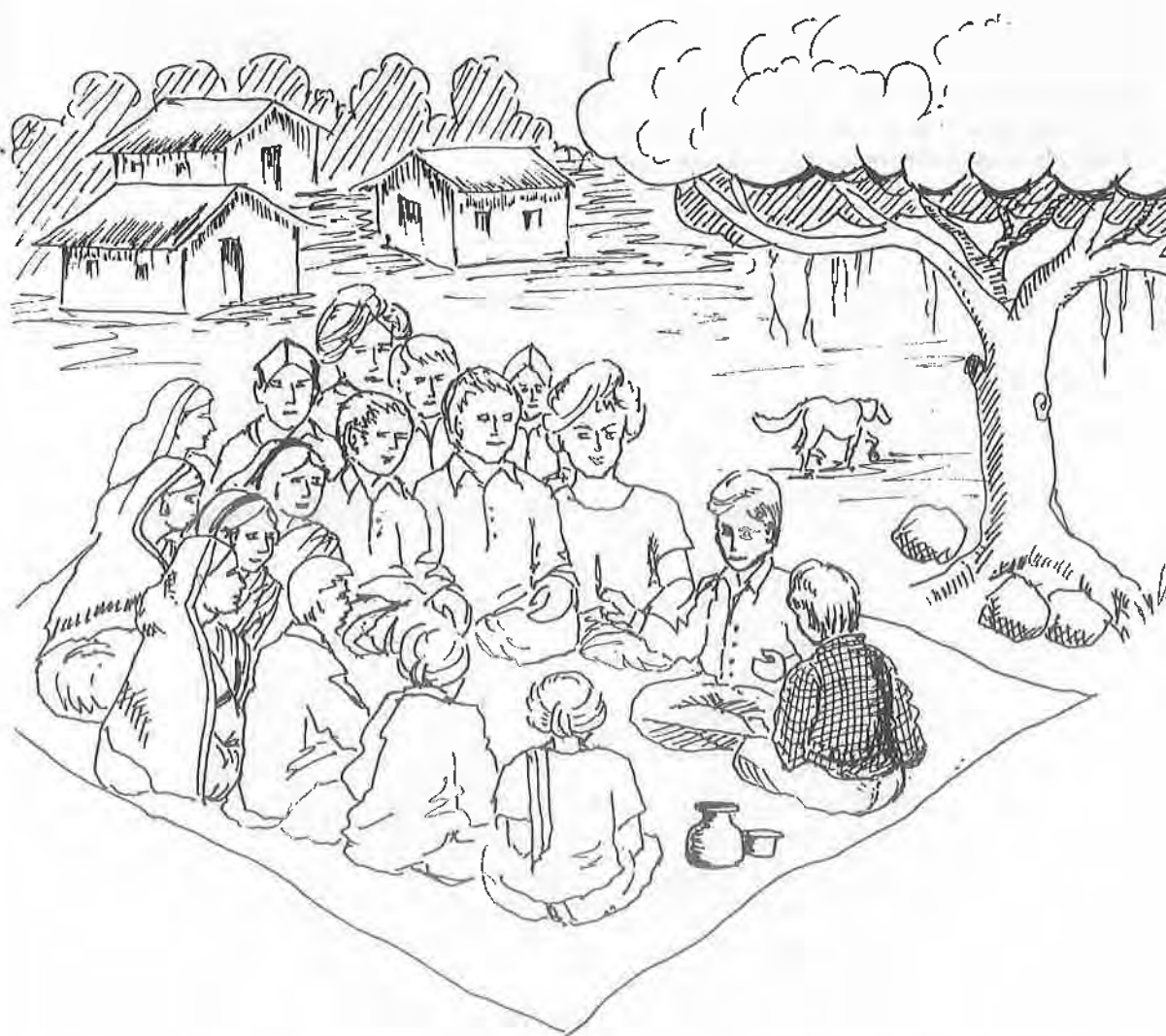
This approach to watershed development promotes the development of local self help groups through the support of NGOs, financial institutions and the local and state governments. Training, logistical support, access to credit and some funding are made available. The process is outlined below:

- identification of compact micro watershed;
- selection of participating organisations viz, government agencies, NGOs, research institutions and banks;
- conduct of base line survey;
- assessment of potential for various activities relating to dryland development;
- identification of appropriate technologies;
- formation of watershed community, SHGs and strengthening of the organisational capacities of all participants;
- implementation of watershed programmes;
- assessment of credit packages for individual farmers, SHGs and community investments;
- disbursement of credit on a household basis;
- periodical monitoring by a committee representing different implementing agencies;
- documentation of experiences relating to physical and financial progress and constraints in programme implementation;
- carrying out mid term corrections;
- completion of programme implementation; and
- programme evaluation.

Important features of this approach

- Projects must be owned and implemented by the watershed community.
- Technical agencies of government, NGOs and banks will provide guidance in planning, project preparation and implementation.

- The watershed community will own the usufruct rights from all common property resources; manage and use the common properties productively to generate a surplus for repayment of loans.
- The loan will be in the name of an registered organisation representing the watershed community. There will be no individual loans for basic soil and water conservation works.
- A committed project team approach needs to be followed while developing the organisational and managerial capacities on the part of the watershed community. The involvement of NGOs will be crucial in facilitating community participation.
- Ground level institutions must be evolved to ensure maintenance of soil and rainwater conservation structures.
- Many farmers are assumed to have sufficient resources to undertake complementary activities and hence they will be considered for loaning directly by banks.
- Small farmers and agricultural labourers with less financial strength and poor access to institutional credit sources will be motivated to form homogeneous groups with the active support of NGOs.
- Credit requirements will be assessed on the basis of household units which include consumption and production activities. Repayment schedules will be drawn based on income generating capacity of the family as a whole.



NABARD's Maharashtra Watershed Project Experience

The programme aims to develop micro watersheds in an integrated and comprehensive manner for achieving and supporting a sustainable production system. Initially ten watershed projects, each with an approximate area of 1,000 hectares were targeted to be developed. The different agencies of the state government, the agricultural universities and research centres, banking institutions and NABARD are playing a supportive and advisory role to the NGOs and the village watershed community. NABARD provides grants for project planning, implementation and for training and support of NGOs and community members.

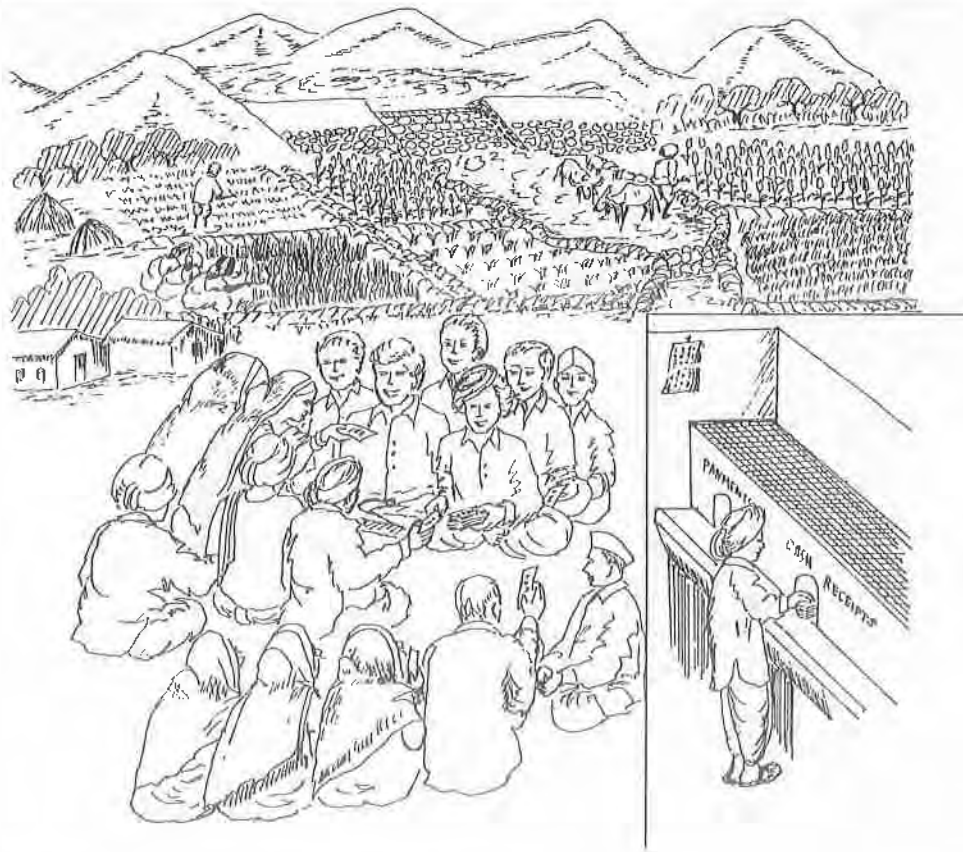
Community action is ensured by making WDA members contribute money and labour towards the costs of developing and maintaining the watershed. In addition, steps are taken to ensure that the community commits itself to: reducing the livestock population to the carrying capacity of the land, social fencing, stall feeding and banning the cultivation of water-intensive crops.

The programme is getting the full support of the Government of Maharashtra. The state government has permitted the watershed community to undertake treatments to common property resources including forest lands and have also provided for the sharing of usufructs and terminal benefits from the same.

Initial results from the programmes are encouraging. One of the first villages covered under the programme, previously required a supply of drinking water from tankers during the summer. It now has a year-round supply of well water due to implementation of conservation measures and recharging of ground water. There are indications of an increase in rabi area and kharif output and generation of more employment.

The community's decision to ban free grazing and felling of trees coupled with soil and moisture conservation measures have improved biomass production, which in turn, led to the development of dairy and other complementary activities.

Currently, 16 projects are under implementation and 19 projects (covering an area of 54,000 hectares) are under preparation or in pre-sanctioning stages. Based on the feedback from the first phase of the programme, a second phase of assistance is being negotiated and an extension of the programme to a few other states like Andhra Pradesh, Orissa, and Gujarat is being contemplated and initial steps have already been taken.



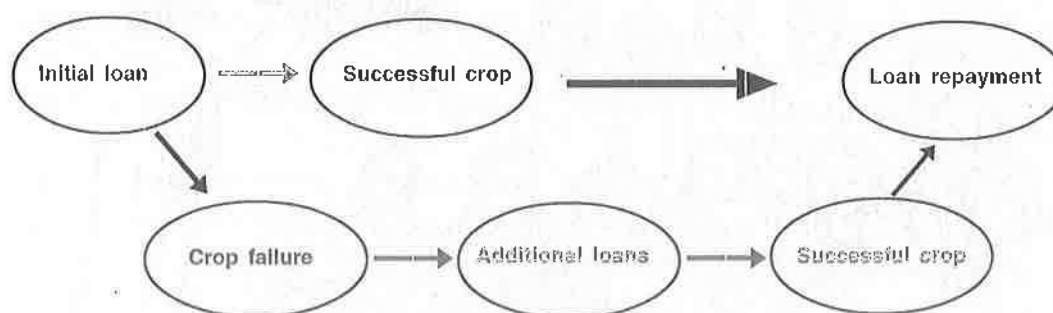
NABARD's experience with cyclical credit

Cyclical credit is another approach to extend credit to dryland farmers. The idea is to make short-term loans which can be rescheduled and supplemented by additional credit in the event of crop failure. The farmer is to adopt the recommended technology and repay the loan based on yields obtained during each year. The repayment capacity is assessed on the basis of crop cutting experiments conducted in the project area and determined with respect to the normative income level to be obtained from different crops in each project area.

The experience

Cyclical projects were implemented at seven locations by NABARD. The following are some of the insights gained:

- despite the assurance of additional credit, farmers who borrowed in the initial years did not borrow in the subsequent years for fear of accumulating unsustainable debts;
- there were difficulties in fixing project-specific normative yields for different crops;
- the technology packages evolved were only for selected crops; often these did not match the farmers' preference for cropping patterns which were decided based on the on-set of monsoon, availability of soil moisture, etc;
- certain critical components, such as drainage and other common investment activities were neglected; often leading to crop failure;
- delays in crop-cutting experiments and consequent difficulties in fixing repayments frustrated the objective of providing timely credit;
- declaration of drought through "annavari" system (followed by the State Government) directly affected the repayment performance in the watershed area, even if the crops were not affected by drought; and
- wide variation in yield parameters among individual plots in the same watershed area as a result of soil texture, fertility, drainage facilities, etc., could not be represented through the crop cutting experiment yields.



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Contributor: V. Puhazhendi

Institutional credit for small and marginal dryland cultivators: the self-help group approach

Respond to the needs of farmers Crop loans are an annual necessity. To be of use, crop loans have to:

- respond to the needs of farmers;
- be uncomplicated to access;
- be disbursed in time (so that the season is not lost); and
- be adequate (neither more nor less than what the farmer can manage).

Dryland cultivation is usually not a bankable proposition as land holdings are fragmented and small (less than 2.5 ha) along with unclear land ownership titles. Yet majority of the resource-poor farmers engage in risk-prone agriculture on drylands. As a result of mainstream financial institutions ignoring the dryland farmers, compelling them to borrow from money lenders at disadvantageous terms, self-help groups have emerged as an alternative.

What are self-help groups?

- Small groups — 20 persons per group or less.
- Voluntary groups — no one is forced to become a member.
- Participatory — the smallness ensures everybody's participation in decision-making.
- Homogeneous — the members have shared needs and interests.



*Information kit produced by
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Institute of Rural Reconstruction.*

How a self-help group operates

- All members decide to save money regularly and over a period of time they build up a pool of savings.
- The savings are individually accounted, but the money is held in a common fund.
- Group meetings are regularly held, usually once a week or at least once a fortnight.
- Loan requests from members are received at group meetings and assessed based on the borrowers' urgency of need, ability to manage the loan, ability to manage the activity for which the loan is sought, ability to make repayments, fund availability and other practical details.
- Approved loan requests are financed out of the common fund. The terms of lending and repayment are decided by consensus by all group members.
- The groups have their own norms and violation of norms is penalised.

How to form a self-help group?

The idea has to be accepted by at least a section of the poor in any village. The acceptance is secured over a period of time and interaction. A tentative group is formed, with some people unsure of their continuation and association with the group. It may take up to 12 weeks of regular interactions for membership to crystallise and for them to start thinking of themselves as a group.

The norms of functioning are established and routinised. Regular meetings, saving, lending, recoveries, establishing rules and regulations, establishing sanctions for violations of norms, book keeping and documentation are established. Staff engaged in group formation have to keep in weekly contact with the group formed.

Training programmes are arranged for group members to equip them to work together and efficiently. Towards the close of this period, which can take up to two years, groups develop the necessary management skills and the capacity to relate with other institutions to enhance their own development. At the end, most groups continue on their own, without the need for regular contact with the staff involved in working with the group.

Foundation of self-help groups

The process starts with what the poor farmers have:

- capacity to save;
- willingness to work in groups; and
- capacity to make decisions.

Principles of self-help groups

- All members contribute to build the capital of the institution.
- All members share a stake in the business of the institution.
- All members take responsibility for managing the institution.

Role of self-help groups in cropping on drylands

- Easily accessible, need-based, timely and adequate credit.
- Many groups are also engaged in collective procurement of inputs.
- Source of credit for watershed development programmes.
- Surplus funds being invested in community irrigation programmes, etc.

In India, banks have institutionalised policy changes that permit them to lend to unregistered self-help groups. Transactions costs are significantly lower both for the borrowers and for the bank. Repayment records have been good and self-help groups are merging as the preferred option for lending to the poor. The Cauvery Grameena Bank, Mysore District, Karnataka, India is experimenting with the idea of its own officers forming self-help groups in the villages they work in.

Training topics

- How to conduct meetings
- Unity
- Group concept
- Roles and responsibilities of members
- Problem solving
- Decision making
- Book keeping
- General information on various subjects
- Linkages and resource mobilisation

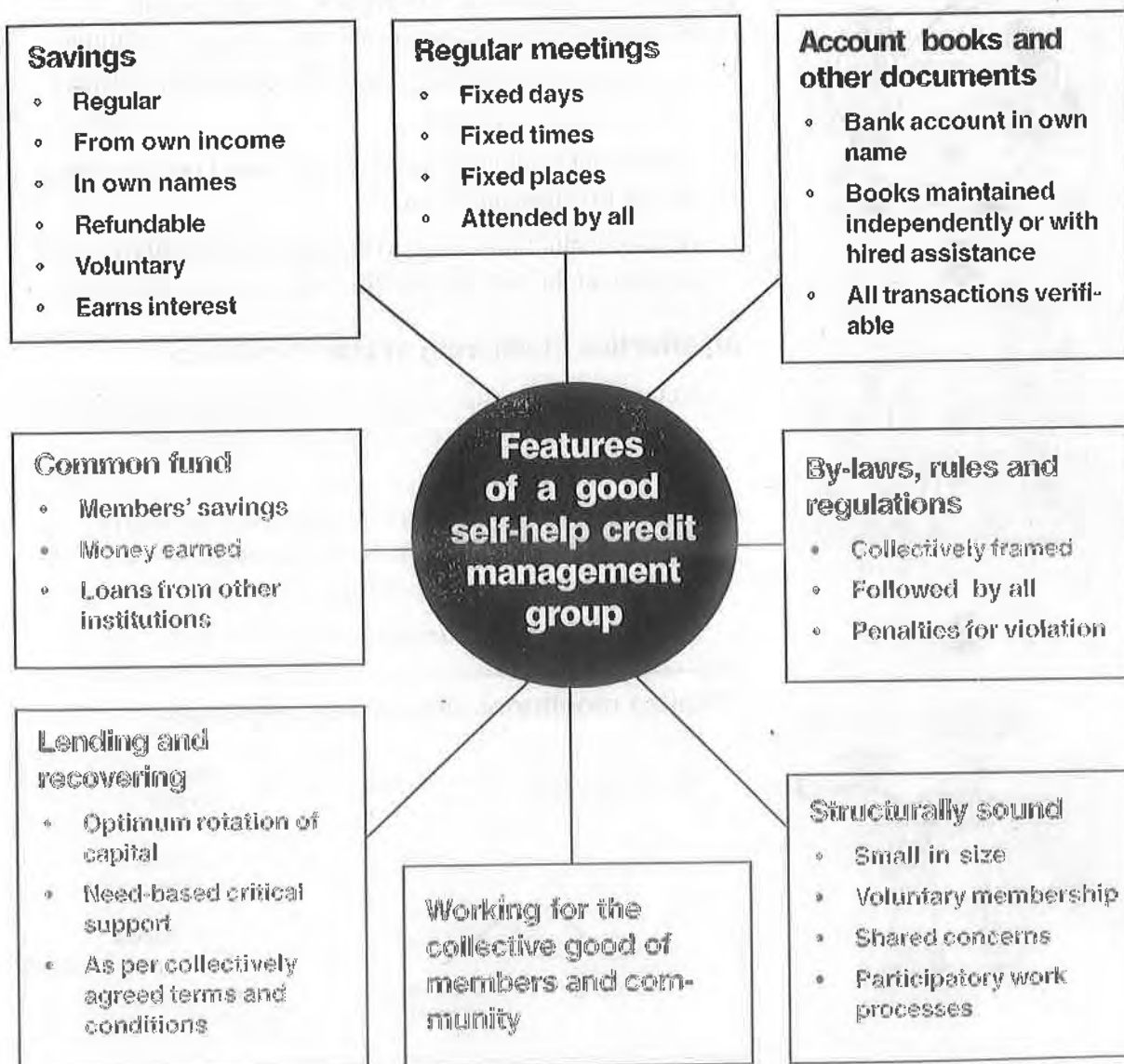
Documents kept by self-help groups

- Admission book
- Minutes book (considered as the Mother Book in which all transactions are verifiable)
- Cash book
- General ledger
- Savings ledger
- Loan ledger
- Bank pass book
- Members' pass books (issued by the group)
- Stock book
- Receipts and payments vouchers



Socially-functional groups: a whirlpool of activities

- When Revamma's husband became ill in the middle of the night, she could only think of her sangha. "No problem, said her colleagues," and they arranged for a cart and transported him to the hospital in Chitradurga. They also took turns in bringing food for him to the hospital. A crisis had been averted.
- "It is the coconut season and I need Rs.300 for just 15 days with which I can earn my money." Who else, but his sangha would consider helping Chikkamadappa.
- "I am not interested in selling the shop, but if you want to sell it, you will first have to buy my portion from me", said Venkatamma's brother, with whom she jointly owned the store that was running at a loss. A loan of Rs.600 was given for a week, and she was able to buy his portion, sell away the store, repay the sangha, and redeem an acre of land that had been mortgaged for months.
- After the field day, the farmers grumbled that they were too poor to afford the improved implements. "Individually you can't, but why not let the sangha buy and rent the implements to you?" suggested the MYRADA worker. The members went a step further and several sanghas got together to jointly run this community service.



Contributor: Vidya Ramachandran

Techniques for monitoring and evaluation of projects

Monitoring is a continuous or recurrent process that can be perceived and conducted at three levels: Programme monitoring, Evaluation and Impact monitoring.



Monitoring is the process of measuring, recording, collating, processing and communicating information to assist the process of project management in assessing the progress of project implementation.

Evaluation is a process by which the programme inputs, activities and results are analysed and judged against explicitly-stated norms. It is a method of determining how far an activity has progressed and what more has to be done to attain the objectives. It involves comparison of actual objectives regarding project operation, performance and impact with those originally specified or planned.

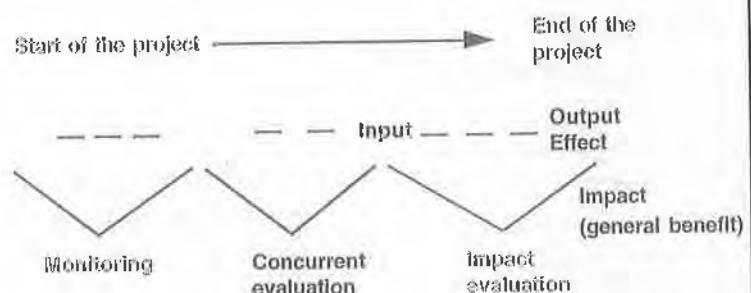
Thus, monitoring and evaluation are important management functions providing feedback of performance of the job in project implementation. The role of monitoring and evaluation in the project sequence can be traced as follows:

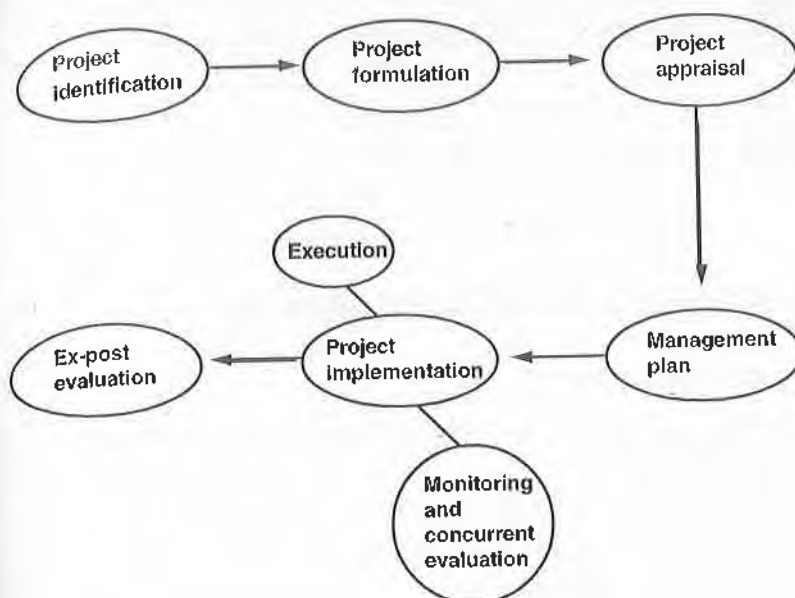
- monitoring involves assessing the input/output segment of the project sequence;
- concurrent evaluation assesses the project progress from output to effect stage; and
- impact evaluation relates to assessment after the project is over, on the overall benefits to the society as a whole.

An effective monitoring system is able to:

- Detect problems (deviations from schedule, emergence of unforeseen technical problems) early enough for remedies to be applied.
- Provide realistic, adequately summarised and easily interpreted information on the likely progress of the project, both technical/social and financial.
- Identify those who failed to do things on time.

Project monitoring and evaluation stages





Programme monitoring is a short-term monitoring of day-to-day activities and finances to provide immediate feedback to management for adjusting and fine-tuning of activities to ensure that they conform to plans, budgets and objectives.

Components of monitoring and evaluation

Targets

Progress targets must be developed allowing sufficient time for the completion of work. Compare targets with actual achievements to see whether remedial measures are required, either by the project's sponsor or by the aid agency. If targets are unrealistic, there will be continuous misconceptions regarding actual and planned progress. Targets must be feasible and close to being optimal. If targets are quite unrealistic, they may be revised from time to time as the need arises.

Channel of instructions

The methods by which the targets are communicated to the project supervisors are often unsatisfactory. It must ensure the supervisors are instructed on their role in a timely and comprehensible manner. Often, no formal provision is made for this and junior staff are expected to decide upon their responsibilities from a circulated generalised over-all description of the project.





Feedback mechanisms

A systematic reporting system will facilitate objective identification of reasons for delay and, forms a reliable basis for forecasting future progress. Without proper identification of reasons for delay, it is difficult to devise effective remedies. Timing of a reporting system must be appropriate in relation to the duration of the project cycle to identify delays before they become serious.

Techniques used in monitoring

Self Monitoring

The process by which the community and the beneficiaries can participate in monitoring their own progress in development initiatives.

Advantages:

- People become more aware of the processes involved, which often facilitates the activities themselves.
- The cost of monitoring activities is largely returned to the beneficiaries as employment wages.
- Indicators can be registered more frequently at less cost, and duration of monitoring can readily be extended because the responsible persons are resident on site.
- It can facilitate discussion and revision of the objectives themselves.

Disadvantages:

- It requires more careful and precise selection of indicators in which the communities participate.
- Often needs a period of training.

Traditional method

Periodical reports like monthly reports, quarterly reports, etc. in prescribed formats.

Limitations/deficiencies

- Targets are often unrealistic.
- Lack of a systematic method of converting targets into instructions at the right time to the right people.
- There is no methodical checking of what has to be done, by whom and when. Certain activities may be overlooked.
- Distortion in reporting and delayed communication result in delayed decision-making on cross check measures.
- Physical progress summary tends to be presented after issues have already arisen because deviations are picked up after they have become serious.
- It gives no guidance to the project manager on the relative importance of project activities at any one stage.
- Provides no logical basis for summarising the state of progress. It remains as an undigested, unclassified list of everything that has happened. The overall picture is concealed.
- Instead of identifying the problem, the reports often end up reassigning the blame.

Improved method: Critical path method

It involves realistic working methods and rates of implementation to generate a feasible plan and provide a means of implementing it. It consists of the following steps:

- * Assembly of a complete list of all activities needed to complete the project together with the relationships between them (that is, which job must follow which) and the length of time required to complete them.

- Calculation of the time needed to complete the project and the dates on which each job should be commenced and finalised.
- Setting up instructional and feedback links between the project manager and executives.

Critical path activities

Delay in any activities will automatically lengthen the project. The continuous line of activity from the start to finish of the project is known as the critical path. The method of project control depending on this sort of analysis is referred to as the critical path method (CPM). The length of the CPM is the minimum time in which the project can be completed.

Basic data in CPM on the extension activities of an agricultural assistant (8 circles).

Activity number	Activity description	Duration	Activities preceding it
1	Mass meeting	January (4 weeks)	
2	Selection of groups of farmers	February (2 weeks)	1
3	Group meeting of selected farmers	February (2 weeks)	2
4	Identification of yield gap on individual landholdings	March, April (6 weeks)	3
5	Understanding farmers' perception of technologies		
6	Identification of production constraints		
7	Setting goals on yield levels		
8	Preparation of technology plan for land development and crop production		
9	Documentation of technology plan	May-October (24 weeks)	8
10	Follow-up on implementation of technology plan		
11	Collection of yield data	November (2 weeks)	10
12	Group meeting on performance appraisal	November (2 weeks)	11
13	Mass meeting on publicity of performance	December (4 weeks)	12

Evaluation is normally a once-only exercise to determine if a project was carried out efficiently, effectively, within budget and conforming to objectives. It can be midterm, or ex-post, and may be used, for example, to decide whether a project should be continue or not and if so, whether and what changes to make in design and/or management.

Monitoring the management

In addition to field level implementation, project monitoring should assess the management as well, for the effectiveness of the institutional set-up.

Checklist for monitoring the management

- Whether a standard review mechanism has been scheduled.
- Whether proper training/orientation has been given to extension workers on the extension mechanism.
- Whether the requirements like teaching materials, audio-visual aids and stationery have been supplied to extension workers.
- Whether inspection, supervision and guidance are organised with reference to identified steps in the extension approach.
- Whether the reporting system has been standardised.

Checklist for monitoring the effectiveness of the institutional set up:

- How effective is the institutional set up?
- What are the bottlenecks?
- What corrective mechanisms are put in place?

Techniques used in evaluation

Capital investment appraisal methods such as payback period, rate of return, benefit-cost ratios, net present value (NPV), internal rate of return, etc. may all be used for economic evaluation. In addition, different statistical or econometric methods may be used to analyse the data. Presentation of results should be suitably designed to match the requirements of users.

Impact monitoring is to determine long-term, sustained changes that occur because of intervention, whether or not they are planned. Impact monitoring does not allocate blame for what is done or not done. It just looks at the result and provides impacts to long-range planning and design of future interventions. *(Some information adopted from Drake Hocking, 1993)*

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Contributor: B. Gopalkrishna Hebbar

Joint progress review

A monitoring instrument for partnerships in rainfed area development

What is JPR?

Joint Progress Review (JPR) is an intermediary tool in the project cycle. It brings together the development agents three to four times a year on the site where action is happening. It aims to strengthen self-responsibility among implementing partners in watershed development programmes. Wherever government departments join hands with community groups and NGOs towards a common development thrust, it helps identify synergies and strengthen roles.

Other tools in the project cycle such as participatory planning, monitoring, self or external evaluation can benefit from JPR results.

JPR also provides the basis in forming terms of reference for evaluations and towards decision-making in watershed management committees at the project level, coordination committee at the district level or at the joint project committee at state level. JPR is directed by the knowledge and logic of farmers, because its process gives an opportunity for farmers to set the agenda.

The rationale

The monitoring and evaluation (M and E) approaches promoted by Swiss Development Cooperation (SDC) attempt to address the missing elements of people's perceptions in the traditional management tools. These are derived from lessons learned such as:

- M and E should be understood as means to promote learning towards a common goal;
- M and E should be guided by the spirit and values which contribute to sustainability;
- M and E should focus more on effectiveness (doing the right things) and less on efficiency (doing the things rightly);
- criteria identified for project success should mainly be those of the focus groups;
- M and E efforts should not be based on our intellectual assessment and logic alone;
- qualitative measurements are as important as quantitative data; and

The essence of JPR is that it cares for the partners' own perception of progress and not primarily for prescribed targets or goals.

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Purpose of JPR

- To review the work, processes, structures and assets created by way of project intervention.
- To jointly analyze reasons for outstanding achievements as well as shortfalls together with the concerned focus groups.
- To negotiate solutions and assign responsibilities for implementing solutions on the ground.
- To document major observations.

Participants in JPR

All implementing partners responsible for parts or entire components of a project; representatives of the concerned population.

Periodicity of JPRs

Every three to four months prior to special evaluations or upcoming planning events.

Duration and methodology

Two to three days each; sample survey based on random selection of sites to be visited; focus group representatives as field guides; treatment plans and maps as reference materials; findings (whether conclusive or disputed) to be entered in forms and signed by all parties.

Thematic focus of JPRs

Emphasis on the effectiveness of implementing of physical, social or institutional components of the project; may be combined with financial or administrative review if required.

- try to attach more importance to "human beings" perception of life quality.

The application of JPR findings

In the past, JPRs generated a wealth of operational findings and were carried to the point of decision - making on site as to what change to be made, who are responsible for the change and when would change be implemented.

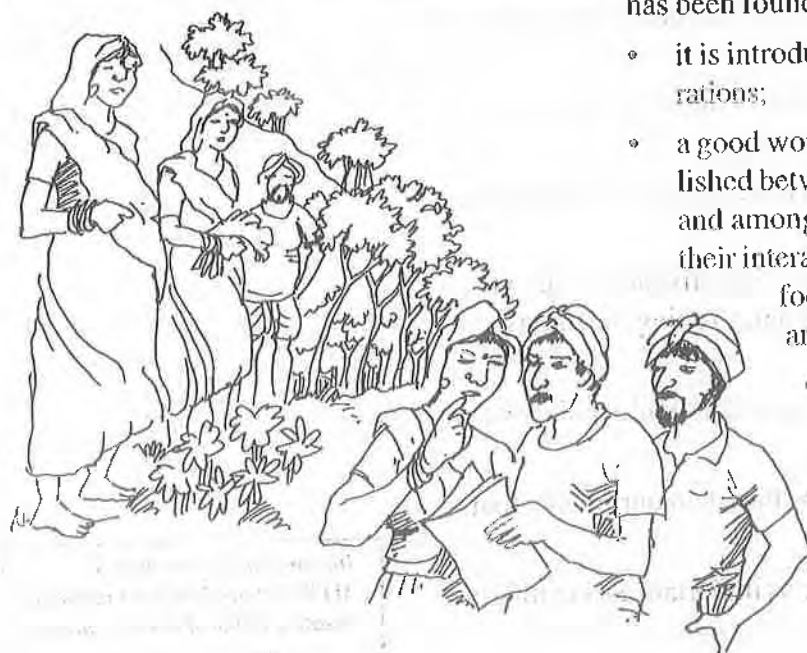
The JPR instrument can be systematically linked to the broader framework of agreed plans and other management steps in the project implementation cycle.

The following conceptual refinements are yet to be systematically addressed:

- taking the JPR findings into village level meetings;
- systematically carrying forward the JPR results in their backward/forward linkages, i.e., relate these to action plans, analyze shortfalls and feed these back into the next JPR round; and
- regularly using JPR results in district and state level meetings.

In spite of the above constraints, the instrument has been greatly enhancing the operational insight into project implementation on the basis of shared assessments on site. JPR has been found to be most useful if:

- it is introduced with adequate preparations;
- a good working relationship is established between outside support agencies and among farmers on one hand and in their interactions with the community focus groups on the other hand; and
- support organizations are willing to spend sufficient time in the project areas and carry a transparent process of negotiating solutions right on the ground.



Lessons and conclusions

JPR as an instrument has strengths on two levels:

JPR Process

- JPR helps realize the strengths and potentials of all partners through joint management.
- It provides a common basis of judgment on project success.
- It facilitates joint collaboration on the ground and reduces gaps between planning and implementation.
- It enhances self-responsibility and promotes transparent management.
- It builds bridges between diverging opinions and removes prejudice.

JPR Results

- JPR contributes in understanding farmers' logic when assessing the value of a project intervention.
- Makes appreciation of good work visible; contributes to self-esteem.
- Allows for site specific and locally adapted solutions.
- Generates qualitative lessons for higher level management.
- Is a regular indicator for the quality of dialogue and collaboration between partners.
- Helps document and record key aspects of implementation.
- Indicates extent of compatibility between norms/guidelines and the results of participatory planning.

Sample format of JPR for a watershed program

Date: 30 October 1996

Survey No.	Sub-and micro-watershed	Activity	Observations	Remarks for next JPR
24, 25	2/2	Boulder bund N.T. B. C. B. Farm Forestry	Activities executed match with the treatment plan. Performance satisfactory. For better upkeep a minimum of three years maintenance period is required.	
178, 179	4/6	Diversion channel	Planned but not executed due to lack of funds and to be taken as spill over.	Follow-up
Signature of Joint Progress Review Committee Members				
SDC	MYRADA	DLDB Agriculture	DLDB Horticulture	DLDB Forestry

Contributors: N.R. Jagannath and M. Sommer

8 Appendices

Appendix 8

Glossary of terms

A

acid soil A soil with a pH value < 7.0 . Usually applied to surface layer or root zone, but may be used to characterize any horizon.

alkali soil A soil that contains sufficient alkali to interfere with the growth of most crop plants.

alley cropping/farming Growing annual crops between rows of trees or shrubs, often leguminous. Pruned material from these is used as mulch around annual crops and also as fodder and fuelwood.

arid climate Climate in regions that lack sufficient moisture for crop production. In cool regions, annual precipitation is usually less than 250 mm. It may be as high as 500 mm in tropical regions. Natural vegetation is desert shrubs.

B

bench terrace An embankment constructed across sloping fields with a steep drop on the downslope.

biodiversity All species of plants and animals, their genetic material and the ecosystems of which they are part.

biomass The weight of material produced by a living organism or collection of organisms. The term is usually applied to plants to include the entire plant, or it may be qualified to include only certain parts of the plant, e.g., above-ground or leafy biomass. Biomass is expressed as fresh weight or dry weight.

bund A ridge of earth placed in line to control water run-off and soil erosion, demarcate a plot boundary, or other uses.

C

chute spillway Open channels with steep slopes consisting of an inlet, vertical curve section, steep sloped channel and an outlet. These can be constructed in all areas irrespective of rainfall and soil characteristics when run-off is to be carried along the steep slopes and sudden drops.

community forestry A form of social forestry, where tree planting is undertaken by a community on common or communal lands.

compost Organic residues, or a mixture of organic residues and soil, which have been piled, moistened and allowed to undergo biological decomposition. Mineral fertilizers are sometimes added. Often called artificial or synthetic manure when produced primarily from plant residues.

contour An imaginary line connecting points of equal elevation on the surface of the soil. A contour terrace is laid out on a slope at right angles to the direction of the slope and nearly level throughout its course. A ditch is sometimes constructed along the contour to store and conserve water.

contour border strips These are strips on contour with no cross slope along the width and are spaced at 0.3 m vertical interval. The levees in between the two strips measure 0.24 sq. m and are most suitable for the medium to deep soil with intake rates of more than 8 mm per hour and where the annual rainfall is around 750 mm.

contour bunds These are earthen embankments on contour. The bunds may be closed with hook up bunds at right angles to the contour bund or kept open and are used to break the long lengths of slopes to intercept run-off against the bunds for absorption.

contour farming A system of farming sloping lands in such a way that ploughing, preparing land, planting and sowing and cultivating operations are done on the contour. It creates numerous ridges and furrows, which help to conserve soil and moisture in low rainfall areas.

coppicing Cutting certain tree species close to ground level to produce new shoots from the stump. Also occurs naturally in some species if the trees are damaged.

cover crops A close-growing crop grown primarily for the purpose of protecting and improving soil between periods of regular crop production or between trees and vines in orchards and plantations.

crop residue The portion of a plant or crop that is left in the field after harvest, e.g., millet straw.

cropping pattern The yearly sequence and spatial arrangement of crops or of crops and fallow on a given area.

cropping system The cropping patterns used on a farm and their interaction with resources, other farm enterprises and available technology which determine their makeup.

D

deforestation The permanent removal of forest and undergrowth.

diversion drain Channels designed across the slope for the purpose of intercepting and diverting surface run-off to save arable lands from the damage due to overflow. These are adaptable in all areas irrespective of soil and climatic conditions. The channel is designed usually with trapezoidal shape and vegetated with suitable species.

drop structures Mechanical checks constructed across the nala or drainage channels to check the water velocity with a weir for conducting excess run-off. They are also constructed as drop inlet structures.

drought The absence of precipitation for a period long enough to cause depletion of soil moisture and damage to plants.

drought tolerance The capacity of plants to survive drought; specifically adaptations that enhance their power to withstand drought-induced stress.

E

erosion (1) The wearing away of the land surface by running water, wind, ice or other geological agents, including such processes as gravitational creep. (2) Detachment and movement of soil or rock by water, wind, ice or gravity. The following terms are used to describe different types of water erosion:

accelerated erosion Erosion much more rapid than normal, natural, geological erosion; primarily as a result of the activities of humans or, in some cases, of animals.

gully erosion The removal of soil and water concentrated in deep, narrow channels.

natural erosion Wearing away of the earth's surface by water, ice, or other natural agents under natural environmental conditions of climate, vegetation and so on, undisturbed by humans.

rill erosion An erosion process in which numerous small channels of only several centimeters in depth are formed; occurs mainly on recently cultivated soils.

sheet erosion The removal of fairly uniform layer of soil from the land surface by run-off water.

splash erosion The spattering of small soil particles caused by the impact of raindrops on soils. The loosened and separate particles may or may be subsequently removed by surface run-off.

G

groundwater Water that occupies pores and crevices in rock and soil below the surface and above a layer of impermeable material. The upper limit of groundwater is the water table.

I

indigenous Native to a specific area; not introduced. Opposite of exotic.

indigenous knowledge Local knowledge unique to a given culture or society.

infiltration The downward movement of water into the soil.

intercropping Growing two or more crops in the same field at the same time in a mixture.

L

land-use system The way in which land is used by a particular group of people with a specified area.

leaching The removal of soluble materials from the upper soil layer by water moving vertically down.

legume Any plant species from the family Leguminosae (e.g; beans, peas) many of which have the ability to fix atmospheric nitrogen via bacteria in or on their roots.

M

manuring Application of animal dung, compost or other organic material used to fertilize the soil.

mixed cropping Cropping system which involves raising of various crops.

mixed intercropping Growing two or more crops simultaneously with no distinct row arrangement.

monocropping The repetitive growing of the same, single crop on the same land.

mulch Plant or non-living materials used to cover the soil surface with the object of protecting the soil from the impact of rainfall, controlling weeds or moisture loss and in some cases, fertilizing the soil.

multiple cropping Growing two or more crops in the same field in one year at the same time or one after the other.

N

natural vegetation The vegetative cover that would exist in a given area without interference from humans.

nala A rivulet or streams of shallow depth.

nala bunding Construction of bunds of suitable dimensions across the nala or gullies to hold the maximum run-off water to create flooding of the upstream area temporarily for some days or weeks, with supplanting arrangements at suitable intervals to drain the water.

P

participatory rural appraisal (PRA) A set of facilitative and participatory technologies developed in the late 1980s by researchers and NGOs, to build upon local people's capabilities and to empower local people in the process.

pasture A portion of land covered with grasses or grass legume mixtures suitable for grazing

percolation, soil water A qualitative term applying to the downward flow of water in saturated or nearly saturated soil in response to the pull of gravity.

pH The negative logarithm of hydrogen ion activity (concentration) of a soil. A pH of 7 is neutral; less than 7 is acidic; higher than 7 is alkaline.

pollarding Cutting back the crown of a tree in order to harvest wood and browse to produce regrowth beyond the reach of animals and/ or to reduce the shade cast by the crown.

productivity, soil The capacity of a soil to produce a specified plant or sequence of plants under a specified system management. Productivity emphasizes the capacity of soil to produce plant products and should be expressed in terms of yield.

pruning Cutting back plant growth, including side branches or roots.

R

rainfed drylands Areas with less than 800 mm of annual rainfall, where crop production depends entirely on rainwater. It is estimated that 19% of the land area in developing countries belong to this category; with approximately 25% in Africa, 28% in central America and 20% in Southwest Asia to less than 11% in East and Southeast Asia.

remote sensing Involves systematic study of multispectral responses of terrestrial objects captured by sensors from aerial or space platforms. The multispectral responses of an object is the record of electromagnetic energy that is reflected or radiated by the object in discrete wavelength bands of the electromagnetic spectrum.

reforestation Replanting of a forest which has been chopped down or destroyed by fire.

ridges Long parallel raised strips of earth usually on the contours, into which seeds are sown.

run-off The portion of the precipitation on an area that is discharged from the area through stream channels. That which is lost without entering the soil is surface run-off and that which enters the soil before reaching the stream is called "groundwater run-off" or "seepage flow" from groundwater.

S

salinity A measure of the total amount of dissolved salts in water. The degree of concentration of salt solution.

sapling A young tree, no longer a seedling but not yet a pole, a few meters high and about 2.5 cm in diameter at breast height.

satellite imagery The art and science of obtaining information about an object/area through satellites orbiting in space. The information received from the satellite is processed at the earth stations and converted into pictures called satellite images.

seedling A young stage of plant grown from a seed.

semi-arid Term applied to regions or climates where moisture is more plentiful than in arid regions but still definitely limits the growth of most crop plants. Natural vegetation in uncultivated areas is short grasses, shrubs and small trees.

sequential cropping Growing two or more crops in sequence on same field per year. The succeeding crop is planted after the proceeding crop has been harvested.

silt The part of the soil beneath the topsoil; usually does not have an appreciable organic matter content.

slope The incline or angle of the land surface, which can be measured as a percent or ratio or in degrees or grades.

soil conservation A combination of all management and land-use methods that safeguard the soil against depletion or deterioration caused by nature and/ or humans.

soil organic matter The organic fraction of the soil that includes plant and animal residues at various stages of decomposition, cells and tissues of soil organisms and substances synthesized by soil organisms.

strip cropping Planting of alternate strips of grasses, or grains with other crops on contour in order to conserve moisture and decrease erosion.

stubble mulching The use of stubble of crops or crop residues left essentially in place on the land as a surface cover before and during the preparation of the seedbed and at least partly during the growing of succeeding crop.

W

watershed A topographically delineated area that can collect water and drained by a river system with an outlet. It includes all land areas extending from the ridge down to the stream for which water is collected. It is synonymous with catchment area or drainage basin. A drainage, however, can involve several towns or regions and even countries.

watershed management The process of guiding and organizing land and other resource uses in a watershed to provide desired goods and services without adversely affecting soil and water resources. It is also defined as the application of business methods and technical principles to the manipulation and control of watershed resources to achieve a desired set of objectives such as maximum supply of usable water, minimization of soil erosion and siltation problems and reduction of flood and drought occurrences.

water harvesting The term used to describe the process of collecting and storing water from an area that has been modified or treated to increase precipitation run-off. A water-harvesting system is a complete facility for collecting and storing run-off for productive purposes. The system consists of a catchment or water-collecting area, a water storage facility and various auxiliary components such as sediments or trash traps, fencing, and evaporation control.

Unit abbreviation

cm	centimetre
dS/m	decisiemens/meter
ha	hectares
m	meter
Mha	million hectare
m ha m	million hectare metre
mm	millimeter
mt	metric tonnes
qtls or qt	quintals

1871-1872

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